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Navigating Climate Change: Rethinking the Role of Buildings

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Abstract: This paper focuses on the design of buildings as part of society's response to the climate crisis in the aftermath of the COVID-19 pandemic. It draws on a broad literature to address two interrelated goals—first, to align regenerative development and design with the necessary bottom-up adaptation strategies and human agency, and second, to identify new, broader possible roles of buildings and responsibilities of design professionals. This required a comparison of current green building and emerging regenerative approaches and identifying the relevant characteristics of top-down and bottom-up mechanisms. The paper accepts that adaptation to climate change will, to a large extent, depend on people's day-to-day actions in the places they live, and argues that the built environment will have to be infused with the capability to enable inhabitants' greater agency. Viewing buildings as playing a connective role in the existing urban fabric seriously challenges the primacy of the individual building as the focus of environmental strategies. The roles of building design professionals will likely expand to include mediating between top-down imposed government controls and increasing bottom-up neighborhood-scale social activism.

Keywords: climate change; buildings; design professionals; COVID-19; green building; regenerative development and design; top-down/bottom-up

1. Introduction

All major changes in the global climate system are disruptive—those in the past have "led to extinction of many species, population migrations, and pronounced changes in the land surface and ocean circulation" [1]. The current concentration of atmospheric carbon has already set planet-changing forces in motion that "cannot be stabilized for centuries" [2] and the window for preventing the Earth's climate system crossing dangerous points of no return is rapidly closing [3,4]. Despite 25 years of *United Nations Climate Change Conferences*, global greenhouse gas (GHG) emissions have increased more than 40% over that period.

Our collective inaction on climate change carries profound consequences and the resulting urgency requires us to both make greater leaps in our efforts and now make them in an even shorter time frame. In 2011, Orr [2] emphasized that "in the second decade of the twenty-first century . . . it would be sensible to recognize that we have squandered any margin of safety we once had and are in a planetary emergency and need to act accordingly". However, despite a number of countries showing reductions [5], with the exception of holding steady from 2015–2017, global emissions continued to increase for the remainder of the decade [6]. To keep the possibility of limiting global warming to what is considered a relatively safe 1.5-degree increase, global GHG emissions will now need to fall by an average of 7.6% each year between 2020 and 2030. Had serious climate action begun in 2010, the cuts required per year would have been 3.3%. Clearly, "greater cuts will be required the longer that action is delayed" [7] and, if delayed too long, even the most significant cuts will not prevent catastrophic impacts [8].

1.1. A Decade to Change?

A decade is an infinitesimal period of time within the 3.8 billion years of the evolution of life on Earth or even the 6000 years of human civilization. Yet now, a decade is seemingly the measure of the timeframe available to us to make unprecedented changes in the ways that we inhabit the Earth. Over the next 10 years leading up to 2030—the date that the scientific community points to as critical in curbing anthropogenic GHG emissions—the progress we now make *each year* thereby becomes hugely important. Worrisomely, current climate change is unfolding faster than almost all past events and thereby "making it more difficult for human societies and the natural world to adapt" [1].

The ideas explored in this paper are framed by the rate at which societal changes are possible in relation to the accelerating pace of climate change and, more specifically, the changes that are realistically possible in transforming the built environment to support both mitigation and adaptation strategies within this unfolding context. Climate-related events are anticipated to occur with greater intensity and frequency with consequences that extend well beyond the design of the built environment: Increased burdens and social unrest created by mass migration both within countries and between countries and continents; threats to food production and supply, economic and financial systems, national security and the very nature of democracy as "governments struggle to cope with the consequences and to persuade their people to accept the major social and economic transformations required" [9].

The paper accepts that for the foreseeable future we will be navigating through a difficult, turbulent period and there is a need to help people prepare for a changing world—what Yunkaporta [10] characterizes as the creation of "cultures and societies of transition" towards a qualitatively different future era. The paper also accepts Harari's characterization of the future as one where we "will increasingly have to deal with things nobody ever encountered before" and will have to "feel at home with the unknown" [11] (p. 256). We will have to learn, it would now seem, how to "respond and adapt to, and evolve with change and surprise, while avoiding changes threatening the life-supporting and life-enhancing capacity of global and local social-ecological systems" [12] (p. 56).

1.2. Aims, Contribution, and Limitations

Cities have clearly played a major role in creating the climate crisis and will be critical to any response [13]. Buildings that comprise cities are among the longest lasting of human artefacts and the majority of the current building stock will still exist in 2030 and beyond. Significant reductions in the GHG emissions associated with existing and new buildings will invariably be integral to any efforts to address climate change and, indeed, they represent one of the most cost-effective methods to do so [14]. However, rather than attempting to anticipate how future buildings will or should be designed technically—these have received considerable attention over the past two decades—the paper has two interrelated goals: First, to align regenerative development and design with necessary bottom-up adaptation strategies and human agency, and second to identify new, broader possible roles of buildings and responsibilities of design professionals.

The paper furthers the discourse on regenerative development and design by reframing green building practice and aligning this with discussions regarding the call for a "new professionalism" [15,16]. Here, the paper takes a more speculative view rather than discussing possibilities in relation to current practice and the multitude of conflicting demands and challenges it already faces. While architects and other building design professionals are, to a large extent, at the service of clients and practice governed by regulation, the calls for them to subscribe to a new "ethically-based, collaborative and deliberative" set of principles and practices [16] (p. 219) are reflected in many of the paper's propositions. Moreover, although the paper focuses on changes in a building design professional's everyday working relationships and practices [16], the complex issues we face clearly extend beyond single disciplines. A further contribution to new knowledge resides within contrasting ideas and issues previously considered largely separately in other domains.

The paper draws upon a large body of existing published research and sources to achieve its primary goals and to present a number of contextual issues that may directly and indirectly frame the future production of buildings. Although it has strived to present a balanced position, the work invariably has the limitation of being selective in the sources and runs the danger of drawing too heavily on those considered more valuable to the paper's overall ambition and to not adequately present counterarguments.

1.3. Organization of Paper

Given the broad range of issues covered in the paper, it is useful to declare how they have been structured. The paper is subsequently organized in eight sections which, in broad terms, make a shift from those more related to mitigation to those related to adaptation, and from those that relate to green buildings to those related to regenerative approaches. Section 2 explores similarities and differences between the climate crisis and the COVID-19 pandemic to provide insight into how other societal priorities can compromise progress on addressing the climate crisis. Section 3 argues the need for a shift from the current prevailing anthropocentric worldview to an ecological worldview one. This is considered critical in shaping how we frame environmental issues and, more broadly, inhabit the planet. Section 4 identifies key relevant characteristics of buildings before examining green building and regenerative approaches in Sections 5 and 6, respectively. Section 7 distinguishes between top-down and bottom-up approaches to both situate regenerative approaches and roles of building design professionals. Section 8 provides an extensive discussion of the implications for building design professionals before presenting the key conclusions in Section 9.

2. A Changed World: Competing Priorities

While the outfall of the COVID-19 pandemic is currently unknown, it is not possible to ignore how it may compromise efforts to address the climate crisis [17]. It has been argued that the efforts to revive economic activity after the COVID-19 crisis will inevitably "determine the shape of our economies and our lives for the foreseeable future" and, equally important, "will have effects on carbon emissions that reverberate across the planet for thousands of years" [18].

The escalating numbers of COVID-19 disease cases and associated deaths have overwhelmed hospitals and healthcare professionals and sparked unprecedented stringent peacetime measures that included closing international borders, limiting citizens' movements, gatherings and interactions; closing non-essential businesses, schools and universities, theatres and cinemas; and cancelling or postponing spectator sporting events. This subsequently evolved to conflicting messaging between government's willingness to "open their countries" as soon as possible to avert long-lasting damage to their economies and public health authorities advise that such action should be dictated by medical science (see [19]). While COVID-19 has led to postponing welfare reforms, environmental policies, and other actions deemed "non-essential" [19] (p. 227), it has also provided a glimpse into system vulnerabilities, pervasive societal disruptions resulting from a lack of preparedness and structural and systemic inequities: What services and work are essential to a society; the limits to government help to communities; and our lack of understanding interdependencies.

