Enhancing Regenerative Design Practices in the United Kingdom's Construction Industry

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Abstract. This study uniquely explores the potential for expanding regenerative design practices within the United Kingdom's construction industry. Regenerative design is a key method for combatting environmental degradation and biodiversity loss through the implementation of new habitats, circular economies and promoting the coexistence of humankind and the natural environment. This research consists of an industry survey investigating current awareness, implementation and obstacles surrounding regenerative design.

This survey identified significant gaps in knowledge, prohibitive costs and delays in the local authority approvals process as critical hindrances to progress. Despite 72% of respondents to the survey identifying they were aware of regenerative design, a small fraction of this number demonstrated solid understanding and application of these practices, with only 25% of participants identifying themselves as having an above average understanding of regenerative design. Recommendations to overcome these roadblocks to progress include integrating regenerative design into academic courses by developing specialised modules and workshops, establishing standard details for regenerative features to reduce the delays incurred during technical approval processes and offering financial incentives to encourage wider adoption through tax breaks and public-private partnerships.

This research underscores the urgent requirement to adopt regenerative design, to revolutionise the construction industry from sustainability focused principles to active repair and net-positive approaches. These practices are the only way to reverse the destruction already inflicted upon our natural ecosystems and prevent future harm to human health.

Future research should aim to build on what has been accomplished to date and begin assessing how specific actions may lead to wider implementation of regenerative design.

Keywords: Regenerative Design, Biodiversity Net Gain, Construction

1. Introduction

Regenerative Design is stated by the Arup group (2023) to be "an approach in which human and natural systems are designed to co-exist and co-evolve over time", providing both socio-economic gains for humanity and more resilient environments for the nature with which we share them.

The philosophy and need for regenerative design can be summarised by Carl Sagan's quote in his book Pale Blue Dot: A Vision of the Human Future in Space:

"Look again at that dot. That's here. That's home. That's us. On it everyone you love, everyone you know, everyone you ever heard of, every human being

who ever was, lived out their lives. The aggregate of our joy and suffering, thousands of confident religions, ideologies, and economic doctrines, every hunter and forager, every hero and coward, every creator and destroyer of civilization, every king and peasant, every young couple in love, every mother and father, hopeful child, inventor and explorer, every teacher of morals, every corrupt politician, every "superstar," every "supreme leader," every saint and sinner in the history of our species lived there – on a mote of dust suspended in a sunbeam." (Sagan, 1994)

This draws particular attention to the mortality of our planet and how we must do all we can to protect and repair it.

Following the Second World War, an emphasis on needing to better understand and cater for the environment began to develop (Cole, R. J., 2011), signalling the beginning of a generation that aimed to consider more than simply themselves when creating the built environment. This has led to practices such as 'green' and 'sustainable' design, wherein more consideration is given to preserving our world.

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Sustainable design is commonplace in the construction industry today and is described by HDR Inc. (2022) as "methods that seek to minimize or neutralize the impacts of buildings on the natural environment which in turn creates a state of homeostasis that will not negatively impact future generations", effectively meaning that ecosystems encountered during development are left no better or worse than they were prior to construction commencing. Sustainability remains the standard practice for the construction industry of today but is not the 'saviour' that many often see it to be, as despite the fact that no harm is being done to ecological systems, nor is any benefit being brought. As such, sustainable construction practices lead only to delaying the inevitable climate collapse, as opposed to seeking new paradigms, such as regenerative design, to actively repair our world. Regenerative design is a less commonly encountered design philosophy within the construction industry, due to the "fundamental shift in the values that guide our decisions and, ultimately, a reframing of economic objectives that drive growth and exploitation" (Arup, n.d.) required to implement it effectively and safely. The key differentiators between sustainable and regenerative design are the net gain of biodiversity (biodiversity net gain, BNG), implementation of circular economies and mimesis of natural systems (biomimicry). It is a widely accepted premise across the industry that for a design to be considered regenerative, a measurable gain in biodiversity between pre- and post-development must be observed. Figure 1 provides a simple visualisation of the differences between conventional (or degenerative), green, sustainable, restorative and regenerative design.

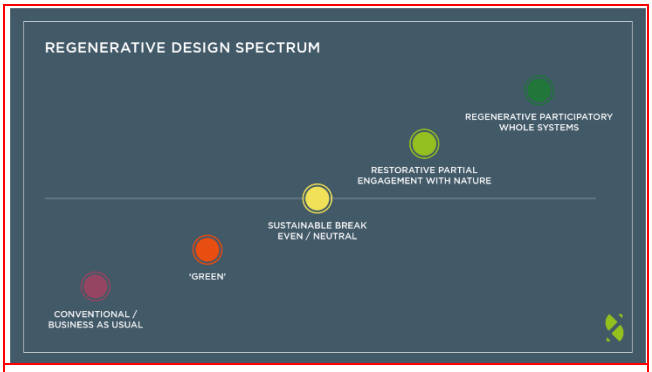

Fig. 1 Regenerative Design Spectrum (RSK, 2022)

Regenerative design of infrastructure is often compared with the urban regeneration of underutilised or derelict urban communities and while the two are often complementary, urban regeneration is predominantly defined as being the improvement of the appearance, infrastructure and economy of an area (RWInvest, n.d.), as opposed to identifying and targeting biodiversity as a key area of investment. Despite this, the two are not entirely incompatible, as such sites can lend themselves to biodiversity net gain, due to the relatively minimal investment required to demonstrate a gain, when the initial comparison point is fully urbanised. As discussed, regenerative design is an umbrella term for any design practice aimed at increasing the biodiversity of an area, however, there are a number of key methods which serve to offer the most significant return on investment in terms of biodiversity net gain, as listed below (Akabogu, D., 2023):

- Biomimicry, "the design and production of materials, structures, and systems that are modelled on biological entities and processes" (Oxford English Dictionary, 2024).
- Circular economies, defined by the European Parliament as "a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible".
- Restoration and reconnection of habitats, wherein existing habitats are repaired, protected and pathways designed to 'reconnect' them, promoting their growth and increasing their future resilience.
- Sequestration of carbon, the process of capturing and removing carbon dioxide from the Earth's atmosphere. The simplest method of which is reforestation/planting to provide greenery that will photosynthesise carbon dioxide.

2. Literature Review

2.1 The Need for Regenerative Design

According to PNAS (2018) and EurekAlert (2019), 50% of global plant species have been lost and the net productivity of global land has decreased by 23%. Paired with the fact that the construction industry accounts for c. 39% of global carbon dioxide emissions (Global Alliance for Buildings and Construction, 2018), it becomes clear that the construction industry is rightfully a clear target for decarbonisation and regenerative practices. The UK government has recently made steps towards this by increasing the level of regenerative design applied across the country through their publishing of the 'Local Nature Recovery Strategies' policy paper, which sets out clear steps that can be taken to heal natural ecosystems. This includes (DEFRA, 2023):

- Creating wetlands

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Fig. 2 Clifton Wastewater Treatment Works (Stantec, 2021)

- Restoring peatlands

Fig. 3 Peat Bogs and Peatlands (Historic England, n.d.)

- Hedgerow and tree planting
- Sustainable management of existing natural habitats – e.g. grasslands and woodlands

This document accompanies the legal requirement of the Environment Act 2021 for each of the 48 areas set out by the Secretary of State to prepare a plan for healing nature and undoing the years of rapacious practices that have left England as "one of the most nature-depleted countries in the world" (DEFRA, 2023).

2.2 Benchmarking Biodiversity

In order to compare regenerative designs, a system to quantitatively benchmark levels of biodiversity must be implemented at the start of a project. In the United Kingdom, biodiversity net gain is measured using the Government's relatively new statutory biodiversity metric, which itself is based on several weighted factors, as listed below (DEFRA, 2021).

