urban science

Review

Nature Positive: Interrogating Sustainable Design Frameworks for Their Potential to Deliver Eco-Positive Outcomes

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Abstract: Built environment design is implicated in virtually all socio-ecological sustainability problems. Nonetheless, paradoxically, construction will be essential to creating sustainability by increasing social and natural life-support systems. Given the rates of land, resource, water, and biodiversity depletion, urban development must do more than restore nature. It must increase nature and environmental justice in real, not relative, terms. The necessary technologies and design concepts for nature-positive development already exist. However, most sustainable building regulations, design criteria, and performance standards only aim to regenerate landscapes and integrate more nature into cities. This cannot sustain nature or society. This paper canvasses contemporary sustainable design and development thinking and finds that a progression toward 'nature positive' is occurring. However, so-called 'sustainable buildings' still do not compensate for past inequities or nature degradation, let alone the material flows, pollution, or biodiversity losses they themselves cause. This is partly because current standards and measurements are based on existing conditions, not sustainability standards, and do not distinguish net-positive from regenerative outcomes. Positive Development (PD) theory provides a comprehensive alternative to conventional sustainability frameworks, planning analyses, decision-making structures, design paradigms, and assessment tools. This paper provides criteria for evaluating the potential of conventional and alternative methods for achieving nature-positive outcomes.

Keywords: sustainable design paradigms; nature-positive development; eco-positive retrofitting; green building assessment; net-positive design; positive development; ecological restoration; nature-positive business; sustainable design criteria; urban planning analyses

Citation: Birkeland, J. Nature Positive: Interrogating Sustainable Design Frameworks for Their Potential to Deliver Eco-Positive Outcomes. *Urban Sci.* **2022**, *6*, 35. https://doi.org/10.3390/urbansci6020035

Academic Editor: Maria Rosaria Guarini

Received: 27 February 2022
Accepted: 20 May 2022
Published: 30 May 2022

1. Overview

Humans may never have sufficient knowledge or capacity to survive without nature. Yet nature has proven unable to adapt to the stresses and traumas caused by urban development. It is now possible, however, for built environment design to create structures that substantially increase social and natural life-support systems—economically. 'Net-positive design' principles and practices can create multifunctional, adaptable, nature-positive, and beyond zero outcomes [1,2]. Nevertheless, contemporary city planning barely mitigates the damage caused by past planning models; sustainable architecture only 'greens' some residual spaces and surfaces left over after development; and urban design rarely provides palliative care for surviving ecosystems.

Meanwhile, extinction rates keep skyrocketing [3]; 75% of the earth's surface is developed; only 8% of the world's waters and 17% of its lands are 'protected' [4]; and all wilderness areas are subject to increasing invasion and contamination. In this context, merely avoiding additional damage to nature does not alter the negative trajectory. Even if projects and products began to offset all their own lifecycle impacts, this would not redress past ecological damage or the material flows from new construction [5]. Therefore, 'PD' (Positive Development theory) argues that nature-positive development should increase ecological space sufficient to over-compensate for its share of past and present deficits [1,6].

Today optimistic terms are increasingly heard, such as net zero, regenerative, resilient, and climate positive. More significantly, the term 'nature positive' is taking off in corporate circles [7]. This suggests real progress since economists traditionally used terms such as 'natural capital', which portrayed nature as an inert resource. By nature positive, however, most companies only mean restoring the damage caused by their own operations and supply chains. This usually involves rehabilitating damaged landscapes or simply preserving existing patches of nature elsewhere. Such commitments imply net-positive ecological outcomes, but only constitute recovery and renewal. They do not increase nature in a whole-system sense.

Buildings that make improvements over unsustainable buildings often make dubious claims of being 'inspired by nature', but these are usually worse for nature than no building at all. Many replace natural ecosystems with simplified landscapes. When the baseline for assessing impacts is *existing* (pre-construction) conditions—versus pre-urban nature or total consumption rates—then nature positive is not a paradigm shift. PD introduced the term 'net positive' to mean measurable whole-system increases in the 'public estate' (environmental justice, equity, etc.) and the 'ecological base' (nature, biodiversity, etc.) to expand future options [2]. Accordingly, nature positive, correctly used, would mean beyond pre-development (not pre-construction) conditions. If nature is not increased at a rate that outpaces global depletion, the outcomes are environmentally negative.

Although cities only occupy roughly 3% of total land area, habitat losses due to their ecological footprint are far greater [8,9]. Some hope that enclosing a third [10] or half [11] of the earth's surface in nature reserves might preserve adequate wilderness. However, even if feasible, legal borders would not protect nature from pollution or politicians. Artificial, permeable borders can be removed suddenly. Recently, for instance, invaluable American national parks were unilaterally reversed by presidential decree [12]. To preserve wilderness areas, cities must increase the 'positive ecological footprint' of nature by creating productive ecosystem regenerators within urban areas. This means that development must change dramatically.

Currently, nature preservation is only feasible if undertaken as a part of commercial development projects, funded by investors and stakeholders. Hence, funding nature-positive sustainability in a capitalistic economic order requires physical redevelopment. It is paradoxical that only development can save nature, but true. To do so, however, completely different standards are required (Section 7). PD posits that, through nature-based, multifunctional, adaptable design, with low-impact structures and materials, built environments can measurably increase the net (beyond zero) gains for nature and society. 'Social net gains' must include benefits to the public, not just stakeholders, and 'ecological net gains' must include increases in nature, not just regeneration activity.

Conventional sustainable design paradigms only aim for 'more good and less bad' relative to existing conditions which, in a global context, is not sustainable (Section 5). Whole-system gains for people and nature must go beyond arbitrary thresholds such as typical buildings, existing sites, or other narrow boundaries. Biodiversity cannot survive for long in ever smaller, polluted, simplified, and isolated habitats. Progressive design paradigms aim for ecological restoration, but that would not address the accelerating consumption and depletion of nature. Restoring natural habitats after destroying them will not slow down extinction rates [13]. In contrast, PD aims to correct and over-compensate for the continuing growth in world population, material flows, pollution, wealth disparities, and other socio-ecological problems.

Some design professionals and practitioners see themselves as 'practical' people with no need for theoretical analyses. Hence, many unwittingly perpetuate unconscious, outdated theories. Sustainable design is replete with intellectual and institutional legacy issues. The transition to genuine sustainability cannot occur as long as the 'DP' (dominant industrial, mechanistic, reductionist, anthropocentric, etc., paradigm) persists behind our sustainable development frameworks, strategies, and tools. Since most design theories and practices build upon precedents, vestiges of the DP still permeate aspects of these

paradigms, as discussed below. Hence, changing the hearts and minds of consumers cannot magically lead to systems design change without deconstructing the DP (Section 2).