At the beginning of 2020, anthropocentric GHG gas emissions had already pushed amounts of atmospheric carbon dioxide passed a global average of 415 parts per million (ppm). While reduced automobile use, air travel, and industrial production has been dictated by the COVID-19 pandemic [20,21], there is every sign that this is only a temporary respite. Indeed, unlike COVID-19, "*Climate change doesn't "peak"*—and then flatten out and then maybe dissipate or be permanently prevented by vaccine—so normal life resumes" (italics in original) [22]. Of the number of similarities and differences between the climate crisis and the COVID-19 pandemic, three are particularly relevant to this paper:

2.1. Ignoring Early Warnings

Climate crisis and the COVID-19 pandemic were foreseen, warnings were offered and were not acted upon in a timely manner. Scientists have known about the relationship between carbon dioxide gases and atmospheric warming for almost two centuries [23–25]—and it is their work characterized as "cutting-edge 19th century science that we're now refining" [26]. By the late 1970s, scientists had produced "incontrovertible evidence" that the atmosphere was changing, that human activity contributes to the change through their "use of fossil fuels and exploitation of the land", and that this would lead to a "warmer earth with a different distribution of climate regimes" [27]. The primary questions since then have surrounded our ability to project the long-term consequences of a warmer planet— "to peer into the world of our grandchildren, the world of the twenty-first century" [27]. While techniques to predict future global warming were still very much in their infancy in the 1970s, scientists were already raising the concern that human activity "may be capable of causing irreversible changes without being aware of it until too late" [28] (p. 610). The Intergovernmental Panel on Climate Change's (IPCC) Assessment Reports from 1990 to 2014 cast a sobering view of the consequences of unabated increase in GHG emissions and global warming, with each report conveying a more urgent situation than the previous.

The threat of a global pandemic has been known for decades. In 1990, virologists were identifying a number of conditions that could "lead to the introduction of new, potentially devastating pathogens—climate change, massive urbanization, the proximity of humans to farm or forest animals that serve as viral reservoirs—with the worldwide spread of those microbes accelerated by war, the global economy, and international air travel" [29]. Following the 2014–2016 West Africa Ebola outbreak, alarms were raised of the "significant chance that an epidemic of a substantially more infectious disease will occur sometime in the next 20 years" [30] and that would rapidly cross international borders [31]. Moreover, although the intelligence community warned of the dangers it posed in January 2020, the US Government's Administration did not heed them and was surprisingly dismissive of the threat, making the country unprepared when cases rapidly escalated [32,33].

2.2. Responses to COVID-19 and the Climate Crisis

COVID-19 and the climate crisis have considerable adverse social and economic consequences. Political leaders were willing to control the COVID-19 pandemic and economic outfall at seemingly *any* cost—for example, at the time of writing this paper the US Congress and the Federal Reserve had "committed more than USD 6 trillion to arrest the economic downturn from the pandemic" [34]. By contrast, the cumulative cost of weather and climate disasters in the US since 1980 exceeds USD 1.6 trillion [35], a number that will certainly grow given the anticipated future increases in their frequency and intensity. Although it is difficult to access the data concerning the funds the US government had spent on climate change over the same period for research, technology, international assistance, and adaptation, it is probably less than USD 200 billion [36,37].

Climate change is still considered both temporally and spatially distant, and combating it is relegated to a lesser political priority in favor of immediate threats and reducing GHG emissions has yet to receive the same political urgency, commitment and financial investment as COVID-19. The possibility of a prolonged economic recovery, increasing disruptions caused directly and indirectly by climate change, the estimated USD 50 trillion cost of halting global warming and reducing net carbon emissions to zero by 2050 [38], and the scale of necessary resources and capabilities to do so, may collectively further dampen political will.

Three issues are exposed or amplified by the above. First, strategies based on science and those prioritizing economic or political demands were pitted against each other [39], with the latter prevailing. Second, similar to climate change, the pandemic revealed the consequences of conflicting messages from authorities of getting society to consistently engage in responsible behaviors. More generally, this exposes the need to "understand the relationship between crises and public responses" and "how little we know about, learning under stress and urgency in the middle of a crisis" [19]. Third, the climate crisis and COVID-19 disproportionally affects the most vulnerable populations worldwide and members of society—those "living in poverty, the working poor, women and children, persons with disabilities, and other marginalized groups" [40]. As such, demands for climate action reform in political and economic systems are increasingly intertwined with calls for reform against racial injustice and economic and social equality [41].

2.3. Coordination and Cooperation

The need for concerted global coordination and cooperation has been identified as a consideration in seriously addressing climate change. Agreement came close at the 2015 *Conference of the Parties-21* (COP-21) in Paris but was seriously weakened when the US—the second largest emitter of GHGs—withdrew in 2017. Similar concerted international measures to control the pandemic and alleviate the economic damage are considered as providing "the greatest chance of achieving public health goals and enabling a robust global recovery" [42]. While there has been an ongoing cross-border exchange of COVID-19 data among medical experts [19], the growing nationalism and self-interest shown by countries, as well as states and provinces within them, often competing with each other for medical supplies, does not bode well for concerted international health and economic recovery efforts [43].

3. Shifting World Views

Buildings are critical elements of our collective cultural memory—an embodiment of society's values and technological capabilities at the time of their creation—and they also capture the priority society places on environmental issues. All human endeavor, including settlement patterns and building practices, is shaped by the prevailing worldview and value system of the societal and cultural context within which they emerge. Worldviews are the "stories we tell ourselves about how the world is created, what it is made of, how it is structured and how it functions" [44] (p. 23). They shape the underlying assumptions that determine what we believe, the questions we ask, the solutions we seek and the methods we deploy, and are seldom questioned unless they no longer equate with our experiences. While such "stories" are contested, Western societies still hold a prevalent anthropocentric worldview that implicitly places human enterprise as dominant over and essentially independent of nature.

Climate change is largely framed in *human* cost—loss of lives, loss of property, disrupted food supply, etc. However, climate change is also "driving widespread and rapid changes in the abundance, distribution and ecology" of wildlife [45] (p. 22) and biodiversity loss is also increasingly cast as an "existential" crisis [46]. Equally important, Western society's search for, and structure of, knowledge remains largely entrapped in the dominant Cartesian–Newtonian mechanistic scientific paradigm of the mid-17th century, one that favors rational, analytical, reductionist, linear thinking [47], seeks objectivity and places considerable faith in technology.

We need, it would seem, a qualitatively different view of our relation to and place within the natural world—that is, a renewed social–ecological system. Indeed, a major challenge we face this century resides in transforming what we value, instilling an enduring responsibility of stewardship as a societal priority, and rethinking economic systems and development within social and planetary boundaries [48,49]. Such a shift could be precipitated by increased competition for resources in an increasingly destabilized world or more optimistically assumed in this paper, through the replacement of the prevailing anthropocentric worldview.

Du Plessis and Brandon [12] highlighted several key characteristics of an ecological worldview, including that: Humans are an integral part of an interdependent and interconnected living system; the processes, flows, and relationships in nature are embraced; and, interactions within systems are acknowledged at all scales and across the physical, intellectual, emotional, social, and spiritual aspects of existence. Importantly, they suggest that "(h)umans, their social structures, and their biophysical environment, form one integrated social-ecological system in which humans and their artefacts are an indivisible part of the biosphere and they, like any other organism, participate in and co-create the metabolic and change processes that shape the biosphere". Although the knowledge and laws revealed by a mechanistic paradigm are still "immensely useful" in engineering and technological pursuits [12] (p. 55), an ecological worldview recasts this knowledge within a whole-systems frame to understand interrelationships and create connections.

Indigenous Worldview

Accepting the generalization, Indigenous people's worldviews hold deep reverence for the land and other species, view everything dependent on everything else, consider humans inseparable from the living and inanimate world, and all things are sentient, contain spirit, and need to be respected [10]. Moreover, contrary to Western conceptions of land as a "bundle of rights", within the Indigenous culture's "gift economy", the property carries a "bundle of responsibilities" [50].