- Size
- Condition
- Strategic significance
- Difficulty of creation or enhancement*
- Time taken for a habitat to reach its target condition*
- Distance from habitat loss*

*Only applicable to constructed habitats

This statutory benchmarking allows for all construction projects in the UK to be compared, allowing for maximum transparency during the design and review processes. Each of the above factors contribute 'biodiversity credits' to a scheme, which are assessed to determine whether the mandatory 10% biodiversity net gain has been achieved, as current legislation sets out that a development must demonstrate a minimum of 10% biodiversity net gain before planning permission is granted.

2.3 Applied Regenerative Design

BedZED is a flagship urban regeneration community located in the South of London, where integration of as many sustainable and regenerative building practices as possible was targeted. It was aimed at being a zero-carbon community, where all requirements for fossil fuels and environmentally detrimental practices were mitigated during the design phase. Large areas of open, green space were included, such as a local village square, gardens for the vast majority of properties, green roofs to collect and recycle rainwater and a large, open sports field. Each property is predominantly passively heated, through highly efficient insulation, solar energy retention and airtightness, with any surplus heating provided by a district heating network powered by a biomass boiler. The biomass boiler itself is then powered by sustainably sourced wood pellets. Prior to the biomass boiler being installed, the district heating network was powered by a woodchip-burning plant, which was fuelled by the waste produced from the maintenance of on-site trees and vegetation, providing a circular economy for the residents and removing the need for external fuel. However, in 2005 this plant was removed due to restrictions placed on its operation by the Council over fears of noise complaints, highlighting one of the array of roadblocks faced by innovative and regenerative designs.

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Fig. 4 BedZED Zero Carbon Community – Sutton, London (Bioregional, 2019)

2.4 Regenerative Design and Development: Current Theory and Practice. Cole, R. J. (2011)

In this paper, Cole explores regenerative design and its implementation, with the presiding view being that, as of the publication of his paper, regenerative design is significantly more difficult to implement in the built environment due to minimal understanding and a lack of appropriate legislation/guidance than sustainable and conventional design practices. The immediacy required by stakeholders and clients to ensure the financial viability of projects means that regenerative design is often overlooked in favour of green or sustainable design practices, as these are far better understood and offer a more recognisable reputational benefit – through widely known accreditation schemes – for the project while maintaining profitability. A key problem is summarised when Cole states "While green design, for example, can offer LEED or BREEAM rating as a measure of performance, regenerative design will not be able to give such a declaration. As such, this will require a qualitatively different type of acceptance by clients and stakeholders of a building's current and potential merits", showing that while regenerative design offers a far greater benefit to the area being developed, the lack of a certification scheme to allow comparison and easy recognition of regenerative design means that companies are less willing to incorporate regenerative practices into their projects.

Fig. 5 BREEAM Sustainable Categories (Illumine-I, 2022)

Also, Cole notes that "The need for discrete performance criteria in green assessment methods also carries the potential consequence of fragmentation", whereby assessment methods diverge over time and the ability to compare their results is diminished, hindering the ability for organisations to compare and contrast schemes. This in turn may lead to results being displayed in such a way that could mislead the public regarding the benefit a project brings about. As such, a legislated method of comparing regenerative projects – such as the UK's approach – is required globally. Furthermore, the author states 'most green assessment tools have wrestled with accommodating regional distinctions and cultural differences as they are increasingly deployed outside of their countries of origin", further hindering the progress afforded by providing adequate tools and methodologies for implementing change. This once again adds to the reluctance of design teams to implement regenerative practices, as there is a raft of pre-existing legislation in all countries that must be adhered to, which could potentially prohibit the implementation of regenerative designs. Also, creating a single overarching guide for regenerative design cannot be capable of serving everywhere, regional distinctions must be made to account for varying ecology, climate, economies and needs.

Cole continues to discuss how the current ideology of improving the climatic impact of construction is "premised on incremental advances rather than more fundamental challenging of practice norms", which would allow for a complete overhaul of the way design and construction are considered both in the UK and worldwide. A fundamental re-evaluation of the construction industry as a whole may be the only way to truly integrate a regenerative approach at all stages of a development, resulting in a vast financial hindrance. Cole also describes the fact that the longer timeframes required to see a noticeable increase in

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biodiversity are yet another source of dissuasion for prospective projects, with constructors and clients far preferring the relatively immediate gains of sustainable or green design over the long-term foundational improvements made by regenerative projects. As such, regenerative design must be seen as an investment in the future rather than a 'tick box' as most sustainable requirements are viewed nowadays. A further key consideration made by Cole is the view of humanity's environmental repair projects. Currently, views expressed on climate change and humanity's actions to remedy it are often pessimistic in nature and the warnings provided are grave. While these messages are intended to elicit a sense of panic and urgency, in practice, as Cole points out, "offering a positive vision that strikes accord with human values may be more effective in creating change than presentation of alarming facts", suggesting that a positive 'look how far we have come' view could potentially lead to an increased sense of drive for the industry, as a sense of progress can often inspire further effort from all involved in a project. While the need for change is dire, identifying regenerative construction as another positive method for healing the environment and communicating its benefits positively could help accelerate the progress made.

Cole finishes the paper: "With regenerative design and development one is, perhaps, witnessing the convergence and assimilation of what were once considered idealistic and seemingly distant notions, now as necessary and potent directives for current best practice and future main-stream practice", demonstrating the fact that despite the views expressed previously, progress is being made towards regenerative design – another opportunity for more hopeful words as mentioned previously – with the implementation of such designs gradually being seen as more attainable, a key first step in the journey to industry-wide adoption, which will in turn help to repair the damage caused by rapid modernisation over the past 100 years.

2.5 Towards a Regenerative Paradigm for the Built Environment. du Plessis, C. (2011)

Following Cole's editorial regarding the current theory and practice surrounding regenerative design, du Plessis investigates the current and potential future paradigms of sustainable and regenerative design, citing problems such as the private sector's "perpetuation of the structures of society that created the [environmental] crisis in the first place" as a key factor in pushing regenerative design through to the mainstream. The structures du Plessis refers to are not simply "the systems of production or the organisation of the economy, but include the very worldview that underlies modern society" reaffirming the points set out in Cole's paper regarding the requirement for a fundamental re-examination of the way humans approach the built environment. Moreover, du Plessis states that "this worldview holds that nature can be seen as a machine that can be understood and managed by reducing it to its parts." Citing W. E. Rees's paper in D. Satterthwaite's book 'The Earthscan Reader in Sustainable Cities', "Humans are seen as separate and above nature". This once again solidifies the fact that in order for a design to be deemed regenerative, the relationship between nature and humanity must be seen as cooperative and equal, as the construction industry "seeks understanding of whole systems" (Cole, 2011).

The paradigm that supports regenerative design as a practice is defined by du Plessis to be one "that calls for profound and radical changes to the structures of society, including the dominant worldview, in order for the Earth to remain fit for human habitation". Once again reinforcing the need to move past current thought and push for the progression of natural integration, as previously discussed. Arguably one of the most important methods for allowing the progression of regenerative design is proving to the world that regenerative design offers economic or financial gain for those who invest, as monetary gain is always the driving force behind any form of progress. As is often highlighted within densely populated urban environments, du Plessis posits that "the modernization project was expressed in the built environment through embracing the principles of the Modern Movement and automobile-based town planning schemes", highlighting the fact that not only does automobile-centric design not serve populations as optimally as public transport, but it eliminates many opportunities for the implementation of regenerative design practices. The greater land usage required for road networks removes potential areas of reconstructed watercourse, while large areas of car parking cover land that could instead be used for the construction of ecologically dense wetlands, grasslands or woodlands. Only by viewing construction holistically can the best solutions for integration be reached.