The environmental crisis is largely a result of accumulative, irreversible impacts that are not accounted for in design regulations or assessment tools. DP planning analyses and design methods use 'closed-systems' frameworks that exclude indirect impacts, in part to be able to apply conventional accounting tools and metrics (Section 3). These use system boundaries (legal liabilities, supply chains, property lines, etc.), beyond which largely immeasurable but cumulative impacts are ignored. Closed-system accounting cannot capture the impacts of consumption, social inequities, and looming ecological tipping points. These bounded frameworks form conceptual visors that limit the duty of care to nature, the disadvantaged, and future generations. PD reverses all aspects of DP sustainable development, which includes institutional frameworks and methods as well as physical design.

From a financial standpoint, sustainability is more practicable with 'eco-positive retrofitting', as discussed below. Despite its unavoidable material flows, retrofitting can affect global socio-ecological issues because it can pay for itself through energy, water, and health savings [14]. However, this requires a radical break from the weak ethic of 'do no harm' in built environment design [2] (pp. 23–42), [1] (pp. 111–135), [15]. 'Efficiency with amenities' cannot create whole-system sustainability, especially when disparities of wealth and opportunity are accelerating. For instance, climate refugees will intensify the problems of growing social displacement and ecological fragmentation [16]. Many migrants are moving to unlivable slums, for which there are no real plans, other than to abandon cities to contaminate the oceans as sea levels rise [17].

If guided by net-positive standards, planning methods, design tools, and processes of eco-governance, the potential for authentic nature-positive outcomes is possible with available technologies and design concepts. Built environments could even begin to catch up with and eventually outpace the rate of damage from most man-made and exogenous forces. However, they must be substantially redesigned and retrofitted to increase life-support systems for nature and society. These include universal access to basic needs, such as just, nature-positive, and climate-safe urban environments that reduce insecurity, social grievances, and even some of the causes of war. After all, democracy means little where people have real choices.

Box 1 provides a sampler of how established design concepts—in combination—could provide basic needs and better distribute public benefits.

Box 1. A sampler of eco-positive retrofitting actions for cities.

Source: (Birkeland 2005) [15].
Most retrofitting has only aimed to solve particular problems, such as structural weaknesses or legal requirements. 'Eco-retrofitting' focuses mainly on energy efficiency. 'Eco-positive retrofitting' aims to create net-positive natural and social life-support systems through a combination of multi-functional, adaptable, nature-based, and passive systems.

1. Climate and carbon

- *Carbon:* With net-positive (beyond zero) design, buildings and streets can sequester *more* carbon than they emit over their full lifecycle using permanent, building-integrated vegetation. Such multi-purpose systems can produce oxygen, reduce the urban heat island effect, and improve mental health through biophilic amenities, etc. Some building materials now absorb carbon.
- *Sea level:* Sea water will infiltrate freshwater aquafers through rocks and earth below sea walls. Flooded coastal cities will contaminate the oceans. However, lower levels of coastal buildings can be sealed with non-toxic waterproof membranes, and streets and walkways can be constructed at higher levels in the medium term while fossil fuels are being replaced.
- *Urban cooling:* Solar-powered water sprays, drip wire screens and fountains, outdoor shading structures, and the Venturi Effect, or even roof water containers (that heat up in the sun and release heat indoors to the building at night), can enable outdoor social activity in hot urban centers or heat waves (although urban ponds and streams alone have little effect).

Box 1. *Cont.*

2. Integrated energy

- *Urban wind:* Single-function structures for phone or radio towers, bridges, overpasses, and signs for roads or buildings seldom pay back their environmental costs. They can be designed or modified to support urban wind generators and solar cells (although less efficient at that scale) to power signs, nearby buildings, streetlights, etc., or simply to feed into the grid.
- *Algaetecture:* Buildings can be retrofitted with bio-reactive algae facades to supply hot water and space heating. The algae panels shade the building while generating biomass and heat. The biomass is collected via floatation, and the heat harvested via a heat exchanger. The algae grow by eating waste carbon from nearby combustion processes.
- *Solar windows:* Building-integrated photovoltaics can embed solar cells in facade materials, shading structures, and interior 'solar blinds'. Some windows have also embedded solar cells, but these 'power windows' are not yet widely available. Windows can also be tinted or be automatically responsive to changing sunlight. Skylights can reduce lighting costs during the day.

3. Energy saving retrofits

- *Passive thermal:* Buildings can provide all their own heating, cooling, and ventilating needs in moderate or hot climates with passive solar energy retrofits. Retrofitting design for resource autonomy, efficiency and other benefits can work with any constraints, such as sites with poor solar access and regulations for preserving historic building facades or aesthetic features.
- *Trombe walls:* Trombe walls are well-known passive solar systems that can be added to windowless, sun facing walls to generate passive cooling, heat storage, and ventilation. They can also be installed behind windows that lack a view. They have been used in many homes and large buildings. PD versions include a similar concept for sun-facing roofs.
- *Curtain walls:* Covering old curtain glass windows with films or double glazing can reduce heating and cooling loads. Many of the panels could be covered with outdoor planting boxes if accessible from the inside for maintenance. If replaced by embedded solar cell windows, they can provide renewable energy. 'Window walls' can also replace wasteful curtain walls

4. Flood and wave mitigation

- *Shoreline restoration:* Shorelines are eroding from waves and storms caused by climate change. Although concrete bollards are often used (which support some marine life), more ecological options are also available, such as discarded oyster shells in cages, to support nurseries for marine biodiversity and healthy fish for harvesting.
- *Rural floods:* Dams have poisoned rivers when the water backfills mines and agricultural lands, and they often produce methane. Floods that break flood barriers and dams do far more damage than landscaping that allows for natural flood cycles. Therefore, the movement to unplug old dams has gradually gained scientific acceptance in recent years.
- *Urban floods:* Although conventional city infrastructure has exacerbated urban floods, there are many landscape solutions. These include diverting excess urban water into reservoirs in parks. Flood-prone land can be converted to recreational uses which allow for quick evacuation. 'Daylighting', which exposes buried urban streams, can create ideal nature corridors.

5. Safety

- *Tornados:* Community facilities can serve as refuges in fires (CFRs), cyclones, or other crises. They can store emergency firefighting and medical equipment while serving multiple public functions at other times. Cables are underutilized as reinforcement for strong winds. Semi-underground shelters under new public parks or play gardens are good locations.
- *Fires:* Water pipes can fail in earthquakes and cause urban fires. Buildings can support integrated rainwater storage tanks linked to irrigation systems for landscaping. In fires or extreme heat waves and heat inversions, they can be used to spray mists on the roof, facades, and surrounding streets, which has been shown to improve local temperatures as well.
- *Sinkholes:* Sinkholes can occur where 'dissolvable' underground materials such as gypsum, salt, and limestone are eroded by water that does not drain well. Earthquakes, landslides, and sinkholes are increasing, partly due to oil, water, or resource extraction. In some so-called 'sponge cities' these holes are filled with water, and are designed to drain off when full.