While there has been increasing interest in bringing together "local Indigenous and conventional scientific paradigms" for their collective value in "developing climate change mitigation and adaptation strategies and actions" [51] (p. 242), how, and to what extent, Indigenous knowledge can serve what some consider as a "complement" to climate change science, faces the difficult task of bridging fundamentally different world views [51,52]. Cruikshank [53] (p. 259) captures the cross-cultural differences and comprehension grounded in their Indigenous culture and dangers of simply taking ideas selectively: "Narrative recollections and memories about history, tradition, and life experience represent distinct and powerful bodies of local knowledge that have to be appreciated in their totality, rather than fragmented into data, if we are to learn anything from them". Such explorations of Indigenous knowledge offer several valuable points relevant to this paper regarding the types of knowledge/understanding/experience that are accepted as legitimate bases for making decisions in the production of the built environment: A more critical interrogation and re-evaluation of our own cultural beliefs; how knowledge is acquired, held, and communicated and, importantly, by whom; the contextual setting of that knowledge; and how boundaries are defined, respected, and transgressed.

4. Repositioning Buildings

Buildings are a human necessity—both functionally and culturally. Functionally, they provide the spatial and environmental context for human activities—providing shelter that offers inhabitants safety, sufficient space, and comfortable conditions consistent with the task in hand are essential design requirements. Culturally, buildings provide a manifestation of the aspirations and technological capabilities of the society to which they belong. They are complex human creations. Their design involves the interaction and coordination of a wide range of professions, within a multitude of regulatory agencies and jurisdictions, and typically with demanding time and cost constraints. Their construction requires the involvement and phasing of numerous skills and trades, and changes in operation and use can compromise the initial design intentions. Moreover, buildings represent significant capital investment, both financial and ecological. Despite more rapid societal changes, due to the scale and complexity of the building industry and the long life of buildings, the process of replacing buildings has historically only been capable of slow adaptation rather than sweeping overhaul, and the pace of change in the built environment is largely determined by factors such as disasters, technological advances, revised regulations, and the costs/benefits of alternative strategies [54].

Technological advances impact on building design, sometimes profoundly. While air-conditioning, electric lighting, elevators, and other building technologies have provided architects greater design freedom and inhabitants' greater convenience and comfort, their use has significantly increased building operational energy and associated GHG emissions. Since the birth of modern environmentalism in the 1960s, a number of events, developments, and advances have influenced societal attitudes and the significance placed on environmental issues and these have subsequently influenced approaches to building design and construction.

Figure 1 schematically positions some of the key societal concerns and the concepts and language used in the context of building design in response to them over the past 50 years. While they are presented chronologically for convenience, many of them overlap with each other, coexist, mature, or reappear in different forms and have many interpretations. The 1970s and 1980s, for example, witnessed descriptors such as “low energy”, “passive solar”, “daylit”, and “healthy” to characterize buildings that prioritized specific performance issues before they came under the umbrella of “green” buildings in the 1990s. Similarly, whereas an emphasis on climate change mitigation preceded a need for adaptation, they are now both positioned as necessary requirements.

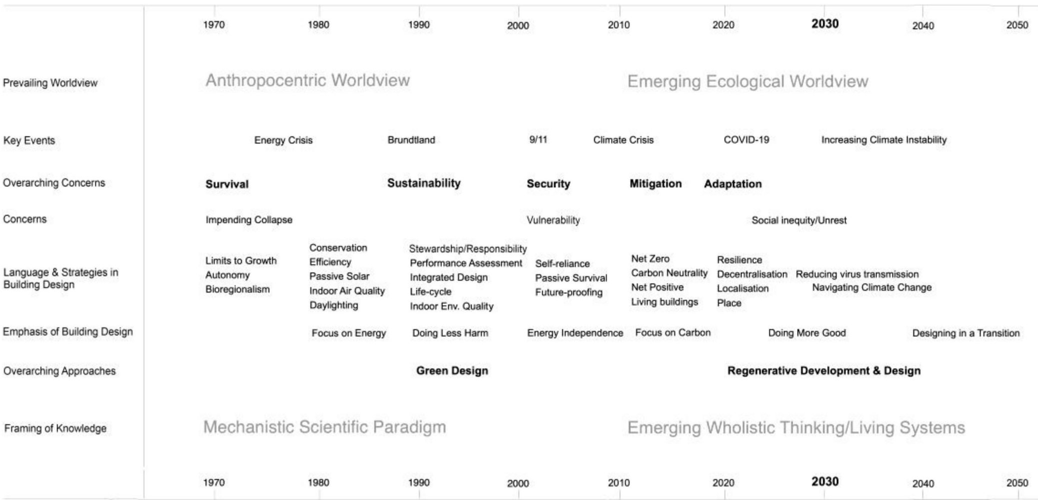

Figure 1. Schematic showing key societal and environmental issues framing building design over the past 50 years.

Building design and planning strategies will now have to simultaneously address the climate crisis and those that prevent or inhibit the spread of future pandemics, all amidst a context of increasing social, economic, and political instability. COVID-19 will likely expand building-related health issues from eliminating or controlling internal pollutant sources to the use of biosafety materials and a host of other design strategies that eliminate or reduce virus transmission [55]. In particular, it will challenge how increased urban density is approached to bring people together safely [56], address the possibilities of future sustained periods of isolation, and alternative ways that public spaces will be inhabited [57]. This will unfold amidst a host of interconnected urban inequities including those who can work safely and online at home with those engaged in manual labor or the service industry and most likely to be exposed to potentially unhealthy conditions [56].

5. Green Building

It has now been thirty years since the first voluntary comprehensive building environmental assessment method—the *Building Research Establishment Environmental Assessment Method* (BREEAM) [58]—was introduced and prompted the development of others worldwide. This culture of assessment places enormous faith in such tools and views them as the single most effective means to create market demand for improved building environmental performance. Bordass and Leaman [15] (p. 4) position this within a broader societal rise of “accountability” as a replacement of “trust”, and reflected in a loss of trust in professional expertise—an “unintended consequence” of replacing professional “ethics by rules and regulations”.

An underlying premise of these voluntary assessments is that if the market is provided with improved information and mechanisms, a discerning client group can and will provide leadership in environmental responsibility, and that others will follow suit to remain competitive. Until the release of BREEAM little, if any, attempt had been made to establish an objective and comprehensive means of assessing a broad range of environmental considerations against explicitly declared criteria and offer a summary of overall performance. Assessment methods institutionalized a broader range of environmental performance issues deemed important, provided the building industry with an understanding of what constitutes “green” buildings, and the importance of assessing buildings comprehensively. Although they made significant adjustments to their scope, structure, and performance criteria in response to shifting environmental priorities and seeking efficiencies in the certification process, they remain profoundly shaped by its initial aspiration of market transformation and its emphasis on mitigation—creating buildings that slow the degeneration of natural systems.

While the characteristics of green buildings and assessment methods have been extensively discussed [59], three are of particular interest here. First, assessment methods largely embody reductive and fragmented thinking that identifies discrete quantifiable performance requirements, and these often translate into a series of isolated design strategies rather than recognizing and encouraging creative synergies. Simply adding attained points in individual performance criteria is seen as the measure of overall performance. Second, they simplify the context and the processes of the systems that they are attempting to evaluate. However, inherent in this simplification is the assumption that both nature and human nature are measurable, predictable, controllable, and replicable factors [60] (p. 445). Third, the expected performance can thereby seemingly be readily established and communicated to clients at the completion of design with a degree of certainty. However, in practice, the actual performance of a building depends on its inhabitants and a host of contextual factors. Concerns regarding the "performance gap"—the discrepancy between predicted and measured energy use—clearly illustrates that all buildings, including green, do not always deliver on the capital asset investment value they promised during design.