Du Plessis continues to explore how the end of the Second World War resulted in a vast increase in development, with the gaining of political independence for many colonies resulting in a rush to 'modernise' in the same way more developed Western economies had previously done so. This meant that – despite attempts to create their own, sustainable built environments – "most of the world uncritically replicated inappropriate interpretations of Modernist architectural ideals to accommodate the needs of rapid

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urbanization". Which then in turn resulted in "an urban form and building stock that was socially dysfunctional, highly resource inefficient and unhealthy (Jacobs, 1961/1992; World Health Organisation (WHO), (1999)" which continues to be seen to this day. As discussed by Cole, specific, targeted plans for regenerative design in more marginalised countries must be created to prevent a rush to replicate – often unsuccessfully – the practices adopted by the Western world. When considering the adoption of sustainable and regenerative design by large multi-national corporations (MNCs), du Plessis discusses how the use of business language and terminology allows for better understanding of the environmental crisis, as typically, MNCs are viewed as being less inclined to adopt sustainable practices due to their increased initial cost. This is referred to as "Sustainable Capitalism" and promotes the idea that future generations will 'inherit' the environment as they would an estate. This is built on the idea that the Department for International Development (DFID, 1999), Sigma Project (2003) and Parkin, S. (2000) proposed, wherein Sustainable Capitalism is founded on the stocks of five individual capitals: financial, human, social, manufactured and natural. Each of which are "considered necessary to prepare the balance sheet of sustainable development". Framing the environmental crisis in such a way allows for a greater understanding of the drastic scenario the world currently faces, which in turn encourages said corporations to invest in the restoration of the natural world, as the initial investment placed in regenerative design will return a far greater value in the future.

2.6 Regenerative Design, the LENSES Framework for buildings and communities. Plaut, J. M. et al. (2011)

In this paper, Plaut outlines the Living Environments in Natural, Social and Economic Systems (LENSES) framework and how it may be utilised to drive change in the construction industry. The LENSES framework is designed to address the question "How do we synthesize regenerative whole systems principles into a framework that facilitates the type and scale of change needed?".

The framework aims to "simplify, clarify and depoliticize [regenerative design's] key terminology", making sure to explain terms and theories simply and rigorously, helping to create a foundation on which further ideas can be built. Tools such as this will help to 'demystify' regenerative design and provide a key stepping stone to ensuring a wider adoption across the industry as a whole.

Plaut states that "The majority of design and construction projects and the professionals who create them are subjugated by the current economic paradigm and by the social impetus, or lack thereof, of a given project's owner and/or developer. To address this deficit, the LENSES Framework makes a concerted effort to incorporate concepts and methods for addressing the change in social and economic systems, as well as natural systems.", highlighting the urgent need to tackle the often prohibitively high costs and unwillingness of teams to facilitate regenerative design, as is a common theme among most research into regenerative design. Another key aim of the LENSES framework is to reframe how construction/regeneration projects are viewed. Currently, the predominant approach is the "inside-out" thinking model, which "is characterized by the question 'Where can we go from here?' […] The solutions are based on improving existing, and in many cases, deeply flawed models." Showing the need to reassess the method in which the industry approaches a project from the outset, as when 'outside-in' thinking is applied – where questions such as "Where do we want to go and how do we get there" are asked – a more holistic and thorough approach to implementing regenerative design is promoted. This echoes the thoughts of Cole's paper, where the author discusses the "fundamental challenging of practice norms" required to reach a truly integrated society for humanity and the environment and push for the wider adoption of regenerative design across the industry.

In total there are three individual 'lenses' within the framework; foundation, aspects of place, and flows (shown below in Figure 2). Each is visualised as a ring of interlinked words in concentric circles, with the idea being that each ring can be twisted to view each word surrounded by words from the two remaining lenses, helping to "encourage users to consider interconnectedness of the various elements". The blank space left on each lens is designed to foster thoughts of "What is missing? and What else should we be considering?", advocating the idea that regenerative design is never 'complete' and latest ideas should always be welcomed and explored. The LENSES framework continues to examine a project's life further by identifying five phases and likening them to the cycle of life. These being:

"Discovery/conception: exploration, finding out about something; the genesis of ideas.

Design/gestation: development of an idea; creating a detailed plan.

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Implement/birth: to carry out or fulfil something; the emergence of life.

Operate/life: the period during which something continues to function or work.

Decay/death: decline; the end of something, implies the beginning of a new cycle."

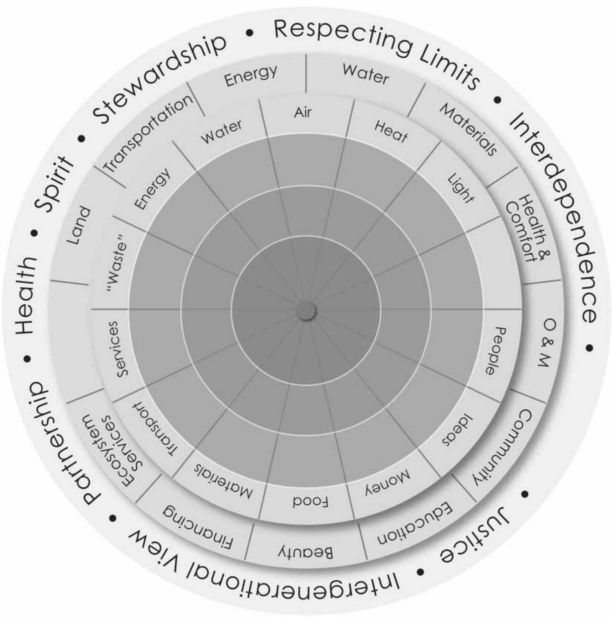

Fig. 6 The LENSES Framework (Plaut. J. M. et al, 2011)

This in turn helps to further cement the idea that the built environment can be thought of as a living organism that requires care – in the form of regenerative design – and must be treated as a complex arrangement of living organisms as opposed to bricks and mortar as it has typically been viewed, promoting a sense of empathy towards the built environment. While the LENSES framework does aid in conceptualising regenerative design, it is not a definitive tool to be used for quantitative comparison, meaning there is still a requirement for a dedicated, universal, evidence-backed tool for baselining such practices in the construction industry globally, and as such, until a tool is developed that can allow for quantitative comparison, no internationally recognisable certification scheme for regenerative design can be implemented. The LENSES framework is aimed at providing the first steps into incorporating regenerative design by demonstrating the broadness and freedom available to professionals within the industry, and as such is still a vital tool for the shift from sustainability to regeneration.

2.7 Key Insights from Literature Review

From the literature reviewed, the conclusion can be drawn that currently, regenerative design can be viewed as an optional 'step above' the industry's standard practice in most of the world, while in the UK, a 10% biodiversity net gain must be demonstrated to receive planning permission. This 10% increase is a good first step into a more co-dependent world but will not provide the more drastic change that is required. The repair, reconstruction and reconnection of natural habitats will allow for a more wholesome integration of nature and humanity, with the end goal of creating communities that actively improve the world they exist in. However, to achieve this, several key roadblocks must be overcome. Namely:

- Increasing the visibility and understanding of regenerative design and demonstrating that sustainable or green designs are in and of themselves, not sustainable practices.

- Creation of a standardised tool for comparing regenerative design and assessing how to have the greatest impact for the minimum investment, not only in the UK but worldwide.

2.8 Gaps in Existing Research

What is preventing a wider knowledge and understanding of regenerative design across the UK's construction industry specifically and how can this be counteracted?

Identifying the exact costs of implementing regenerative design is also problematic, as little research exists into the financial cost of adopting such practices. However, due to the vast variations in project type, size, requirements and existing ecology, finding a general 'rule of thumb' would prove extremely challenging in practice.

2.9 Research Questions

How can obstacles preventing the integration of regenerative design be overcome/lessened?

How can the processes and theory behind regenerative design be better communicated to both the construction industry and the general public?

Why do current projects not integrate regenerative design as fully as they could?

How can regenerative design be seen as the standard practice for construction as opposed to an unobtainable ideal?

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3. Methodology

To understand and assess the reasons for the lack of regenerative design in the UK construction industry, experienced professionals within the industry were interviewed in the form of a questionnaire to form a primary source of research. The survey canvassed 36 participants from disciplines including engineering consulting (21 respondents), planning (eight respondents) and contracting (two respondents). This formed the widest data set practicable and allows data to be subdivided to assess the understanding and application of regenerative design in differing disciplines and assess differences between contracting and consulting businesses' views on regenerative design.