Box 1. *Cont.*

6. Food security

- *Food access:* Urban farms reduce transport impacts and can prevent food shortages in economic or civil crises. Many apartment houses, some restaurants, and even grocery stores use their roofs or rent other roofs to grow their own produce or to create attractive outdoor dining areas. These revitalize urban districts and take advantage of views.
- *Crop rotation:* Industrial-scale vertical agriculture has been established inside abandoned warehouses as well as in new urban greenhouses. Some use rotating container systems for easy access for tending and harvesting the crops and to expose plants to skylights to provide the ideal amounts of sunlight. They are water efficient and produce oxygen.
- *Aquaponics:* Aquaponics is a closed-loop system using aquariums where fish produce the nutrients that grow vegetables. The fish produce fertilizer for the plants that in turn feed the fish, and both can be harvested. Aquaponics can work at the domestic as well as commercial scale, where it can utilize kitchen food waste.

7. Soil production

- *Urban fertilizer:* Silent, non-odorous, vertical processors in urban areas can treat organic waste from the surrounding district to produce soil for urban landscapes or public gardens and provide fuel. They reduce transport impacts. A variety of systems have been used at the individual building scale as well, and some basement systems treat all building-generated sewage.
- *Contamination:* Some soil remediation companies use microbes to decontaminate the earth. Soil can also be effectively regenerated by earthworms and detoxified by mushrooms [18]. While earthworms turn waste into resources, mushrooms can process pollution and remain edible. Both serve as fertilizer. Mushrooms can be net-positive systems that go beyond recycling.
- *Erosion:* Conventional urban stormwater systems channel rain runoff in ways that cause downstream erosion, sedimentation, and water and soil pollution. In contrast, 'water-sensitive landscape' strategies slow down, filter, and store excess runoff or release it slowly. Certain kinds of retaining walls also provide biodiversity habitats (unlike most engineering approaches).

8. Resources and construction

- *Construction:* Hempcrete can sequester carbon and can be poured like concrete or used as boards or insulation. Robotically printed buildings are rapidly advancing and are very efficient. They could soon print out bio-based materials such as hempcrete in lieu of ecologically harmful concrete [19]. Some technical issues remain to be resolved.
- *New IFC materials:* Mycelium (mushrooms) could replace Styrofoam in the highly efficient ICF process (insulated concrete formwork) [20]. These forms could then be filled with hempcrete in lieu of concrete. Since harmful Styrofoam and concrete could be avoided without changing conventional construction practices, there should be little resistance from the building industry.
- *Bio-based materials:* There are many building products from agri-waste (strawboard, strawbale, etc.) or crops (bamboo, hemp, etc.) or dirt (mud bricks, pressed earth, etc.). Many such materials such as straw, bamboo, and hemp can also be pressed into boards. Bamboo has also been used in award-winning architecture as a structural material in its natural form.

Box 1. *Cont.*

9. Land reclamation

- *Desert restoration:* Deserts have delicate ecosystems, but areas that have already been degraded from agriculture into deserts may be suitable locations for new cities or industries (unless the human population is greatly reduced). Such developments could fund the eco-restoration of nearby deserts and halt the further desertification of fertile land.
- *Land rewilding:* Mycelium-based bricks, boards, and insulation can be grown in unlit vertical spaces. This means that agricultural, mining, and forest lands that are currently used for producing (harmful and wasteful) building furnishings and materials could be rewilded—or at least reclaimed for public purposes such as outdoor education and recreation.
- *Off-ground buildings:* There are many reasons for elevated buildings, as traditionally used in tropical climates for cooling, or for underground buildings for fire protection, insulation, etc. These enable the preservation of more ground area for relatively natural land uses, vegetation, and habitats. However, long private-access roads can nullify these benefits.

Box 1. *Cont.*

10. Human health

- *Urban air:* Most facades can be retrofitted with panels that absorb noise and pollution from the streets below. Multilayered structures supporting screens and plants on roofs, over plazas or streets (such as Green Scaffolding) could clean urban air, improve air temperature, and provide better air circulation—as well as other socio-ecological benefits [1] (pp. 136–152), [2]).
- *Furnishings:* Interior fabrics can be produced from low-impact materials such as jute, cork, wool, hemp, bamboo, recycled plastic, or eelgrass—and now even algae. These could reduce the huge cumulative, embodied energy that results from real estate churn and continuous renovations to suit changing occupant preferences
- *Greenery:* The benefits from regular exposure to greenery have long been scientifically validated. Employees, commuters, or students working in or around greenery are measurably healthier and more productive than their counterparts. The additional oxygen and pollution absorption from plants are among many factors [21], which include biophilic amenities.

11. Ecological Growth

- *Nature retrofitting:* Virtually every eco-positive retrofit could support biodiversity as well as collect, store, and treat water; reduce the heat island effect and pollution; improve passive performance; integrate renewable energy systems; increase human health and amenities; increase urban food security; and so on. Generally, green buildings have been ecologically sterile.
- *Green Scaffolding:* These space frames support passive solar heating and cooling, natural systems, biodiversity habitats, rainwater treatment, and storage, etc. They can form the basic structure of the building itself or be used to retrofit all or a portion of a building envelope. Green Scaffolding systems could support up to two dozen eco-services in one building.
- *Nature corridors:* Biodiversity passages throughout cities are now necessary. As cities both densify and spread, the isolation of animals from prospective mates and lack of escape from feral predators, etc., is worsening. Nature corridors, roofs, whole building floors, and walls that are dedicated to particular endangered species, should be designed to deter feral predators.

12. Infrastructure

- *Pollution:* 'Living Machines' have been used to treat waste and pollution from buildings, industries, and truck stops. They use a series of vessels filled with water-based ecosystems to support selected microbes that eat certain toxins. After purifying wastewater, they can grow fish and create biodiversity habitats in a closed loop system, or pre-treat water flowing into wetlands.
- *Road and rail:* Existing roads can be partly shaded with roofs supporting solar collectors or linear algae-based energy production systems for fuel production. Under-used roads have been converted into gardens, bicycles, and jogging paths. There are now low-impact alternatives for road resurfacing and repair using waste such as used plastic, as well as construction waste.
- *Street retrofits:* Urban streets and alleyways are being retrofitted to exclude cars (except for night-time deliveries or emergencies) but include provisions for segregated motorized wheelchairs, bicycles, and pedestrian pathways. These new spaces support social activity, recreation, gardens, and a variety of seating for shaded outdoor resting or coffee shops.

13. Socio-economic gains

- *Sense of community:* Eco-positive retrofitting can preserve established and historic neighborhoods while meeting higher standards and new code requirements. At the same time, they can provide savings and public benefits to offset the costs. Retrofitting can also enable many people to remain in their own neighborhoods as they age or become less physically able.
- *Stability:* Relatively self-sufficient urban settlements in every country could reduce mass migrations caused by autocracies, poverty, climate change, etc. In disadvantaged or impoverished regions, assistance in basic self-help retrofitting, such as insulation, building-integrated food production, water collection and treatment, could increase stability and security.
- *Employment:* Building improvements and garden maintenance will never be completed, so eco-retrofitting provides more regular and healthy jobs than high-maintenance mechanical systems or new building construction. Through retrofitting programs, the unemployed can find healthy jobs in urban farming, gardening, or carpentry, while working close to home.