5.1. Organizational Support of Assessment Methods

Green building assessment methods are managed by and operate within known organizational contexts, e.g., the LEED rating system by the *US Green Building Council* (USGBC). The organizations and their affiliations are responsible for maintenance, continued development, educational programs, professional accreditation, third-party certification of projects and, of significance here, promotion of their use. Importantly, they have sufficient capability to operate as national certification systems and to offer supporting educational programs and accredited programs for professionals [61].

5.2. Green Buildings and Climate Change

The scope and structure of assessment methods represent their developer's understanding of environmental performance issues and, through the weightings assigned to the constituent performance criteria within the overall score, denote the priority given to them at specific points in time. Reducing GHG emissions have been a performance credit in assessment methods from the outset. *BREEAM for New Office Buildings* [58], for example, interestingly organized the performance criteria under *Global Effects*, *Neighborhood Effects*, and *Indoor Effects*, and with the "Greenhouse Gasses" credit, points are offered for reducing carbon dioxide emissions in absolute terms: One credit for carbon dioxide production between 157–120 kg/m^2/year, up to five credits between 53–40 kg/m^2/year. A considerable body of technical knowledge has emerged since 1990 regarding the reduction of operational GHG emissions and, more recently, on the increasing significance of embodied carbon [62,63]. However, despite increasing declared commitments for carbon emissions reductions, few jurisdictions have comprehensive plans for meeting them [64].

5.2.1. Impact of Voluntary Assessment Methods

The two major, most established and internationally deployed methods—BREEAM and US *Leadership in Energy and Environmental Design* (LEED)—can legitimately claim some success in their influence in the non-residential building sector. The CBRE *Green Building Adoption Index*, for example, has tracked the growth of Energy Star and LEED certified buildings for the thirty largest US cities since 2005 and its 2019 reporting showed that the uptake of certified green buildings was 13.8% (42.2% by square footage) of all commercial office buildings [65]. Buildings throughout a city have different GHG emission profiles. Therefore, while 13.8% is low, Mazria [66] illustrates that the large buildings in urban cores—typically representing less than 5% of the total number of buildings in cities—are responsible for approximately half the total of building carbon emissions. The other half relate to the remaining 95% of small buildings comprising the city.

Although buildings are critical in mitigating climate change [67], progress is slow relative to its urgency. While BREEAM and LEED certified new buildings require reductions in carbon emissions, these currently fall short of the targets advocated by the *Architecture 2030* to achieve carbon neutral buildings by 2030 [64]. In 2015, BREEAM certified buildings, for example, were delivering an average of just over 20% carbon reductions [68]. Similarly, of the 111,000 LEED certified projects in 2017, only approximately 6% of these have achieved the highest platinum status that required the greatest GHG reductions [69]. A decade ago, Watson expressed concerns that LEED was "not providing sufficient contribution to halting unmanageable climate change" [70] (p. 3) and, despite revisions to it, others argue for greater priority to be given to reducing GHG emissions [71]. Similarly, the *Passive House* standard represents the most demanding energy performance and while receiving increasing attention, as of 2015 approximately 50,000 such buildings had been constructed worldwide and had "mainly been single-family homes built in affluent areas" [72].

Although a significant increase in the number of new buildings in cities is anticipated between now and 2050, the number of those having low embodied and operational carbon will likely represent only a small portion of the overall building stock per year. Similarly, despite the fact that approximately two-thirds of current and primarily energy-inefficient buildings will still exist in 2050, at this time building renovations that reduce carbon emissions affect only 0.5–1% of the building stock annually [64].

5.2.2. Building Codes

Building codes play an important role in the production and regulation of the built environment and typically evolve in reaction to past catastrophes. Eisenberg [73] emphasized that they are primarily based on a "societal decision that it is important to protect the health and safety of people" from possible hazards and risks posed when inhabiting buildings such as those related to fire and smoke protection, structural integrity and means of egress. As currently framed, by ignoring their impacts on climate change, resources and the destruction of ecosystems, he contended they are inadvertently jeopardizing the health and safety of the broader human population and that we are obligated to re-invent the codes with that larger perspective. As such, Eisenberg advocated a much broader and positive emphasis, extending the notion of health and safety to embrace the broader and intergenerational environmental consequences of buildings and "re-envisioning building departments as not just governmental agencies responsible for preventing the worst practices, but as true community resources for the best design and building practices" [74] (p. 8). Changing national energy and building codes is a "somewhat ponderous process" [75] and, as such, regulations governing building carbon reductions lag behind those being requested in voluntary assessment methods. That stated, one can anticipate more stringent carbon reductions being explicitly included in building codes and standards within the coming decade [76].

Of consequence for this paper, Tenbrunsel et al. [77] (p. 111) identified that regulatory approaches to environmental problems pose four possible difficulties. First, standards tend to direct attention toward the regulation rather than "focus on how to optimally deal with the underlying problem". Second, they can act as a "force against innovation and creativity in solving environmental problems". Third, standard-based systems can "promote self-interested rather than societally based behaviour". Fourth, and importantly, a "follow the rules" mentality may "lead to a more permanent motivational change whereby individual responsibility for societal problems is dramatically diminished". Janda and Parag [78] argued that building professions are "required to comply with energy codes, not to exceed them" and for most, the "need to survive in a competitive and changing marketplace" overrides the "quest for energy-efficient, high-performance or low-carbon buildings". Collectively, these echo Bordass and Leaman's position on the consequences of replacing professional "ethics by rules and regulations" [15].

5.3. Shifting Scales

The majority of building environmental assessment methods were initially conceived to assess *individual* buildings and most began with a version for new office buildings and then subsequently expanded the range of products to include existing office buildings, multi-unit residential buildings, and then other broader applications—schools, homes, etc. Now, the major building environmental assessment methods offer a suite of products, each targeted at a specific building type or situation and, importantly in the context of this paper, versions that address assessing neighborhood or community scale developments, e.g., *LEED for Neighborhood Development* (2006), *BREEAM Communities* (2008), *CASBEE for Urban Development* (2006) [79], etc. As with versions for buildings, the scope and structure of these different systems have been compared with each other, see for example, Haapio [80]. Importantly, the development of larger scale assessment systems occurred *after* gaining experience with assessing individual buildings and, while they reference the performance issues of their building scale counterparts, neighborhood tools are typically distinct tools. It is reasonable to assume that building performance assessment methods would likely have a different structure and set of performance criteria if they were developed as being set within and linked to an overarching context of a neighborhood, community, or city.

5.4. Doing Less Harm

The emphasis and language of "green" building design remains largely one of reducing resource use and adverse environmental impacts [59] and similarly, assessment methods have focused on the extent to which they have done so. However, as McDonough and Braungart emphasized " . . . to be less bad accepts things as they are, to believe that poorly designed, dishonorable, destructive systems are the best humans can do" [81]. While the notion of "net zero" implicitly carries an ambition of "doing no harm" and represents a step-change in performance expectation and is considered appropriate and necessary for each and every building, irrespective of its location, type, or use.

Growing standardization has also tended to homogenize human experience and expectation. Buchanan [82] argued that this, along with the elimination of biodiversity, is collectively destroying complexity and laments the "homogeneity and mediocrity" of the built environment". He suggested that " . . . the true role of design extends beyond problem-solving and utilitarian concerns" [82] (p. 24) to the creation of higher levels of order that generate and permit complexity, diversity, and resilience. Strategically, this involves contributing to the building and maintaining critical structures, functional integrity, and mutually beneficial relationships within socio-ecological systems.

6. Regenerative Approaches

Or [83] stressed that we face " . . . nothing less than a rethinking and remaking of our role in the natural world. It is a recalibration of human intentions to coincide with the way the biophysical world works". Capra [47] argued that this has begun by illustrating how the reductive approaches to scientific enquiry dominant over the past few centuries are gradually succumbing to the holistic nature of the disciplines of biology and ecology and how the machine metaphor is being replaced by one of the networks.