A research form was chosen as the optimal method for data collection due to its ease of use, lack of discussion between participants (avoiding interpersonal influence) and ease of analysing results. However, a survey can lead to inaccuracies in data due to bias of participants or bogus results. As such, each response was carefully analysed to ensure data was valid and usable. Furthermore, if similar research was conducted in the future, a greater sample size should be targeted to further enhance the correlations and trends identified.

4. Introduction to Research

4.1 Aims and Focus

This research aimed to identify the current industry understanding of regenerative design, the current adoption of regenerative design and key obstacles preventing further implementation of regenerative design, while simultaneously building on the work of researchers such as Cole, Plaut and DuPlessis, discussed previously. It offers important insights for the construction industry to build on and may help to improve the thinking and practices involved in modern developments moving forward.

4.2 Industry Research

Initially, a simple research form was created and distributed to various construction industry professionals to approximately determine the current understanding of regenerative design. This allowed for data to be taken directly from a wide demographic of industry professionals, allowing for any conclusions drawn to be as broad as possible. The research form comprised 13 questions and was distributed to participants by email and social media posts – specifically LinkedIn – to reach the most appropriate audience.

Once the form had been distributed, responses were disseminated to identify key trends, such as consensus on constraints to implementation and theories on best practice for enhanced adoption. Trends identified within the data have then been analysed and used to create six key recommendations for the construction industry as a whole. Furthermore, a recommendation for further research that may offer improvements to the construction industry has also been made in section six.

It should be noted that despite the research survey being designed to avoid influencing respondents' answers, this form of data collection can be prone to bias. However, this has been mitigated by sampling from as large a group as practicable. In the future, even greater effort should be made to gather responses from an even larger demographic or to collect data through less bias-prone methods, such as interviews or focus groups.

5. Results

5.1 Overview

This section presents the findings of the research form distributed to construction industry professionals, with the key aims of identifying recommendations to the industry on how to better understand, implement and manage regeneratively designed projects. In total, 36 people completed the research form, with said participants covering a wide range of backgrounds and experience levels, the results for each question are expanded upon below.

5.2 Question 1: What kind of construction industry professional are you?

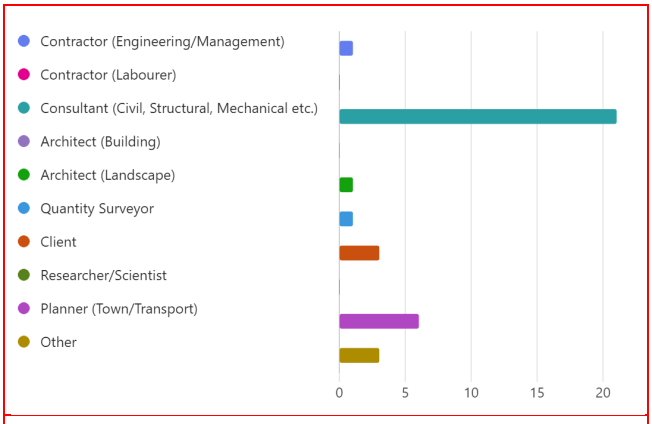

Fig. 7 Breakdown of survey respondents by profession

Question one was designed to gather information about the type of professionals responding to the survey, which in turn was used to inform trends among different fields. In total 21 consultants responded, eight planners (landscape, environmental, town and transport), two contractors (both of

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whom were site engineers), one quantity surveyor, one landscape architect and three clients. This approach enabled generalisation of understanding across the industry, however, future research should prioritise more responses from contractors and clients, as they significantly influence project design and progression.

The substantial number of consultant responses prove useful for this research as the implementation of regenerative design is usually dictated by them throughout the project, meaning the more accurate an image of the consulting industry ascertained, the more focused the recommendations made can be for the drivers of regenerative design.

5.3 Question 2: How long have you worked in the construction industry?

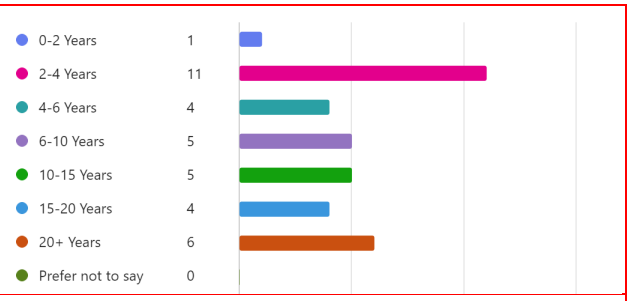

Fig. 8 Breakdown of survey respondents by experience

By requesting participants to identify their level of experience within the industry, trends between levels of understanding and career duration have also been identified – as explained in Section five. Also, the relatively even distribution of experience levels has allowed for a suitably accurate assessment of the current construction industry to be made. The weighting toward less experienced professionals (60% with under 10 years' experience) enables an evaluation of current education and training systems, along with recommendations for improvement. Future research should target professionals with less than two years' experience. This will allow for an assessment of how educational institutions are helping to promote and teach the next generation of the construction industry about regenerative design, as only one participant in this survey belonged to this category.

5.4 Question 3: Have you heard of regenerative design?

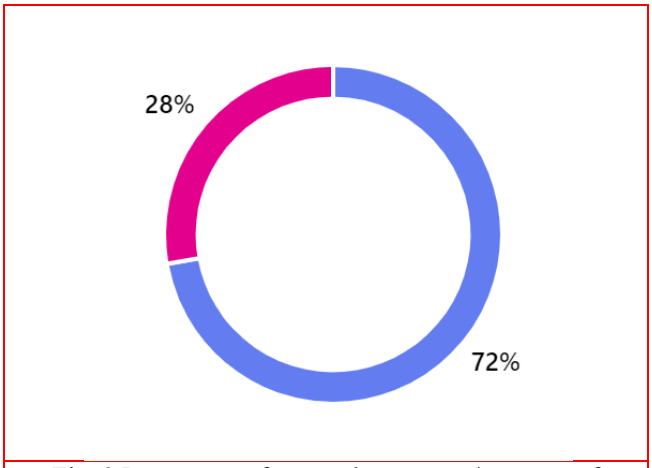

Fig. 9 Percentage of respondents aware/unaware of regenerative design (pink representing aware, blue representing unaware)

This question was designed to understand – at an extremely high level – the percentage of participants who were aware of regenerative design as a practice, regardless of their understanding or application of it. As identified in the figure above, 72% of respondents stated they are aware of regenerative design, proving that the vast majority of professionals have been made aware of regenerative design, even if only by name. Notably, however, of the remaining 10 responses, 60% had previously identified that they had less than six years of experience in the industry – highlighting once again the need for greater education of regenerative design during the formative years of a career. Of the remaining 40%, two identified themselves as having 10-15 years' experience and the remaining two as having 20+ years of experience. The reason for these participants not being aware of regenerative design cannot be exactly identified but may be due to their working in fields not immediately suited to the integration of regenerative design (i.e. industrial design or nuclear engineering).

5.5 Question 4: To what extent do you understand regenerative design?

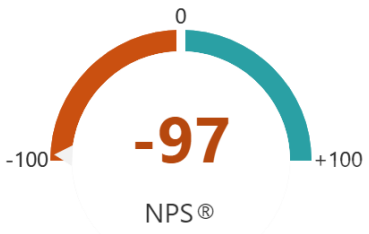

Fig. 10 Net Promoter Score (NPS) for respondents' understanding of regenerative design

Question four was designed to allow participants to assess their own knowledge of regenerative design using a rating

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system from 1-10. This question is useful for a high-level understanding of others' knowledge of regenerative design but the way in which responses are given is extremely subjective, and prone to the Dunning-Kruger effect – wherein people overestimate their knowledge and understanding of a subject due to their lack of knowledge of said subject (Britannica, 2024).