Box 1. *Cont.*

14. Democracy

- *Co-housing:* These are intentional communities that share many facilities. They usually have a common house with a central kitchen and dining room, along with shared equipment, such as gardening tools or cars. They often organize self-governance systems and use participatory design in new housing. Some projects are created by retrofitting whole urban blocks.
- *Education:* Ignorance is the enemy of democracy and sustainability. Children today have little contact with nature and little exposure to ecological design. Nature-positive urban environments using passive and natural systems can expose urban children to means of self-reliance and to the wonder of the complex, interconnected web of life.
- *Politics:* People do not have equal access to markets. Democracy requires environmental security and direct universal access to the means of survival and wellbeing. Otherwise, people can be intimidated or threatened by political interests that use economic manipulation by creating a scarcity of food, shelter, jobs, fair pay, or other basic needs.

The small sampling of potentially nature-positive materials and design concepts in Box 1 are seldom applied in conventional sustainable design. This is largely due to the force of inertia caused by old mindsets, models, methods, materials, and metrics [1]. PD inverts the received conceptual frameworks in the building industry that have forestalled nature-positive forms of eco-governance, planning, decision making, design, and assessment. This paper begins by briefly reviewing the underlying precepts of the DP (Section 2) and how DP closed-system frameworks (Section 3) have shaped conventional approaches toward sustainability (Section 4). Box 2 summarizes some vestiges of the DP in so-called 'sustainable' decision making and design. Sustainable design paradigms are then summarized (Section 5) and compared against criteria for net-positive design (Section 6).

Box 2. Some legacies of the DP.

This lists examples of how vestiges of the DP are still found in most sustainable development frameworks in ways that limit problem definitions and solutions in both decision making and design.

Limited scope of responsibility

- *Control:* Spatial and temporal boundaries offer a means of feeling in control. Attempts to predict, plan, and control the future in a complex socio-ecological system are unrealistic. They must give way to the design of frameworks for built environment design that ensure that buildings are adaptable to unpredictable change.
- *Anthropocentrism:* Hubris can leave people out of touch with reality and limit their sense of responsibility to others. Social and economic constructs that only value the instrumental uses of nature must be replaced by the realization that structures can preserve and increase nature while still providing socio-economic benefits.
- *Time boundaries:* Developers do not yet take responsibility for a share of past damage that construction has caused, let alone their added damage. Their duty of care to society must include ethical and ecological outcomes. While limits on liability are necessary, *voluntary* certification and award schemes need not limit accountability.

Box 2. *Cont.*

Limited scope of analyses

- *Limits:* The faith that business-as-usual growth is ok as long as it stays within certain catastrophic limits causes fruitless debates over where those limits are. It also allows professionals to narrow their analyses to their direct (easily measured) impacts only. Economic growth must ensure that net ecological 'growth' by design is included.
- *Reductionism:* The legacy of early science was to reduce every problem down to an underlying cause or two. The notion of boiling down complex issues into single variables (energy, carbon, cars, etc.) is still found in urban design and planning. 'Whole-system' planning analyses and strategies must recognize the 'butterfly effect'.
- *Atomism:* The idea that society is composed only of individuals (like atoms), with *presumed* equal access to power and resources, has legitimized dominance relationships. The legal concept that corporations have the same rights and limited responsibilities of individuals, despite their disproportionate power, must be abandoned.

Limited scope of strategies

- *Single-functions:* Dividing building plans and land use patterns into different 'types' or zones (using the old factory model) was seen as efficient despite its environmental impacts. Separate rules of different building types and zones must be supplanted by multi-functional, mixed-use planning that provides for basic needs locally.
- *Efficiency:* The concept of efficiency is still based on saving money and materials (profit) through more outputs per unit of input, regardless of the social value of the object or activity. This reductionist approach must yield to the aim of producing more environmental and public gains from fewer resources using multifunctional design.
- *Recycling:* Circular recycling systems are slowly replacing linear industrial systems that use pipes, wires, roads, and linear supply chains, which are especially vulnerable in social or environmental crises. However, it must be recognized that circular systems are, on their own, at best value-adding, and cannot have net-positive impacts.

Limited scope of actions

- *Mitigation:* The notion that buildings need only to reduce energy consumption and carbon emissions and produce renewable energy must give way to the understanding that buildings can reduce the urban heat island effect, sequester more carbon than they emit, and produce more oxygen than used—while increasing urban ecosystems.
- *Restoration:* While sustainable designers always try to improve the human environment, they generally only add greenery in buildings and restore the leftover landscapes. The weak goal of regenerating the area lost by the building footprint (ground area) must yield to increasing the positive ecological footprint of nature
- *Adaptation:* Lowering expectations, rather than facing climate problems and designing nature-positive solutions, is fatalistic. The defensive idea of fortifying buildings and making nature more resilient must be converted to creating diverse and adaptable environments that improve the urban climate while making all citizens better off.

Limits scope of accountability

- *Externalities:* Building assessments exclude remote, bio-accumulative, long-term problems that do not affect stakeholders since they are hard to measure. The idea that developers are only responsible for doing no *added* harm (beyond a threshold defined by legal, business, or other boundaries) must become a duty to 'do net good'.
- *Boundaries:* The systems boundaries used in building evaluation methods effectively externalize problems onto future generations or other social groups. Simple methods and tools that discount or ignore the complex, remote, cumulative damage that characterizes development impacts must move toward net-positive methods.
- *Flexible standards:* The expectation that standards should build upon existing norms reinforces 'unsustainable' precedents. Most standards are determined (indirectly) by developers and are flexible to avoid hardship by allowing exemptions. Instead, buildings must be flexible or easily retrofitted to meet changing needs and conditions.

PD theory aims to foster the shift from the DP to genuine sustainability on many levels and scales [1]. The contextual overview (Sections 1–6) is followed by a summary of basic PD standards for ecological and social development; 'social' includes economic, democratic, and government aspects (Section 7). These provide criteria for evaluating whether various

reforms to environmental governance, planning, decision making, or design can increase social and natural life-support systems. Two examples of PD reforms are summarized here: new analyses for urban planning and design (Section 8) and an opensource net-positive design 'STARfish' app (Section 9). The criteria for evaluating design and assessment tools are provided (Section 10), after the PD design app is introduced, to enable comparisons.

2. The Dominant Paradigm

Because the DP has been extensively deconstructed by many philosophers since 1980, it is only briefly summarized here. The origins of the sustainability crisis have been traced back to ancient times, even as far back as the origins of agriculture, urbanization, or monotheism. Most scholars, however, attribute the DP to the influence of Bacon, Descartes, and Newton, who effectively redefined human progress as linear, rather than cyclical, and, in effect, legitimized the exploitation of nature [22,23]. Authors use different critical lenses (anthropocentric, instrumentalist, mechanistic, reductionist, etc.) to diagnose how these social constructs led to the cultural imbalances that underly the sustainability crises [24–27].