Over the past two decades or so, "regenerative" approaches have garnered increasing interest as a means of reframing building practices which *increase* human impacts in ways that are consciously and, more broadly, beneficial [84,85]. Indeed, their "worthy", albeit "audacious", ambitions [86] (p. 370) offer considerable potential to nurture the complex systems thinking necessary to understand and respond to the interdependent disruptions to sociocultural and ecological systems caused by climate change. While many of their core tenets—systems thinking, community engagement, respect for place—have long individual histories in architectural discourse and practice, regenerative approaches tie them together in a cogent manner. Hes and du Plessis [44] and Mang and Haggard [87] emphasized how such approaches logically emerge from an ecological worldview and represent a co-evolutionary, partnered relationship between sociocultural and ecological systems rather than a managerial one and, in doing so, builds, rather than diminishes, social and natural capital.

"Co-evolutionary" speaks to a continually adapting relationship over time, making it necessary to reconcile how the timeframes and rates of change of people and their socio-cultural systems match those of ecological systems across various scales, how commitment and engagement is nurtured and sustained, and how to deal with uncertainties in outcomes. The interrelationship between people, socio-cultural, and ecological systems and, in turn, their consequences for the built environment are constantly evolving. While natural systems adapt in order to survive, human systems are "endowed with volition and intentionality" [88] (p. 239), and each system and relationship between them will be affected differently by a changing climate.

6.1. Locally Relevant

Above all, regenerative approaches prioritize the understanding and engagement of the unique qualities and potential of both places and the people who live in them. Indeed, operating within the context of the place, it is argued, ensures the relevance and resilience of projects, and their ability to adapt [89]. By contrast, most green assessment methods have wrestled with accommodating regional distinctions and their structure and emphasis offer little instruction regarding understanding and engaging local ecosystems and their processes. The emphasis on place and, by implication local communities, is of considerable significance in adapting to climate change. While the climate crisis is driven by the aggregate of GHG emissions globally, the consequences will be experienced on a local scale as will the community capabilities to adapt to changes.

Mang and Reed [85] emphasized the potency of using "pattern literacy" and the "story of place". Pattern literacy proposes "understanding patterns of relationships between parts as clues to understanding how these systems are sustained, how they self-organize and how emergent outcomes are produced" [85] (p. 29). As a complement, "stories" support the means of providing "a coherent organization of information, and the relationships and connections between discrete pieces of information and different types of information" wherein, an "underlying narrative structure enables relating this information and these relationships and connections in a way that reveals a holistic, understandable picture" [85] (p. 28/29).

6.2. Regenerative Development and Design

Mang and Haggard [87] made an important distinction between "regenerative development" and "regenerative design". Current building design typically accepts a client's predetermined set of functional requirements and seeks solutions under tight time and budgetary constraints, and green buildings create incremental performance advances rather than more fundamental challenges to current design norms. Moreover, the production of any building must recognize that stakeholders have different expectations and priorities, and those holding greater power over resources and decision-making typically dictate outcomes.

By contrast, regenerative development emphasizes the co-production of the built environment and aspires to greater equality between all stakeholders and shifts the role of design professionals to that of "facilitator of a process of revealing rather than acting as mastermind" [89] (p. 18). It invests more upfront to discover what stakeholders value in order to reveal the "right phenomena" and identify the most effective leverage points for the development of the potential and regenerative capacity in the socio-ecological system in which the project sits. Here, regenerative development relies on facilitated stakeholder meetings that, through an iterative process and validation with the community during follow-up, resolve competing views and arrive at a shared agreement of what could or should be manifested in the project and, in particular, how it supports the larger socio-ecological system in which it sits as an overriding guide.

In addition to creating more value in the longer term, the extended time investment offers three benefits. First, it permits stakeholders to co-invest in a project, collectively set a direction for the work from the outset, and to begin nurturing a broad culture of stewardship. Second, it permits a design team's self-actualization and growing their capacity, as well as enabling them to engage with and learn from a broader community of stakeholders. Third, it facilitates an understanding, caring, and lasting commitment of the stakeholders to share any risks as the project unfolds. The long-term engagement of stakeholders is critical since, if the momentum is lost, "projects can degenerate into business as usual" [90] (p. 561).

6.3. Embracing Uncertainty

There is little certainty and controllability in complex adaptive systems: They can only be navigated by propositions of what are more or less likely to occur. Regenerative development and design focus on understanding past and present contexts; revealing relationships, interactions, patterns and potentials; initiating transformative learning and building the capacity necessary to negotiate uncertainty and future surprises. However, while continual change, uncertainty, and unpredictability are characteristic of complex systems, Western perceptual systems are oriented towards "order, maintenance, optimization, and predictable equilibrium states of adaptation to the external world" [91] (p. 243) and have adapted for *certainty*.

Rather than accepting and embracing uncertainty, Mang and Haggard [87] argued that we have largely strived to make our lives more predictable and controllable through the deployment of increasingly energy-intensive technologies. Acknowledging these tendencies, regenerative development strives to build our individual and collective capabilities to work with complexity, change, and uncertainty. Proponents of regenerative approaches see the self-healing abilities of living systems, with the rethinking building design in relation to natural systems, and the innate human creative and entrepreneurial spirit, as collectively offering a positive path through the uncertain future created by a changing climate [44].

6.4. Dissemination of Regenerative Development and Design Practices

The USGBC and LEED were introduced to encourage sustainable practices in design and development by means of tools and criteria for performance measurement. The USGBC and its affiliations are responsible for the maintenance, continued development, educational programs, professional accreditation, third-party certification of projects, and the promotion of LEED and green building practices and has considerable financial and human resources to do so. While Lyle's 1994 *Regenerative Design for Sustainable Development* book [92] expanded the application "regenerative" capabilities of natural systems to human endeavors, *Regenesis* [93]—a Santa Fe-based collective of professionals in design, land-use planning, business and development—provided the considerable conceptual and practice understanding of regenerative development and design.

Regenesis was founded in 1995, approximately at the time of the creation of the USGBC (1993) and LEED (1998), but with the ambition to "bring together pioneering educators in the fields of permaculture and ecological design with thought leaders in the worlds of business planning and organizational development" [93]. It has been only relatively recent that *Regenesis* has offered various educational training programs for practitioners working in the built environment, community development, and higher education fields on how to develop the regenerative thinking needed to enable projects to transform the relationship between social and ecological systems.

7. Top-Down and Bottom-Up Approaches

Jasanoff argued that "[1] iving creatively with climate change will require re-linking larger scales of scientific representation with smaller scales of social meaning" [94] (p. 238). This, she suggests, requires synchronizing scientists' "impersonal knowledge of the climate" with the "mundane rhythms of lived lives and the specificities of human experience". While not explicitly referencing the value of lived experience—local ecological knowledge and Indigenous wisdom—this highlights the need of bridging between large-scale, scientifically-framed climate change issues with day-to-day activities of people in specific places and, more generally, top-down formal systems with informal bottom-up systems and efforts. However, within the production of the built environment, this involves a large number of forces and participants acting across multiple scales, and the distinction is not always clear.

7.1. Top-Down Approaches

Through "top-down" processes, "policy decisions from the national level are passed on to lower levels" [95] (p. 11). Within the context of creating buildings, policy-makers and regulatory bodies possess significant authority to proactively implement changes in buildings related to health, safety, resource use, and more recently, carbon emissions. However, this is complicated given that different levels of government (federal, provincial, municipal) may or may not share the same commitment to specific societal concerns or agendas, but are permitted or constrained by those having the greater power. By contrast, "bottom-up" processes value the "involvement of the local level in policy-making and subsequent impact on higher levels" [95].

As argued earlier, there is increasing unlikelihood of political agreement and concerted action to reduce global GHGs in a timely manner. Therefore, as a necessary complement to political action, a greater responsibility will likely be placed on neighborhoods and communities to find ways to navigate climate change within the constraints and opportunities afforded to them locally. The notion of "bottom-up" can logically be extended here to the ways and extent that people engage in and care about the places they live and thereby align with regenerative development.