With an average response of 3.2, this question demonstrated that the understanding of regenerative design is far lower than the awareness of it – echoing the findings of Cole's paper 'Regenerative Design and Development: Current Theory and Practice'. In total, only 12 people rated their understanding as greater than or equal to five, with the highest response overall being only seven. This identifies that even though the majority of participants know of regenerative design, only one third have the confidence to rate their knowledge as equal to or above average. This may be due to an unwillingness for more experienced designers to rate their knowledge highly as they are aware of their own limitations – more akin to impostor syndrome – despite multiple respondents having a varied career of constructed and proven regenerative schemes. While drawing concrete conclusions from the data gathered from question 4 is not feasible, it does clearly demonstrate that once again, more emphasis must be put on regenerative design by educational institutions and construction related companies alike in order to see a wider uptake across the industry.

5.6 Question 5: If you are actively implementing regenerative practices in your projects, please describe them below.

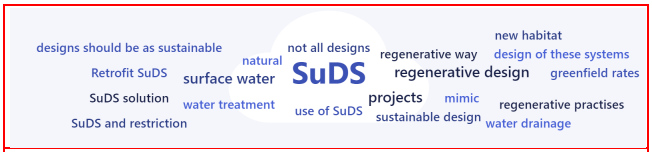

Fig. 11 Word cloud demonstrating common regenerative design practices

Question five was a written response question, asking for examples of regenerative design being implemented across the UK currently. Similarly to question four above, this question aimed to further investigate the understanding (or lack thereof) of regenerative design identified by Cole's research.

As the word cloud above demonstrates, the majority of responses revolved around SuDS (sustainable drainage systems) and surface water management. This is likely due to recent scrutiny of water companies and the controlling/mitigating of combined sewer overflows (CSOs) into rivers and seas. This has therefore brought greater attention to drainage practices such as retrofitting SuDS and installing constructed wetlands as a method for protecting the natural environment. SuDS can be excellent methods for introducing biodiversity and managing surface water and wastewater respectively, however, what this does demonstrate is the fact that more awareness must be raised regarding other regenerative design practices – such as the implementation of circular economies and biomimicry – in order to develop a more wholesome approach.

Other practices raised by respondents as being regenerative include recreating natural landscapes through planting of indigenous species of trees and grass (biomimicry) and the use of district heating networks (DHNs) and district cooling networks (DCNs), such as London's SELCHP network. While these district heating/cooling networks do offer more environmental benefit than individual gas-powered boilers for buildings, they are not in and of themselves a regenerative practice. However, through the implementation of a circular economy these can become regenerative. For example, in developments near large datacentres, the excess heat generated by the computing clusters can be collected via liquid cooling systems and redistributed to local buildings. If the energy used to power these datacentres is then sourced sustainably, i.e. through wind generation or biomass waste burners on the development, the complete system becomes self-sufficient and thus relieves any reliance on pre-existing infrastructure.

This highlights again the need for greater information and awareness of the difference between sustainable design and net-positive regenerative design, like Cole's research suggested, each of the suggestions above are "premised on incremental advances rather than more fundamental challenging of practice norms".

5.7 Question 6: Could there be additional practices adopted in projects where regenerative design is being implemented? If yes, please specify.

Fig. 12 Word cloud showing how regenerative design could be further implemented on schemes already specifying regenerative design

Question six provided the opportunity for respondents to suggest any extra steps they believed could further increase the level of regenerative design implemented across their

projects. Only 14 of the total 36 participants responded to this question, with multiple highlighting the need for greater education and the introduction of standard practices for regenerative design. One particularly insightful suggestion discussed the potential for tax reductions based on the amount of regenerative design practices incorporated across a development. This would help to ease the increased cost of regenerative design – which 53% of participants identified as being a key roadblock – as developers will be able to justify such practices more readily. This reduced tax model is already applied to research and development through the R&D tax credit scheme in the UK and as such may be a genuinely feasible introduction for improving regenerative design adoption. This would greatly help in developing novel solutions for the construction industry, and while simultaneously mitigating the risk contractors and developers would face when specifying said solutions. These schemes will act as a significant stepping stone in 'Sustainability Capitalism' as described in DuPlessis's paper regarding many MNCs unwillingness to adopt regenerative design due to the higher initial outlay.

Another suggestion was for legislative bodies to provide a 'menu' of regenerative solutions that can in turn be applied to projects across the UK. This would effectively fast track the approvals process for small scale regenerative features and encourage greater integration. This would align with the reduction in tax for research and development costs in reducing risks for regenerative projects, as a clear history of functionality would prove their effectiveness and promote further adoption. Such 'menus' would support Plaut's goals to 'simplify' and 'clarify' regenerative design, enhancing the likelihood

5.8 Question 7: Which of the below do you consider to be regenerative practices?

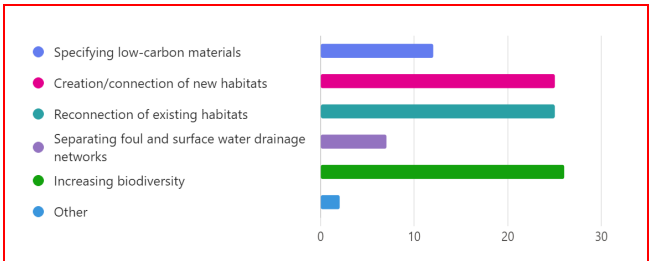

Fig. 13 Breakdown of responses to perceived regenerative practices

This question aimed to determine whether participants were aware of the difference between regenerative design and sustainable design practices, as these are frequently mistaken. The three 'correct' answers were creation/connection of new habitats, reconnection of existing habitats and increasing biodiversity and as demonstrated by figure 13, 25 participants (70%) identified these as regenerative.

Seven participants also identified the separation of foul and surface water drainage networks as being a regenerative practice, which in the literal sense of having separate pipe networks for each would not be deemed a regenerative practice, but when combined with nature-based solutions – such as SuDS and constructed wetlands – can be deemed regenerative. Of the seven responses stating separating flows is regenerative, five had previously mentioned SuDS as a method for introducing biodiversity, showing their deeper understanding of the subject. 12 of the respondents highlighted specifying low-carbon materials as being a regenerative practice, however, on its own, this is incorrect. Specifying low-carbon materials such as limestone calcined clay cement (LC3) is deemed to be a sustainable practice, as it aims to reduce the overall damage being done to the environment, as opposed to reversing damage. What question seven has shown is the lack of understanding from the construction industry around what difference between sustainable and regenerative design is. Clear identification of the fact that sustainable design simply aims to do no more harm to the environment must be provided to the wider construction industry to overcome ever-growing complacency.

5.9 Question 8: What do you consider to be the most significant obstacle(s) to wider adoption of regenerative design?

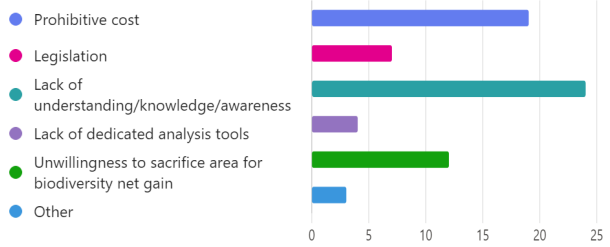

Fig. 14 Breakdown of responses to perceived obstacles to regenerative design

Question eight aimed to determine whether the construction industry viewed one or more of the listed roadblocks to regenerative design as more significant than others, each of which were based on key areas requiring improvement from Cole, DuPlessis and Plaut's respective papers. As figure 14 demonstrates, prohibitive cost and lack of knowledge were identified as the two most prominent hindrances to regenerative design, with 53% and 67% of respondents identifying each of these, respectively. As previously

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outlined in section 4.7, tax relief schemes could offer the greatly needed reduction in cost for regenerative construction, along with the implementation of standard details and increased investment in research and development. With two-thirds of participants identifying a lack of knowledge as a key impedance to greater implementation, this once again highlights the desperate need for wider and more in-depth education around regenerative design as a whole. This could be through the mandating of regenerative design-based modules at universities and colleges, industry wide up-skilling conferences or through more publications of case studies.