A widely read early analysis of the origins of the environmental crisis was *The Death of Nature* (1980) [22] and was developed further by other ecofeminist theorists [28–31]. This analysis draws parallels between the subjugation of nature, slaves, women, and animals and explores the ubiquitous drive for 'power over' others. Ecofeminists traced the perceived need for control on personal and political levels to the gendered, dualistic, and hierarchical view of reality that evolved with androcentrism and anthropocentrism. The idea that exploitation and abuse is an inherent entitlement for some was largely replaced by stewardship and paternalism, which still presume (questionable) ecological knowledge and management capability.

Social constructs are accepted as truth even when they conflict with survival, because they are deeply embedded in the culture. For example, an economic system can define selfishness as rational although it relies (irrationally) on perpetual consumption and population growth [32]. It can portray itself as hard and scientific, even though it values natural resources with transient prices, which fluctuate with sporadic market supply and demand, rather than tangibles such as remaining stocks in nature. It has also perpetuated fanciful assumptions, such as nature's capacity to provide an *infinite* sink for pollution and source for materials—as if a supernatural mother.

When individuals or groups depend on something, they generally want to control it. yet also deny these emotions. Whether it is something cared for such as a life partner or nature, or something distrusted such as immigrants, ethnic groups, or a subjugated social class, it will be devalued and marginalized. Otherwise, those in control would not feel entitled to exercise dominance. This helps to explain prejudice: arguably the biggest obstacle to sustainability. The 'need' for control is still found almost everywhere. Over the centuries, prejudice justified limits on the responsibilities and formal accountability of those in positions of authority.

PD aims to flip these constructs from negative to net-positive (beyond zero). This means thinking outside the conventional negative prism to create whole-system analyses that include remote, cumulative impacts and expand the duty of care to include affirmative action for social and natural life-support systems. One way to progress this is by complementing linear, closed-systems decision making with lateral, open-systems design thinking. The collective imagination has been limited by conceptual frameworks that prioritize reductionist decision making (choosing) over design (creating). Design-based strategies can operate outside the political and policy arenas that continually block positive systems change. In addition, many ideological and structural barriers can be transcended through 'conflict resolution by design' that meets opposing objectives [33].

While ideologically-based approaches continue to create conflict and obstruction, social constructs, such as value systems, are systemic. Inherited social constructs, biophysical systems, and institutional structures are not pre-ordained. Unless deconstructed, however, they will continue to reinforce the barriers to sustainability. Mainstream sustainable de-

velopment has prioritized retaining anachronistic government and corporate structures, or the social and political order more generally, rather than restructuring them on sustainable foundations. Due to the tenacity of the DP, concepts such as 'sustainability' and 'net-positive' are continually watered down.

Early on, for example, sustainability was associated with the 'limits to growth' [34]. System boundaries and negative tipping points, defined by physical limits, are of course real (nutrient cycles, carrying capacity, water, atmospheric carbon, etc.) [35]. However, the limits to growth argument construed the 'problem' as planetary boundaries. Opponents therefore associated sustainability with personal sacrifice, economic constraints, and doom. Boundaries were debated rather than systems solutions, so attention was directed toward downsizing, not public gains. Sustainable development became a matter of reducing negative impacts, not creating net-positive outcomes. This zero-sum framework fostered personal denial and political procrastination because sustainability was made to appear impossible.

In contrast, some *early* international declarations of sustainability had implicitly included the principle of 'not closing off' future options. This meant avoiding irreversible pathways (nuclear and toxic waste, land clearing, species extinctions, etc.). Subsequently, however, the influential Brundtland Report of 1987 reinforced the idea of measuring and mitigating negative impacts before limits were reached, using existing decision-making structures [36]. People did not seem to realize that negative ecological impacts often biomagnify and cannot really be measured. Conversely, they did not realize the potential to create net-positive impacts that expand future options by design. Hence, gradually, most technocratic professional, industrial, corporate and government organizations adopted the DP version of sustainable development. The focus became what *not* to do, instead of imagining what to do—redesigning systems to reverse, not just bend, the trajectory.

3. Closed- versus Open-System Methods

The building fields (engineering, environmental accounting, building assessment, planning, architecture, etc.) were slow to adopt even mainstream 'weak' sustainability. Soon, however, the split between design-oriented versus technocratic approaches became evident [37,38]. Technocrats tended to privilege what is associated with hard science, and nature was seen as soft. Most green design advocates have focused on social change, rather than redesigning planning systems, analytical frameworks, regulations and methods to produce nature-positive outcomes [39]. These intellectual and institutional visors reinforce limited goals and exclude important sustainability dimensions. This is because both ends of the hard–soft design spectrum have largely retained closed-system frameworks that measure the wrong things in the wrong ways. In fact, many champions of sustainable development try to change other people's values, rather than rethinking the conceptual frameworks that have shaped unsustainable development outcomes.

While the Brundtland Report focused on counting negative impacts, PD reconceived sustainability as 'expanding future options' by increasing the ecological base and public estate in ways that support their regions. Whereas PD would reform existing institutions and structures based upon net-positive principles, the Brundtland Report assumed sustainability goals could be managed through existing decision-making processes. This contributed to the notion that nothing should be changed unless everyone was convinced that climate change was real. However, what must be done to build a sustainable society is the same, whether global warming is real, man-made, or non-existent. The designs and investments that could solve the climate crisis (increasing nature, replacing toxic fossil fuels, etc.) would improve social and ecological conditions regardless. That message, however, cannot be heard from within the current 'Overton Window' [40].

The idea of avoiding irreversible directions and diversifying positive options by design is still not taken seriously, since design (like nature) is still deemed soft by many. Only adaptation and restoration have been on the table—which are essentially mitigation. For instance, reforestation, while necessary, cannot offset the carbon already emitted [41,42],

and forests may not survive climate change in any case [43]. However, it was shown quantitatively by 2014 that a building could sequester net carbon and restore nature to beyond its pre-industrial equivalence [44]. Nonetheless, officialdom appears willing to settle for 'adapting' to temperature increases of over 1.5 degrees or, at best, returning to less disastrous levels [45]. Meanwhile, pollution, consumption, over-population, and harmful forms of urban growth continue to breach planetary boundaries.

Since complex systems cannot be measured, 'system boundaries' and limits are necessary within current forms of decision making (comparing and making choices), accounting (adding costs, risks, and benefits), and law (defining duties and expectations). These generally exclude problem solving and opportunity creating by design. As well as being essentially binary and bounded, decision tools seldom question the initial problem definition or worldview from which they come. They facilitate choices by reducing complex issues to their simplest form. Even multi-criteria analyses reduce choices to known options using generic criteria and prioritize certain factors while excluding others. These closed-system frameworks also limit responsibility to what is foreseeable while limiting what is visible: beyond zero was made invisible and ignored in assessment tools.