7.2. A New Operating Space for Design Professionals

Operating between top-down and bottom-up processes creates a new space for design professionals. The United Kingdom Government's *Localism Act 2011*, for example, provided a series of measures shifting power away from central government and towards local people, including: "New freedoms and flexibilities for local government; new rights and powers for communities and individuals; reform to make the planning system more democratic and more effective, and reform to ensure that decisions about housing are taken locally" [96] (p. 1). This prompted the *Royal Institute of British Architects* to release two guides preparing its members for the possible implications of local communities' new powers to decide what is built in their area and the need to consult them on larger developments [97,98]. The guides emphasize the architect's role as "visual communicator and enabler of good design decisions" [97] (p. 11) and "integral design enablers and facilitators of localized plan-making, helping communities and local authorities to maximize the potential of their places" [96] (p. 2). While valuable, they represent a passive, apolitical role for architects and maintain their role within existing regulatory and professional norms rather than challenging them. The emergence of *Architects Declare*, and its expansion internationally, suggest that with the "interlinked crises of climate breakdown, biodiversity loss, and societal inequity" of the climate crisis, architects are willing to push for "radical, systemic change" and "pursue a different practice of architecture" [99].

The research and practice of the *Estudio Teddy Cruz + Fonna Forman* primarily concentrates on the informal and immigrant neighborhoods in the San Diego–Tijuana trans-border urban agglomeration [100,101]. Here, where the respective separate and culturally distinct borderlands place disparities in wealth and poverty and formal and informal urban development adjacent to each other, their work engages social and economic inequities and seeks to influence the political and economic frameworks that guide urban development. As academics, Cruz and Forman also call for a partnering between the university and the community in the co-production of new knowledge and, in doing so, essentially shift the traditional vertical process of knowledge production by experts and subsequent transfer to those who use it, to a horizontal one [102].

Cruz and Forman acknowledge and defend the value of both bottom-up and top-down approaches but focus on bringing them together. Here their work identifies four roles for architects that are of relevance to this paper. First, their role as mediators of new interfaces between "top-down resources" and "bottom-up intelligence" and between "centralized expertise and authority and distributed human agency" (see Figure 2). Second, architects "need to extract the DNA" of everyday practices in informal communities in order to "enable them to trickle-up and inform top-down policies" to reorganize institutional protocols in urban space to permit genuine change. Third, they should seek inspiration in bottom-up practices and multiply their potential by designing the interfaces between institutions and communities [101]. Forth, they need to take a stronger political position and expand the role of design to influence the policy and regulatory context in which the process of building design occurs.

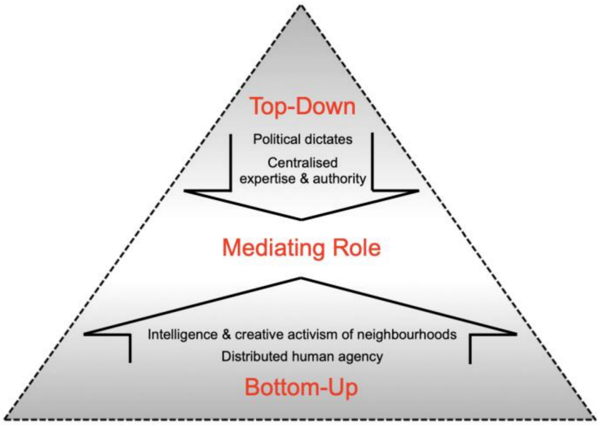

Figure 2. Mediating between top-down and bottom-up.

7.3. Middle-Out

Rather than concentrate on actions and influences emanating from top-down policymakers/regulatory bodies and bottom-up community needs or initiatives, Janda and Parag [78] examined those of building design professionals who operate between them. In contrast to Cruz and Forman, they explored how the influence of design professionals not only operates "up-stream" to influence government and regulatory bodies and "down-stream" to influence their clients and building users, but sideways to other building-related professionals-be they peers and organizations with whom they work, or compatriots and competitors (see Figure 3). This horizontal sideways "middle-out" approach includes that they spread the word, gain new skills, or form new alliances to address emerging issues such as climate change, transferring new innovations, and knowledge [15].

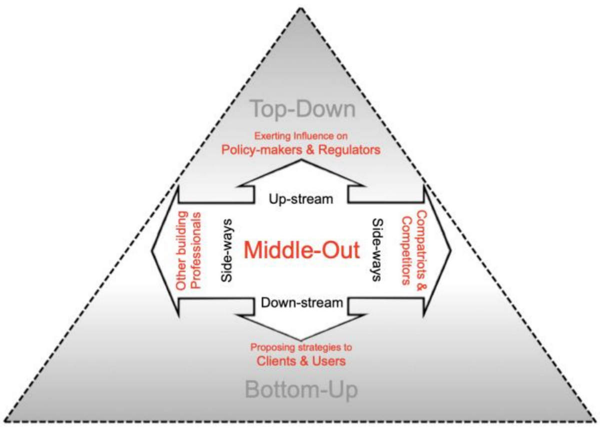

Figure 3. Directions of influence (after Janda and Parag, [78]).

7.4. Regenerative Approaches and Policy

Within the context of creating buildings, policymakers and regulatory bodies possess significant authority to proactively implement changes in buildings related to health, safety, resource use, and more recently, carbon emissions. However, this is complicated given that "different levels of government (federal, provincial, municipal) may or may not share the same commitment to specific societal concerns or agendas but are permitted or constrained by those having the greater power" [103] (p. 223). Bollo and Cole [103] presented the idealized conceptual framework shown in Figure 4 to illustrate possible paths by which the top-down mechanisms that government bodies setting policies (Policy Makers) reach target constituencies (Policy Takers). In the case of building regulations, provincial/state and municipal levels of government are most directly connected to the regional and local contexts within which buildings exist and regulate their development, design, construction, and operations.

Although the framework also identifies bottom-up advocacy methods by which stakeholders of all kinds—including building design professionals and community members—can influence policy objectives, it was conceived to characterize specific building performance issues such as energy efficiency. It is not applicable to characterizing the potential influence of regenerative and development practices which are about changing process rather the specific performance outcome, and their co-evolutionary nature does fall under the umbrella of policy. Regenerative approaches primarily rely on the engagement and interactions between design professionals, communities, and other stakeholders, including those representing local and regional authority. Here, Janda and Parag's [77] middle-out model provided a better representation of what Mang and Reed [104] considered the building of a "field of commitment and caring in which stakeholders step forward as cocreators and ongoing stewards of those solutions" as the way by which regenerative development and design practices will be adopted.

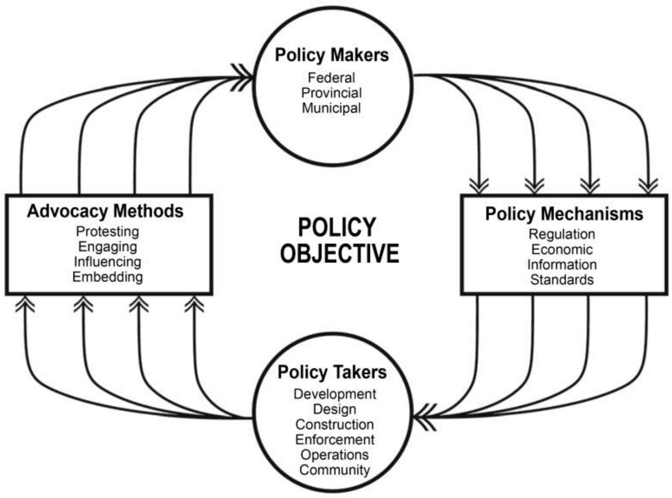

Figure 4. Conceptual framework for understanding the paths of influence in the delivery of low-energy, low-carbon buildings (after Bollo and Cole, [103]).