5.10 Question 9: Expand further on your response to question 8.

Fig. 15 Word cloud showing further responses to roadblocks to regenerative design

Question nine provided respondents with the chance to add their own insight into the reasons that regenerative design is not implemented as fully as they believe it should be. Of the 16 people who responded to this question, seven (44%) identified cost as being a major restriction to regenerative design. Two detailed arguments were raised in this question, one for and one against the implementation of regenerative design, highlighting the need for thorough planning and design, as explained below.

One candidate highlighted regenerative design as being potentially counter-productive, with the need to ensure the design and implementation of habitats is considered in tandem with pre-existing ecological systems, making sure to not preclude indigenous species from their current ecosystem by introducing predators or invasive species. This highlights a key risk of regenerative design, but one that is controllable with appropriate knowledge of ecology and ecosystems.

Another cited the use of the tools CAVAT (Capital Asset Value for Amenity Trees created by the London Tree Officers Association, LOTA) and B£ST (Benefits Estimation Tool created by Ciria) to help in quantifying the financial benefit to be gained through the implementation of both amenity trees and SuDS/blue and green roof systems. These tools could be used by governments when quantifying biodiversity net gain to support the implementation of tax relief for developers or potentially be combined with novel assessment tools to monitor an entire project. Further examination of cost reduction measures is undertaken in section five of this report.

5.11 Question 10: To what extent do you agree that actively implementing regenerative design should be the industry standard for infrastructure design?

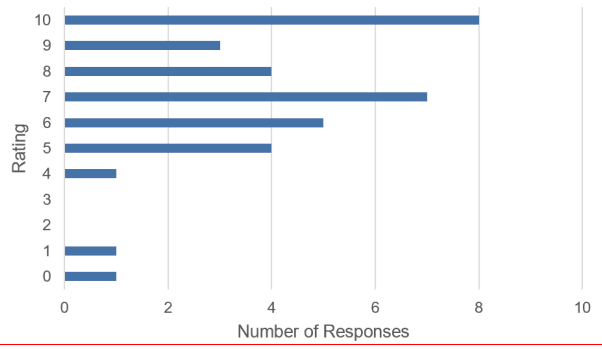

Fig. 16 Breakdown of favourability of regenerative design by number of responses

Question 10 demonstrated the fact that regenerative design is viewed favourably by the construction industry, with an average rating of 7.1 and a response rate of 97%. Furthermore, of the 35 responses, eight (24%) agreed fully with the statement that regenerative design should be the industry standard for infrastructure design by responding with a 10. Of the remaining responses, seven people provided a rating of below five, with their explanations as to why given below in question 11.

5.12 Question 11: Expand further on your response to question 10.

Fig. 17 Word cloud showing common responses for opinions on regenerative design

Following a positive (greater than five) response to question nine, candidates noted that regenerative design is one of if not the only way to fight the climate crisis but is unlikely to become a standard practice in the short term due to its high initial costs. The key message was to ensure a productive balance between saving costs and implementing regenerative design.

Of the seven negative responses to question nine, only three comments were provided, two of these once again identified the need for greater understanding to be able to fully recommend regenerative design, while the third discussed the reduction in urbanistic efficiency owing to land being dedicated to regenerative features. These concerns support

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the perception that the industry currently regards regenerative design as prohibitively expensive and inefficient, particularly in terms of long-term viability. However, alternative evaluation frameworks, such as CAVAT and B£ST which quantify the fiscal benefits offered by biodiversity, alongside innovative design strategies – like utilising roofs and other typically underutilised spaces for regenerative purposes – demonstrate that profitability and appropriate urbanistic densities remain attainable.

5.13 Question 12: Please add any further comments below.

Question 12 allowed for participants to provide any other remarks about regenerative design. One participant provided a response to this question, with insight into how regenerative design can be implemented cheaply and easily, even if only on a small scale:

"It is so simple to provide some biodiversity wins within a project. Put a discarded piece of pipe into a retaining wall, and it becomes a habitat for a small bird at zero cost to the developer. It just takes a little imagination."

This highlights that biodiversity can be improved through small features, while simultaneously reducing amount of waste on site, waste transport requirements and cost. The same intentions can be applied to larger scale features, such as through the use of excess aggregate or crushed waste concrete to create habitats around attenuation ponds to provide amphibious life with shelter or through the use of timber offcuts to create insect and small mammal habitats.

5.14 Question 13: I consent to my responses being used exclusively in the author's research project.

This question was written purely to gain express consent to use given responses in this project. All 36 respondents consented to the use of their responses.

5.15 Conclusion

In summary, the results of this industry survey identified a relatively high level of awareness within the construction industry in the UK, but a significantly lower level of understanding and application. Lack of knowledge, training and examples serve as the predominant obstacle to regenerative design's implementation, with prohibitive cost also preventing wider adoption. Participants suggested greater education and reductions in cost through tax incentives as the most effective methods for broadening the implementation of regenerative design, with the implications of these schemes considered in the following section.

6. Discussion

6.1 Overview

The results of the research form clearly identified the lack of knowledge as a whole across the construction industry. This section discusses the implications of the responses and any correlations between them, including between experience levels and specialisms. Each heading in this section relates to one of the four research questions initially posed in section 2.10.

6.2 How can obstacles preventing the integration of regenerative design be overcome/lessened?

Question two of the research form requested participants identify the level of experience they have within the construction industry, this question helped to establish the fact that broadly, the greater the experience of a respondent, the higher the likelihood they understood regenerative design. Of 14 respondents with greater than 10 years' experience, 10 identified they had some level of knowledge of regenerative design. Furthermore, of these 10, nine were consultants. This is probably due to more experienced employees interacting with a greater number of external professionals and being exposed to meetings with clients/developers at a feasibility stage, when practices such as regenerative design are more likely to be discussed and assessed. Furthermore, when operating at a management/strategic level and being responsible for multidisciplinary schemes, an understanding of all the facets of a development – including regenerative design – are critical for successful project management, necessitating an understanding of all construction practices. What this highlights is the lack of dedicated education for the industry regarding regenerative design. The vast majority of people are made aware of regenerative design only through experience as opposed to education, which prevents a fundamental understanding and curiosity being instilled into professionals at the outset of their career. The need for early career professionals to be exposed to educational resources about regenerative design, be it through university and college modules, company specific training courses or industry wide upskilling events, is a key first step for overcoming the fundamental lack of knowledge of regenerative design. This is further supported by the fact that the only participant who identified themself as having 0-2 years of experience in industry stated that they had no knowledge of regenerative design.

The second key obstacle to regenerative design is the higher financial outset required to design, implement, maintain and manage proposed features, with particular emphasis from

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participants of the survey put on the fact that acquiring planning approval from local authorities can be significantly delayed when specifying non-standard details, due to the risks posed by more complex maintenance, increased land use and lack of historical data. This in turn translates to higher design, investigation and research fees, along with a delay in the commencement of construction, which depending on the timescale for approval may in turn greatly increase construction costs during periods of high inflation – such as in 2023.

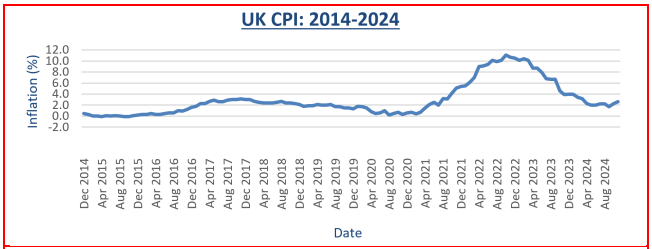

Fig. 18 UK Inflation Trends, 2014-2024 (ONS, 2024)

Question 6 asked participants 'Could there be additional practices adopted in projects where regenerative design is being implemented? If yes, please specify.' Multiple participants emphasised the need to establish a set of typical details for introducing regenerative design in the UK construction industry. This could be accomplished through the creation of a suite - or menu - of standard regenerative details to avoid the need for lengthy discussions between developers, consultants, contractors and approval bodies at the planning stage of a project. This menu of details would then operate in the same way as a pre-existing highway or drainage construction detail list would, where designers are able to specify various solutions across a development without the need for lengthy technical approval processes. While there would be a significant initial cost to create this suite of details, the time savings in the future would negate this initial expenditure. For developers, the cost of design and construction would be lessened, for contractors, construction would be easier as it would be well understood and method statements would be readily available, and finally for the local authority, developments would begin and complete more quickly, adding desperately needed amenity to their constituencies and thus enticing new homeowners, businesses and tourists.