One way of understanding open-systems thinking is to revisit the difference between decision making (choosing) and design (creating things that never existed before) [46]. Recent scientific research affirms what is intuitively obvious, that deciding and designing actually use different neural networks in the brain [47]. Although quite different from the left–right brain duality, this distinction provides a rough *metaphor* for the difference between linear decision making and lateral design. Sustainability requires design: expanding benefits, opportunities, and options through cross-boundary symbioses—not just decision making. Net-positive design therefore aims to integrate design with decision making to create better options and multipurpose outcomes that expand life quality for everyone. Sustainability would surely benefit if decision theory incorporated design thinking.

In summary, closed-system frameworks reinforce limited goals and bounded analyses, and generally ignore current ecological and social deficits. They aim for zero, or self-sufficient, structures that balance inputs and outputs. These do no produce whole-system increases in nature and justice. Merely integrating nature into cities to 'enhance' nature–human relationships in the hope society will change is to hold hands and dance around the maypole. Design *for* nature is now a matter of survival. Nature-positive environments will require critical thought, engagement, design, and action, not just better choices among existing options.

4. Sustainable Governance

Government decision making affecting the environment, whether executive, legislative or judicial in character, is largely based on rights, and nature has had no rights [48,49]. Furthermore, decision processes tend to 'balance' competing interests; inputs and outputs; or costs, risks, and benefits. Non-government organizations that represent the environment or other disadvantaged groups are still presumed to have equal power, resources, and influence. This dualistic, zero-sum approach usually only leads to tradeoffs that balance human interests at the expense of nature. Equity therefore demands the redesign of structures, frameworks, methods for planning, design, and decision making. This includes rethinking the rights and roles of developers, designers, and communities, as well as the reform of approval authority processes and assessment tools.

In practice, developers are the primary decision makers in urban environments, despite planning code parameters. They were not traditionally expected to address ecological or ethical issues. Their duties are proscribed by dated legal concepts that evolved long before the environmental crisis manifested itself. Even 'sustainable' zoning, planning regulations, standards, and assessment schemes limit the responsibilities of developers to business boundaries or property lines. Green building rating tools theoretically exceed building code standards, which only set minimum performance criteria. However, the former also use thresholds, but are voluntary, and usually only recognize specific, conventional actions.

They also set standards low enough to bring more developers on board. In practice, they limit choices, time frames, spatial boundaries, and responsibilities toward nature and human rights.

Designers' decisions are increasingly influenced by these rating schemes, although they still largely omit nature and justice. These omissions are hidden by listing benefits for humans under 'ecological' headings (healthy building materials, indoor air quality, drinking water, etc.). Calling things ecological makes it appear that nature is being looked after. When the natural environment is considered, the performance standards usually label any landscaping improvements to the remaining land or building surfaces as 'positive'. For instance, private green roofs and walls are often deemed to offset the land buried by the development. Even if rating tools were legislated and all projects met their standards, nature depletion and degradation would increase, and environmental inequities would worsen.

Rating tool provisions that concern social sustainability also set boundaries that limit responsibilities. Social criteria in these schemes sometimes call for better jobs during construction, healthier materials during occupancy, communal facilities for the occupants, inclusion of subsidized rental units, and so on. That is, they concern the wellbeing of stakeholders but not the general public. Even criteria for whole suburbs or residential complexes merely call for social amenities within the development's boundaries. Many 'sustainable' housing developments and business parks often increase disparities of wealth and limit opportunities for those that cannot afford to live there. Moreover, few even design for potential environmental crises or for basic community needs within those boundaries.

To contribute to sustainability, environmental governance cannot just use assessment tools with tick box approaches (which avoid assessing actual impacts), while also constraining design thinking by not even recognizing or counting net-positive impacts. Before looking at the PD approach to planning and design, this paper asks whether sustainable design paradigms can address whole-system global issues, such as climate change, sea level rise, and environmental refugees. It suggests that while making significant contributions, these paradigms, to varying extents, still reflect closed-systems frameworks and thus omit to consider the full range of sustainability issues that are impacted by the built environment.

5. Design Paradigms and the DP

Sustainable and green design are umbrella terms. Some of their origins can be traced back over a century [50,51]. Virtually all designers, sustainably inclined or not, have believed that they were contributing to society's betterment. However, sustainable design defined contributions to include environmental quality and ecology, if only for their direct human benefits. The paradigms below are frequently used differently by various authors. For example, 'green' had once meant sustainable, but when building councils emerged and promoted technocratic green rating schemes, green building became associated with mere efficiency and mitigating negative impacts. Nonetheless, despite differing personal interpretations, some broad generalizations about their strengths and weaknesses can be made.

Several sustainable design paradigms began with particular solutions to sustainability, such as energy and resource efficiency, food production, technological innovation, the psychological need for nature, and so on. They gradually became more holistic by incorporating existing sustainable or green design principles. Over time, they may effectively amalgamate. However, they will need to address how cities can be more just, secure and nature-positive. They will also need to counter the institutional impediments to sustainable development, such as assessment frameworks that lack transparency and fail to measure life's essentials.

'Zero-energy' and *'zero-carbon'* buildings produce at least their own energy needs. However, such projects often only count 'operating energy' during occupancy. The energy expended and carbon emitted in manufacturing would be far greater than that used after construction if buildings maximized passive solar design. Zero-energy buildings usually

fail to sequester their own lifecycle carbon emissions, although this has been shown to be possible by 2015 [44]. Energy usage in manufacturing is sometimes unavoidable, so offsetting may be necessary. However, even where another building is retrofitted to offset a project's unavoidable impacts, both should be required to meet 'net-positive offsetting' standards [1] (pp. 327–328).

'Circular systems', the *'circular economy'*, or *'cradle–to–cradle'* design turn wastes into resources by closing resource loops at all stages and scales of production where feasible [52–54]. Circular systems (reuse, reduction, recycling, etc.) in the manufacture and construction of buildings are essential. However, they are seldom net-positive, due to laws of thermodynamics. Upcycling to a higher use will add economic value but barely slow nature's decline. Furthermore, when seen as a solution, they can delay investment in increasing social and ecological life-support systems. To be net-positive, circular systems must increase nature while reducing total consumption, inequitable resource distribution, and wealth disparities.

'Resilience' means the capacity of buildings or nature to bounce back or recover from crises. However, design that addresses the causes of climate change is more urgent than fortifying buildings against ever-worsening climatic forces. After all, fortified buildings cannot withstand tornados. Some adherents disagree about whether ecosystems should return to pre-disaster conditions or be altered to become more 'robust'. Both increasing nature's capacity to recover and transforming nature into new, more resilient but necessarily simplified ecosystems disrespect the intricacies of complex, interconnected ecosystems that took millennia to evolve. Buildings should be designed to adapt, rather than expecting nature to do so. A net-positive, resilient urban environment would also increase ecological space and environmental security for both nature and people.