7.5. Embracing Human Agency

The notion of "adaptation" has historically referred to designing buildings sufficiently generic to permit future possible needs, repurposing them for new use or making changes with relative ease—simple robust structures, column-free spaces, generous floor-to-ceiling heights, and easily replaceable services and building elements. Now, as a necessary complement to mitigation, adaptation is understood as anticipating the adverse effects of climate change and designing buildings to prevent or minimize the damage they can cause and to maintain their functionality. A considerable literature exists on adaptation strategies. Ward and Wilson [105], for example, offer a range of *technical* adaptive strategies to prepare buildings against warmer temperatures, drought and water shortages, more intense storms, flooding, and rising sea levels and power interruptions.

Adaptation strategies will need to equally embrace the technical attributes of buildings, their inhabitants' expectations and behavior and, more generally, "technical" and "social" resilience.

Moreover, in addition to "investing" an expanded value in buildings, it is also about rethinking where and how "intelligence" is placed in buildings. The notion of "automated intelligence" is typically understood in terms of automation of technical systems that provide comfort, safety, and security for building inhabitants. Indeed, a characteristic fundamental to all "intelligent" buildings—as currently defined—is that they are invested with technologies and control strategies designed to free inhabitants from specific operational tasks and enable them to pursue other activities. While human agency—the capacity of individuals to act consciously and to make their own choices—is being increasingly substituted over time, it seems better to prepare for the unpredictable. Indeed, Jones [106] (p. 32) argues that agency "is the means by which we manage risk and take advantage of opportunities by deviating from business as usual". Therefore, it would be prudent to ensure that the built environment is infused with the capability to enable inhabitants' greater agency to adapt to the consequences of increasingly uncertain weather systems, use patterns, and availability of resources.

8. Implications for Building Design Professionals

While many of the issues explored in the paper are still unfolding, it is possible to offer several key implications for building design professionals:

8.1. New Ways of Thinking

Amidst the threat of nuclear war back in the 1950s, the *Russell-Einstein Manifesto* was a major step in the nuclear disarmament campaign by prominent members of the scientific community. Released on 9 July 1955 in London, UK, it asked readers to set aside political feelings and consider "yourselves only as members of a biological species which has had a remarkable history, and whose disappearance none of us can desire". The *Manifesto* continued: "[W]e have to learn to think in a new way". Regenerative development and design have offered the same challenge in the face of the current climate crisis. Addressing and navigating climate change requires an explicit restructuring of priorities and a questioning of the underlying assumptions that directly and indirectly shape design practices and the buildings created through them. Importantly, Mang and Reed's [85] position—that new approaches to design and the tools that support them must be preceded by new ways of imagining and thinking—carries considerable significance in this regard.

Regenerative development and design offer three important characteristics. First, they intrinsically consider that the act of building need not be destructive of natural systems and depleting of the earth's resources, but rather can contribute to and support an abundant and resilient world. Indeed, the "question no longer is how to reduce the negative impact of our actions, but instead how each and every action can contribute to a positive future" [11] (p. 60). Second, they hold the potential to change the way we see buildings, emphasizing the positive role they can offer within larger socio-ecological systems, bringing a wider range of community stakeholders into the development and design processes, and nurturing a community's connection to the place they inhabit. This aligns closely with Hulme's [107] argument that climate change offers the opportunity to "rethink and renegotiate our wider social goals about how and why we live on this planet" rather than being cast as a "problem waiting for a solution". Third, they see the challenge as how the built environment can be consciously transformed in order navigate climate change and lay the foundation to nurture a subsequent thriving world. For regenerative development and design proponents, the license permitted by the current regulatory context will in part limit the extent to which they will achieve their ambitions.

8.2. Amidst Stories

Individual minds are incapable of comprehending complex systems and it is necessary to break down and analyze their constituent parts separately—this is "part of why reductionist science exists, and part of why most scientists practise it" [86] (p. 371). Building design necessarily and constantly moves between reductive and holistic analysis—the investigation and resolution of details within the context of a larger design context. This parallels Capra's characterization of a necessary shift from "self-assertion" to "integration" in ways of thinking and values [47]. Self-assertive thinking, Capra argues, is rational, analytical, reductionist, and linear and, by contrast, integrative thinking is intuitive, synthetic, holistic, and nonlinear. Capra suggests that *both* of these tendencies are: "Essential aspects of living systems. Neither is intrinsically good or bad. What is good or healthy, is a dynamic balance; what is bad is ... overemphasis on one tendency and neglect on the other" [47] (p. 9). As such, rather than being considered as an either/or situation between reductive and holistic approaches, it is the *relationship* between these two modes of working that requires rethinking.

Figure 5 illustrates the issues related to a transition from green building practice to regenerative approaches, themselves set within an overarching shift from an anthropocentric to ecological world view and the associated ways that knowledge is produced. Here, regenerative development and design sit within emerging living systems thinking while the mindset of the planning, regulatory, and financial institution that govern buildings remain dominated by well-established, yet increasingly outmoded ways of operating. Regenerative practitioners will clearly have to operate within a "culture war" and be adept at engaging and negotiating with authorities who may not share the same ambition or are content with existing norms and conventions. In a broad sense, this parallels Berry's position that "we are in trouble right now because we do not have a good story, we are between stories ... and have not yet learned the new story" [108] (p. 187), or, as Cooper [109] considers "we have competing stories, where one is embedded in our society's power structures, economy and social mores, and the other is struggling to find interstices that it can wriggle through in an attempt to get a foothold".

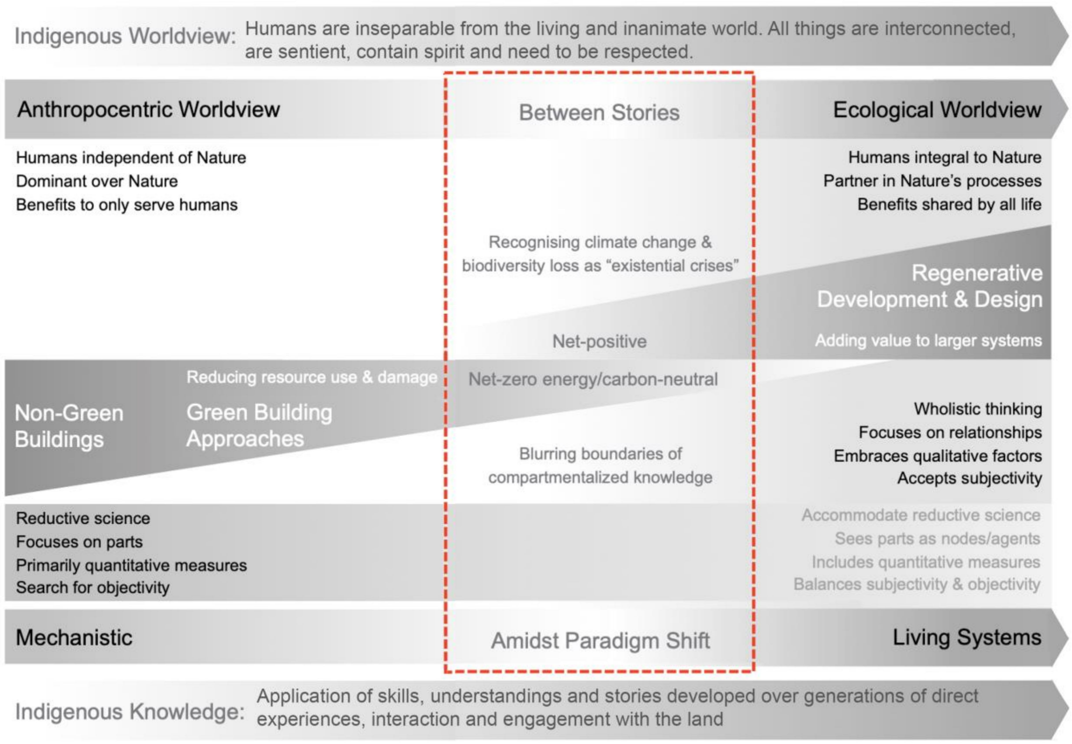

Figure 5. Shifting worldviews and framing of knowledge production.