6.3 How can the process and theory behind regenerative design be better communicated to both the construction industry and the general public?

As previously discussed, education has been identified by respondents as being the most predominant constraint to introducing regenerative design, however, raising awareness of the practice as a whole can supplement education schemes in multiple ways for both construction industry professionals and the general public alike. By demonstrating flagship projects to people and showing the benefits of regenerative design in the real world, an interest in the practice as a whole can be developed. This can in turn inspire people into considering how they can make regenerative decisions in their own life and work. This can be achieved in a multitude of ways, including by leveraging the wide variety of digital tools available today. These can be used to create highly interactive and engaging models of regenerative projects, sparking an interest in people to pursue regenerative design further. This can be combined with virtual reality (VR) or augmented reality (AR) environments, allowing participants to walk through and experience a regenerative project in real time. This can be targeted at both the designers/clients during feasibility/planning stages and at the general public during public consultations.

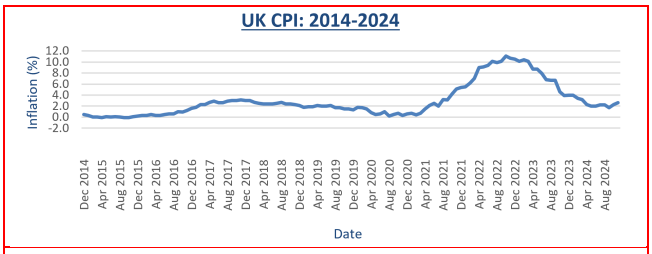

Fig. 19 Example of Virtual Reality being used in Architecture (Medium, 2018)

Site visits can offer the opportunity to interact with regenerative features in the real world and learn how they are built, maintained and managed. Such visits could be offered to primary/secondary school students, university students, prospective buyers and construction professionals alike. These visits can also provide the opportunity for experienced professionals to share their expertise and knowledge with each other, further developing the knowledge pool within the UK. Similarly to VR/AR solutions, this can be targeted at both construction professionals and local communities.

For people solely within the construction industry, technical workshops, conferences and lectures can provide insight into regenerative design, demystifying the subject and promoting a sense of achievability – while also contributing to their continuing professional development (CPD).

For example, demonstrating to engineers/architects that even small areas of planting integrated with human-centric design can offer a significant impact on local biodiversity will prove that for a scheme to be regenerative, it does not have to encroach on large areas of land. With this knowledge, they

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will in turn be more likely to push for the integration of regenerative practices on their own projects, even if only in small areas at first. Detailed case studies can also serve as a viable method for demonstrating to engineering practitioners how regenerative design works. By reviewing a project in its totality and understanding how regenerative design was implemented – including the delays, difficulties and risks – an engineer is more likely to be willing to implement the same practices in their own line of work.

For people who are not directly involved in construction, outreach and promotion of regenerative design can still offer a noticeable benefit to the industry, as they have the ability to influence demand within local communities. This can be achieved by prioritising the use and purchase of regeneratively designed offices, houses and local amenities and asking for accountability from developers to preserve and enhance their local ecosystems. By demonstrating to these groups that regeneratively designed amenities can help to repair the environment, they are more likely to wish to invest in them, thus driving demand and helping developers justify the increased cost of designing with regeneration in mind. Furthermore, by promoting the benefits of regenerative design to local communities, they will be more likely to raise concerns and the desire for regenerative design at local planning consultations, where representatives from prospective projects are present and willing to listen to a community's wishes. When paired with collaboration with MPs and councillors, this offers a genuine opportunity to push developments into adopting wider regenerative practices.

One of the most effective methods for promoting regeneratively designed amenities would be to create a simple certification scheme, which would allow for comparison between different projects and encourage developments to be designed as regeneratively as possible to attract environmentally mindful tenants. Such schemes are commonly seen elsewhere in the construction industry, such as BREEAM, and allow for quick recognition of a project's environmental efforts.

Fig. 20 LEED Certification Levels (Medium, 2024)

6.4 Why do current projects not integrate regenerative design as fully as they could?

The second most commonly identified constraint to regenerative design in question 8 was cost, whether this be the cost of consultant fees to design schemes, the increased cost of materials, loss of profitable land or delays in construction and approval programmes, with one participant stating:

"Private developers are primarily financially motivated business organisations with their main objective to achieve profit. To mitigate against this, consideration of the provision of habitat/BNG as a financial benefit could be utilised and legislated to balance this out."

To address this, five key strategies can mitigate these impacts:

1. Evaluating cost-benefit analysis over a longer period and in terms of biodiversity performance as well as fiscal performance.
2. Optimise the pre-construction planning and design processes to better use given resources.
3. Implement circular economies and greater recycling efforts to minimise material requirements.
4. Standardise as far as is reasonably practicable the maintenance of regenerative features.
5. Implement tax breaks for regenerative schemes to incentivise its implementation.

Each of the above points offer a clear improvement to the construction industry's understanding and application of regenerative design, however, to achieve this, education must first be prioritised – as described in section 5.3. This would in turn enable the formation of steering groups to create resources detailing best practice and lessons learned for the industry.

Steering groups consist of industry experts working collaboratively and sharing their combined experience and knowledge to provide guidelines for the wider construction industry.

Project steering groups around emerging practices have been seen throughout the construction industry previously and have clearly demonstrated their value. For example, the steering group led by David Balmforth that produced C753 –

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The SuDS Manual, created a non-statutory guidance document that is now used almost universally across the UK and has greatly helped to improve knowledge and adoption of SuDS. A similar document detailing regenerative design and development would provide designers with a simple yet comprehensive guide for proven and accepted regenerative design principles.

Fig. 21 Example SuDS feature, made possible by the SuDS Manual (BGS, n.d.)

The construction industry and capitalism as a whole revolves around risk management and as is often seen around the world, introducing new practices is seen as being a potential risk to future operation. This same logic applies to regenerative design and may be one of the key reasons for developers to show unwillingness for adopting innovative solutions.

One of the key areas raised in Question 9 was the risk of precluding some species while over-providing for others, resulting in an imbalance in ecology. Examples of poorly judged introductions can be seen throughout history, where inadequate thought is given to a species invasiveness or there is a lack of understanding around natural competition. This includes the introduction of Water Hyacinths in the Southeast USA (USDA, n.d.), which resulted in the decimation of fish and other plant populations or the introduction of rabbits in Australia (National Geographic, 2023), which lead to overgrazing of vegetative land and significant loss of native herbivorous species. This same problem poses a significant risk to developers as the management of invasive species if accidentally introduced can result in excessive costs, fines from environmental agencies and causing significant – often irreparable – damage to local ecosystems, the opposite intention of regenerative design.

As such, research and development should be a key factor in improving regenerative design across not only the UK but the rest of the world. Understanding all the risks associated with introducing new habitats and natural systems is critical for ensuring a long-lasting and effectively functioning ecosystem. The knowledge gained by conducting this research can then be used to create a suite of standard details that are known to function and offer optimal biodiversity gain without threatening local populations. This subsequently allows for regenerative-focused developments to progress through both the planning and design phases more quickly and without the need for extensive investigative periods, once again reducing the financial outlay required.