'Regenerative design' calls for the continuous improvement of existing social and environmental conditions [55,56]. Some regenerative designers misuse the term net positive to mean restoration [57] or, sometimes, leaving nature or buildings 'better than they might otherwise have been after construction'. They seldom over-compensate for biodiversity losses occurring during resource extraction, manufacturing, transport, and construction. Other misuses of net-positive include using 'net-positive biodiversity' to mean regenerating remaining landscapes; 'net-positive waste' to mean only recycling all onsite waste; 'net-positive water' to mean only purifying what falls on the site; and 'net-positive energy' to mean only producing more energy than the building uses. Sending water and energy across site boundaries does not mean they are used for positive purposes.

'Biomimicry', or nature-inspired innovation, uses nature as both a muse and a model for more eco-effective products [58]. While nature is miraculous, however, it provides few prototypes for social equity, community building, or nature-positive design. Creating sustainable living environments involves more than using clever, efficient components. After all, new marketable, profitable technologies seldom, if ever, increase nature and environmental justice. If biomimicry were net-positive, it would direct more ingenuity toward transforming markets toward sustainability, rather than prioritizing products that are commercially successful. Projects or products should at least meet the UN Sustainable Development Goals [59]—if not net-positive standards and criteria (Section 7).

'*Biophilic urbanism'*, like most sustainable design paradigms, calls for incorporating natural elements into urban environments [60–62]. It emphasizes how psychological and physiological wellbeing is enhanced by greenery, natural forms, views, and even aesthetic references to nature in building design [63]. Some proponents believe that artificial products, such as petrochemical grass or artwork depicting images of nature, are as good for health as nature itself. Other biophilic designers advocate design that benefits nature as well [64]. However, for biophilic design to be net-positive, projects would need to increase ecosystems and improve human–nature relationships in real terms, not just assimilate it [65].

'Permaculture' advocates design *with* nature [66,67]. It integrates food production with human habitats to achieve local eco-productivity and self-sufficiency. A parallel movement, focused on farmland rather than residential areas, is 'natural sequence farming' [68]. Some

members of both positions advocate using non-indigenous species that are better suited for land regeneration. That is, managing landscapes for greater productivity is sometimes prioritized over protecting native ecosystems. Some call working with nature 'co-evolution', which wishes away the reality of power relationships. Net-positive permaculture would not only work with nature to reverse the impacts of industrial agriculture, but also work *for* nature to address global ecological issues.

'Bioregionalism' calls for the better alignment of government, industry, and commerce with a region's natural resources [69]. It recognizes how the design of economic and political structures can conflict with or support the natural environment. It holds that systems of planning, manufacturing, and construction should correspond with the unique environment, geography, and other strengths of the region. Bioregionalism also stresses educating all ages to understand their local natural environment and 'live in place' [70]. Whereas permaculture emphasizes residential-scale self-sufficiency, bioregionalism advocates regional self-sufficiency. Hence, some exponents of globalization and free trade have strongly opposed the latter. PD incorporates bioregionalism and proposes systems of regional governance and planning that could support their bioregions.

'Nature positive' is a fairly recent term in the business community that often only refers to restoring environments damaged during product manufacture or project construction [71]. This is a retronym since some mining and agriculture companies have undertaken nature restoration projects for decades. Nevertheless, many manufacturers and retailers are now aiming beyond cleaner production to redress the harm caused throughout their supply chains. Genuine nature-positive projects will require multifunctional, adaptable design to increase ecological carrying capacity and appropriate biodiversity. To be net nature positive, each development should compensate for its share of past, cumulative losses of nature—which is possible through net-positive design [72].

'Net-positive' design, again, sets baselines and benchmarks relative to whole-system ecological and social sustainability, rather than relative to current norms or pre-construction conditions [1,73]. Instead of improving upon existing conditions, PD aims to take into account global rates of consumption, waste, and biodiversity losses, and the fact that the earth's limits have already been exceeded. Unavoidable cumulative and remote impacts can be addressed by net-positive (multipurpose, adaptable, nature-positive) design. However, this will require that the decision-making structures in government, business, and planning that also shape development be modernized. Hence, PD suggests principles for upgrading systems of governance, decision making, planning, design, and assessment [1].

6. Criteria for Design Paradigms

The following questions suggest some ways in which sustainable design paradigms may not yet be ecologically or socially net-positive. This is often because they only count or offset the additional damage done by the project. It is important to re-emphasize that they use existing conditions as their baseline (zero), instead of pre-urban ecological conditions or regional social conditions. In such cases, a degraded site may be improved by a development, but it would not increase overall sustainability. 'Beyond zero' would not offset the ongoing deterioration of global nature and justice and would thus be only 'less unsustainable'. The questions below can serve as self-evaluation tools for those who want to update their aims and strategies. Critiques cause pushback but are necessary. Fortunately, green building and business organizations have shown a willingness to move toward sustainability once environmentalists' positions have been widely accepted.

6.1. Questions regarding the Ecological Dimension

Does the sustainable design paradigm:

- Utilize only recycling, downsizing, or upcycling, which, although essential to sustainable production, are reductionist approaches that do not, in themselves, increase nature, equity, environmental equity, or life-support systems?

- Potentially delay meaningful change by setting standards that reward small improvements over current practices which, although less harmful, can divert investments toward mitigation measures that perpetuate unsustainable systems?
- Call for fortifying buildings in ways that cause more embodied energy and resources than necessary, yet may not withstand the escalating, unpredictable future environmental forces that such robust structures contribute to?
- Add amenities or green the site and building (in addition to efficiency measures) but fail to create sufficient new 'ecological space' to support biodiversity habitats and nature corridors, protect endangered species, or expand suitable local ecosystems?
- Focus on innovation without considering the 'ecological waste' involved in replacing existing products or the material flows caused by more product sales [74]—even though the innovation may be more efficient in itself?
- Aim only for net-zero, which adds up to nothing and therefore does not correct past damage or increase nature and future options—let alone reduce the ecocidal forces that are still operating on a global scale?
- Call for 'co-evolving' with nature but, given the limitations of human management ability and the time required for nature to co-evolve without losing complexity, are really only expecting nature to adapt to humans?

6.2. Questions Regarding the Social Dimension

Does the sustainable design paradigm:

- Deal with reforming systems of governance, institutions, or regulations that currently impede the creation of net social gains and, thus, only influence processes that affect individual designers or client–architect–builder relationships?
- Rely only on social change, use political approaches, or aim to change markets through commercial success—approaches which often degrade into competitive attitudes and activities in lieu of constructive debate?
- Advocate residential or regional autonomy, but without providing strategies for addressing the global-scale forces that have made this impossible, or simply campaign for others to change their lifestyles, votes, or purchases?
- Fail to expand future options, or even provide direct universal access to basic needs within the built environment (which markets alone cannot ensure) or work toward creating and sustaining the physical pre-conditions for democracy?
- Fail to consider the cumulative, socio-ecological damage from DP development (pollution, poverty, wealth disparities, over-densification, sprawl, etc.), and instead only aim to increase life quality by integrating more relics of nature in cities?
- Call for inclusive and participatory design processes without really creating the structures and conditions for genuine public engagement, as in involving disadvantaged groups or indigenous peoples in processes only to obtain project 'endorsement'?