8.3. Interrogating Boundaries

While the notion of "boundary" is important for enabling distinctions, Picon [110] (p. 10) emphasized the "need to interrogate and even throw into crisis the borders, limits, and lines of demarcation that we have inherited, sometimes unconsciously". He continues that the need for "a new way of evidencing and mobilizing boundaries that are not impermeable, but rather porous: Boundaries that can facilitate exchanges—changes even—of identity, rather than forbidding them". Moreover, Meadows [111] (p. 99) reminds us that "boundaries are of our own making, and that they can and should be reconsidered for each new discussion, problem, or purpose" and that those that have served us in the past may not be appropriate in solving new problems that society faces. Of relevance to this paper, such notions relate to expanding professional responsibilities and practices, reexamining the role of buildings, and bridging academic disciplines in professional education.

The production of the built environment is currently governed and constrained by a number of boundaries, many of which evolved to define and protect private ownership at various scales. Well-established property lines, for example, are defined by a set of legal codes and regulations as a reflection of the structure of property-rights [112]. This overarching frame clearly reinforces the primacy of the *individual* building as the focus of environmental strategies. However, Fedoruk [113] referenced an emerging tendency to view buildings as potential resource nodes within a cooperative networked infrastructure, such as a district energy system or smart grid network [113] (p. 16) and "[a]s buildings are integrated with distributed energy and information communication systems, they can be seen not as stand-alone entities but as nodes within these networked systems" [112,113].

8.4. Demonstrating Success

Discussions about regenerative development and design continue to garner widespread attention regarding shifting the role of buildings and changing the scope of the design process. However, their application is still in its infancy and faces a number of practical and operational concerns for established design professionals and developers, including: Living systems thinking representing too great a leap [90]; the additional up-front time needed to engage stakeholder input and commitment by clients may not be possible [114]; and the scale of projects that most design professionals work at may be inconsistent with regenerative aspirations [86]. While expanding the role and responsibility of building design professionals, it also demands that they become more skillful at illustrating the regenerative development's ability to create projects that fulfill value-adding roles and convince clients to expand the scope of work beyond meeting a narrower set of functional performance requirements.

Importantly, regenerative development and design pose challenges of demonstrating "robustly and clearly not just that its claimed benefits and outcomes can be delivered, but that they are worth the substantial effort clearly required" [115] (p. 358). More specifically, how can one know at the outset if and to what extent a project can be acknowledged as offering value to the context in which it sits given the uncertainties inherent in the evolutionary nature of complex systems? While there are currently no formal ways of "measuring" success, proponents of regenerative development place faith in the forging of a shared vision, responsibility and ownership amongst a broader range of relevant stakeholders by being co-creators, and building-in the feedbacks necessary for continuous improvement and providing greater assurance to maintain the initial ambitions of a project. Their contributions over the next decade are not likely to be initially judged in terms of the number of built projects and their associated carbon reductions, although it will be critically important that regenerative projects demonstrate they can achieve substantial project numbers and reductions.

8.5. Urban Context

Only a few regenerative development and design case studies have been published and the majority of these are essentially rural areas with small, coherent, and fairly affluent community groups (see [87,116]). Urban and suburban areas in cities are not spatially homogenous in terms of the diversity in social and economic equity, demographics, proximity to services, and accessible natural amenity. Of relevance here, is that different neighborhood communities within cities have qualitatively different engagements with place, coherence, and capabilities. Regenerative development and design may be considered unfeasible in these more complex urban situations with powerful social and political pressures. Unless unable to offer case-studies in these contexts, regenerative design will likely restrict their applications to the fringes of (re)development.

9. Conclusions

9.1. Relevant Differences between Green and Regenerative Approaches

A major portion of the paper has been devoted to contrasting current green building design and assessment methods that are set within a mechanistic, reductive scientific paradigm with emerging regenerative development and design that respect living systems and wholistic thinking. Two issues proved significant. First, there is an inherent tension between one that focuses on parts and aspires to defined outcomes, with one that recognizes that connections and relationships between them are paramount within interdependent, nested, complex adaptive socio-ecological systems. Second, there are significant differences between current green approaches for which a body of practical experience exists and emerging regenerative approaches without a sufficient track record to fully support their claims. Here, in advocating regenerative development and design, the paper aligns with Fenwick's challenge of the validity of "using 'evidence' obtained from past practice and distant contexts" when engaging complex adaptive systems [117].

9.2. Urgency and Adaptation

Unquestionably, there is a need to make significant global GHG emissions reductions within the coming decade and that designing buildings that function within a carbon-constrained world will increasingly dominate the future work of architects either through their proactive efforts, shifting client expectations, or more stringent regulations. That stated, despite the urgency claimed by the climate science community, the paper cannot find any compelling evidence that we will make the necessary reductions in GHG emissions from the built environment by 2030. Here, three issues are important. First, as with past environmental issues, addressing climate change with the seriousness it deserves will likely continue to be compromised by other seemingly more pressing societal and political priorities. Second, fundamental shifts cannot be readily or quickly assimilated within the design and production of buildings. Indeed, Tschumi suggested that "[a]rchitectural and philosophical concepts do not disappear overnight" [118]. This implies that new emphases and strategies will only be assimilated partially and selectively within an existing design context—the extent of which will vary depending on a firm's commitment, capability (small or large practice) and experience in designing low-energy/carbon buildings. Third, green building strategies, although having led to a number of environmental performance improvements over the past 30 years, they have not yet yielded the necessary reductions in carbon emissions from the built environment.

One of the paper's key assumptions is that the foreseeable future will be one of navigating the resulting consequences of insufficient mitigation progress and, as such, there is a need to critique approaches in their ability to guide building practices through this period of increasing difficulty and urgency—one that will likely precipitate a significant cultural and societal transition. While we can expect new infrastructure and buildings to be made more resilient to the stresses generated by a changing climate, adaptation will, to a large extent, depend on people's day-to-day actions in the places they live—a position central to regenerative development.

Adapting to climate change, similar to regenerative development and design, depends on engaging community members. Unlike green building practices that align more closely to top-down mitigation strategies and draw on the expertise of the design team members, regenerative approaches position building design professionals as co-learners and co-creators with community members and other stakeholders—those who will be most directly influenced by the climate crisis. In this regard, Clay, Colburn, and Seara's [119] research reinforced how inter-personal relationships, social capital, and social networks help "reinforce the cohesion and resilience of a community and thus its ability to respond and adapt to a disruptive event, returning to the original or a more desirable state" [118] (p. 335).

In the same manner that mitigation and adaptation are both necessary in navigating the climate crisis, many of the green building design strategies and associated technical knowledge remain valid regarding reducing environmental impacts. As illustrated in Figure 5, as regenerative development and design gain acceptance, such knowledge and experience will need to be recast within wholistic thinking, a greater understanding of interactions between strategies, and a host of qualitative factors.

9.3. Mainstreaming Regenerative Practices

Regenerative development and design are currently in the same position as the emergence of green building was 25 years ago, but are unlikely to be mainstreamed in the same way or as fast. There are two issues here: First, they do not have the same organizational promotional support of Green Building Councils such as the USGBC that green building has enjoyed and will rely on direct engagement and involvement of community members and stakeholders. As a practice, *Regenesis* emphasizes that "regenerative development is based on the premise that we cannot make the outer transformations that are needed in our communities without first making inner transformations, both individually and collectively, in how we think, how we work, and, ultimately, who we are as people" [92]. Second, and most significantly, they are framed within an ecological worldview and attendant whole-systems thinking, while the institutions that govern buildings are not.

There are a number of as yet unknown factors that will influence future societal actions and the rate at which they unfold. The COVID-19 pandemic, for example, has illustrated that major catastrophes can strengthen or create community. Most importantly, the new actions, practices, and stories emerging from the sudden human tragedy, disruptions, and economic impacts of COVID-19 may well be sufficiently potent to expedite the replacement of an outmoded worldview. While most may wish to return to a pre-COVID-19 normality, perhaps the quarantine or self-isolation and the closing of local amenities during the COVID-19 pandemic have provided a pause, permitting people to reflect on what they value in their communities, how climate change may affect them and, by extension, the whole Earth.

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