In order to reduce the overall financial outlay for a regenerative scheme, government incentives, such as tax relief for developers could be trialled and implemented across the UK. This could be in the form of claiming a percentage of the total project cost as a deduction from corporation tax or through a reduction in property tax for a given period. These percentages would vary based on the level of regenerative design being implemented, such as starting at 5% and growing to a maximum of 25% depending on the total biodiversity net gain. The eligibility of these schemes could be assessed against pre-existing and tested certification schemes while a distinct regenerative assessment scheme is developed. Prior to these schemes being approved, the authority providing the relief would thoroughly vet and approve prospective developers. Once approved, it would then be critical throughout these schemes for the government to audit projects, including the strict penalisation of malpractices or misuse of incentives. Also, public-private partnerships could further mitigate cost to developers, by pooling resources to fund innovative projects and ensure early adoption of regenerative practices – operating on a similar model to Private Finance Initiative projects such as the Queen Elizabeth II bridge. Similarly to tax relief schemes, suitable government oversight would be required to prevent misuse of public funds. There are already numerous tax breaks available for construction companies in the UK, such as the Enhanced Capital Allowances, ECAs (HM Treasury, 2021), where businesses are encouraged to invest in energy efficient plant and machinery and in return receive 100% first year tax relief on said investments. This proven history of tax relief schemes could improve the likelihood of a new scheme being implemented around regenerative design based on the successes it has fostered and the suite of lessons learned because of them.

6.5 How can regenerative design be seen as the standard practice for construction as opposed to an unobtainable ideal?

Similarly to points explained above, education remains the key hindrance to seeing regenerative design as the industry norm. Current sustainable design practices are seen by the

majority of the construction industry to be the action required to reverse the environmental damage already inflicted by mankind. However, as visualised in figure 1 (Section 2.1), sustainable design aims only to prevent further damage – or to break even – rather than actively repairing the environment. This has therefore led to a misunderstanding – or perhaps complacency – in the belief that the industry is taking significant enough action to avoid the impending climate disaster. However, as more designers, developers and contractors are made aware of the benefits and necessity of regenerative design, a culture of wanting to do the best for the environment can be fostered. This method aligns with the need for a holistic and fundamental re-evaluation of our industry as discussed by Cole and Plaut in their respective papers (Cole, R. J., 2011), (Plaut, J. M. et al., 2011) and will provide the most effective method for changing the industry's view as a whole. While education at a school/college/university level will enable future generations of construction professionals to better understand regenerative design, it does not tackle the problem of educating the current experienced workforce. As such, accessible and targeted conferences could be held as a way to introduce regenerative practices to already practicing engineers. Said conferences could host lectures about lessons learned, known risks and how to manage them, and highlight how to make regenerative schemes as profitable as practicable. These events could include case studies of regenerative projects such as the previously mentioned BedZED scheme, which will demonstrate to participants how regenerative design can be implemented.

Fig. 22 BedZED Regenerative Community (LifeEdited, 2016)

Finally, the integration of emerging and novel technologies may offer a cost-effective and time-saving method for broadening the adoption of regenerative design. Artificial intelligence (AI) is the most prevalent emerging technology today and is currently a key focus for all industries across the world, with the potential for its integration acknowledged as being an effective tool for optimising efficiency. The three areas below highlight where AI could have the greatest impact on the construction industry in relation to regenerative design's implementation and maintenance.

1. Optimisation of the design process. Generative AI programs can take high level design theories and progress them to a concept stage extremely quickly. Thus, providing designers with ideas for maximising the potential of a scheme, through material selection, life cycle assessments and impact to local ecology.

However, despite the significant opportunities AI offers for design optimisation, data privacy must be considered thoroughly prior to any systems being implemented. Confidential projects or sensitive data – such as badger sett locations in the UK – must be considered and the AI tools' data retention policies must be fully understood and approved.

2. Monitoring and adaptation. As discussed in previous sections, maintenance remains a significant risk to adopting authorities, however, through the implementation of AI and internet of things (IoT) devices, schemes can be assessed continually throughout their lifetimes remotely. This could potentially allow for early warning of impending issues or highlight areas where changes could be made to further enhance biodiversity. Again, while these technologies do allow for reduced human oversight, it remains critical for frequent reviews of data to ensure the system operates optimally.

3. Energy optimisation. Through modelling and simulation, artificial intelligence offers the ability to assess and suggest amendments to energy generation systems to maximise efficiency and further reduce reliance on external sources (such as fossil fuel plants and natural gas).

All of the above will ease the increased labour requirements in the design and maintenance phase of a project, but despite these benefits, it must also be noted that AI based systems require significant initial investment and high-quality, accurate data. Moreover, before widespread adoption of AI as a tool to aid regenerative design, clear demonstration of its benefits and risks must be undertaken to allow for safe and appropriate adoption.

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7. Conclusions

The findings of this study emphasise the urgent need to integrate regenerative design into the United Kingdom's construction industry to address the ongoing destruction of ecosystems for human gain. Despite an increasing awareness among industry professionals, a lack of comprehensive understanding and excessive costs remain prohibitive barriers to wider adoption. This research highlights the potential of regenerative design to transform construction practices from merely sustainable – or no further harm – to actively net-positive, fostering biodiversity and ecological resilience. In conclusion, the adoption of regenerative design is not just a technical challenge but a cultural and systemic shift. By prioritising innovation, education, and collaboration, the construction industry can drive forward in creating a built environment that coexists with, rather than destroys, the natural world. The shift to a regeneratively focused construction industry is a vital step towards ensuring a healthy future for both the planet and humankind. In order to achieve this within the timeframe required to achieve goals such as the government's net zero by 2050 and accord with the Paris Agreement, six key recommendations to the construction industry have been proposed below.

7.1 Recommendations to The Industry

The six recommendations made below identify the key steps to be taken by the construction industry to further implement regenerative design and begin reversing centuries of climate destruction. These recommendations have been ordered in terms of feasibility and impact.

1. Regenerative design to be taught at universities and colleges alongside typical modules, to ensure regenerative practices are understood by all in the industry, thus fostering a culture of biodiversity-centric design. Upskilling events and conferences to be held to educate experienced professionals, demonstrating key case studies and lessons learned.

2. Feasibility of financial incentives – such as tax breaks, subsidies and grants – for introducing regenerative design practices to be assessed, such as a reduction in corporation tax based on overall project cost and total regenerative practices/features implemented.

3. All local authorities to create a list of standard regenerative construction details for use on developments, based on research conducted on existing local ecosystems, ensuring minimal risk is posed to pre-existing habitats and landscapes.

4. Interoperation between all stakeholders to be increased, allowing for greater integration of all systems, including drainage, power/heat generation and waste management.

5. Better embrace technology and the benefits it offers to design through digital twins, simulation and artificial intelligence to ensure the most optimal specification of solutions and use of resources.

6. Develop a certification and comparison scheme for regenerative projects, similar to those already seen across the buildings industry, allowing for quick recognition of the efforts made by developers to repair the natural world.

By integrating regenerative design into education systems and offering financial incentives the UK could catalyse a paradigm shift in the construction industry, transforming it from a resource consumer to a net-positive contributor to global ecosystems. Given the fact that the construction industry alone contributes to between 25% and 40% of UK carbon emissions and up to 39% of total global emissions (Global Alliance for Buildings and Construction, 2018), the potential reductions in greenhouse gases by beginning to consider regenerative design as the societal norm could prove transformational.

7.2 Limitations of the Study

The findings of this study are restricted by a relatively small sample size of 36 respondents, which may limit the generalisability of the results for the wider UK construction industry. Furthermore, the reliance on self-reporting introduces the possibility of biases such as the Dunning-Kruger effect. In order to mitigate this bias, question seven was written to test any given participant's understanding of regenerative design. This was then compared to responses to question four to ensure that any positive (i.e. greater than five) response to this question also correctly answered question seven.

7.3 Future Research

Future research should aim to survey a larger number of professionals from a wider array of backgrounds and expertise, with information being gathered through interviews to mitigate the likelihood of bias. Also, a more detailed investigation into the tax relief schemes and

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education curricula, providing quantitative analysis and complete proposals could provide a solid foundation for accelerating the adoption of regenerative design in the future.

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