7. Positive Development Standards

PD argues that it is no longer enough to aim for 'more good and less bad'. Criteria built upon current practices and conditions, whether assessed subjectively or with more tangible (but rather arbitrary) scores, do not change the failed template. To do zero harm (nothing) is unsustainable when development could fund and construct the life-support systems needed to save the environment and improve social relationships. The only thing necessary for tyranny to triumph is for good buildings to do nothing. Moreover, myriad existing buildings continue to do harm. They must therefore be retrofitted quickly and only replaced with new buildings when necessary. Biophysical sustainability requires both new construction and retrofitting, but design must be radically different.

To create the conditions for moral progress, development must increase natural and social life-support systems, ensure that their benefits are equitably distributed, and increase future sustainable options. Creating socio-ecological gains requires the reform of the physical, institutional, and intellectual constructs that impede genuine sustainability

outcomes. PD therefore provides principles upon which to redesign decision making and design systems. It essentially inverts all aspects of sustainability models, methods, and metrics from negative to positive and uses stationary, whole-system benchmarks [1].

The underlying baselines are, again, a net increase in the 'ecological base' beyond pre-urban conditions and the 'public estate' beyond per capita regional social conditions. Ideally, development should over-compensate for its share of negative impacts caused by the same building or product type. This requires, at a minimum, design synergies across several impact categories. This can be assessed using the net-positive design app, with its unique baselines and benchmarks (Section 9). While specific criteria and benchmarks are provided in the net-positive design app itself, some basic PD standards for ecological and social sustainability are discussed below. (Note that *social* sustainability includes sustainable economics, governance, and democracy.)

7.1. Ecological Standards

Ecologically net-positive structures increase the total ecological space and carrying capacity for appropriate ecosystems and biodiversity habitats. Urban development can create ecological space for multiple ecosystem services, functions, and biodiversity habitats to help reverse extinction rates, as well as mitigate the urban climate and ensuing disasters. For instance, design can combine structures and natural systems to reduce risks to nature, people, and buildings from fire, strong winds, floods, landslides, noise, waste, pollution, and so forth [75]. Since all buildings consume some natural resources and land, net-positive impacts should outpace rates of global consumption, contamination, and biodiversity losses. Until a building's ecological footprint can easily be calculated, the *volume* of ecological space should equal or exceed the development's total *floor area*.

Do the standards:

- Increase nature and ecological space beyond pre-development conditions to outpace rates of consumption, undo past damage, increase total nature and biodiversity habitats, support endangered species, etc.?
- Ameliorate climate change through carbon sequestration materials, and sufficient permanent building-integrated landscaping, to sequester more than its own carbon emissions in addition to using renewable materials and energy?
- Provide environmental security for nature and people through proactive measures at the building, site, and regional scale to reduce the risks of floods, fires, pollution, extreme weather, drought, food shortages, etc.?
- Ensure nature-positive impacts occur throughout product supply chains and life cycles, rather than simply making nature more resilient, regenerating degraded environments, or locking in conventional practices and norms?

7.2. Social Standards

Socially net-positive development increases regional social and environmental justice. Urban development should benefit the whole community. Nonetheless, many sustainable buildings (unintentionally) discriminate against the poor, with some even hoarding resources in luxury materials, wasted spaces, or excessive electronic equipment. If any social impacts are actually unavoidable, developers should at least create 'net-positive offsets' by improving social conditions in disadvantaged areas. However, no offsets should be granted for anti-social projects (casinos, gated communities, mansions, etc.) or projects intruding upon wilderness areas or national parks, since they would nullify the public benefits. Processes always matter. PD provides a process for 'genuine' community participation [2] (pp. 251–273). It also provides analyses to help identify social deficits and opportunities (Section 8).

Do the standards:

- Create biophysical systems that provide direct, universal access to basic needs and eco-services (food, water, air, shelter, etc.) and provide social or community benefits beyond project boundaries (public space, gardens, etc.)—not just for occupants?

- Compensate for a project's share of negative social impacts from past or existing development in the district to address problems such as cultural disintegration, social inequities, segregation by class or race, or other forms of discrimination?
- Benefit the wider community by providing public facilities such as shelters, vertical urban farms, community recreational amenities, evacuation routes, and provision for emergencies, as appropriate to the particular location and its deficits?
- Increase physical, psychological, and physiological (biophilic) health by creating accessible spaces for nature and eco-services, and providing shelter for the surrounding community in times of extreme weather or other hazardous conditions?

Economy, democracy, and governance (discussed below) can be regarded as subsets of social sustainability for the purposes of urban design. This is because they are means to an end, whereas social and ecological sustainability are ends in themselves.

7.2.1. Economic Standards

Economically net-positive development processes serve ecological and social sustainability and increase the biophysical bases of a sustainable economy. Development should sustain the economy as a whole, not just owner pocketbooks, and increase life-support systems, not just delay their destruction. Profits do not increase socio-ecological sustainability by themselves, especially when they transfer wealth vertically. Developers have many tools to analyze financial risks or the profitability of building projects. Hence, uneconomical buildings are seldom built. Even though sustainable design can save money, most economic tools still ignore social and ecological factors, let alone aim to increase justice or nature. Financial tools should incorporate positive development principles. While economic instruments can create incentives for doing less harm, they are only beginning to encourage nature regeneration and not an increase in real terms.

Do the standards:

- Emphasize the public benefits of a project or product per unit of resource through multifunctional design, as opposed to single-function approaches that save upfront costs by reducing inputs or outputs but provide few public gains?
- Distribute public benefits equitably and create incentives for development designs that benefit nature and society as a whole, rather than manufacturing demand for 'consumer preferences' that fit the preferred products supplied by businesses?
- Use systems of environmental accounting that conceal pyramidal transfers of wealth, do not question luxury materials and equipment (which are inherently wasteful), or create environments or products that are unobtainable by the disadvantaged?
- Retain economic frameworks that treat negative impacts as 'externalities' or merely focus on efficiency and recycling which, although essential components of design, cannot achieve net socio-ecological gains?

One place where financial profitability and sustainability clearly intersect is eco-positive retrofitting, which increases nature while improving urban life quality. The continual upgrade of cities to support nature-positive economic growth is essential for the sustainability of economies. Eco-positive retrofitting can, for instance, produce continuous job growth, avoid community disruption, protect heritage while increasing diversity, increase density where appropriate, and increase food and water security. Furthermore, it can pay for itself through energy, resource, water, and health savings. Some companies are organized to pay themselves from the energy savings [2] (pp. 23–43). Finally, eco-positive retrofitting can reduce the public costs of environmental damage while supporting the region's biodiversity.

7.2.2. Democratic Standards

Democratically net-positive development should provide the biophysical bases of democracy: direct, equitable, and universal access to basic needs. Political stability through fairness, democracy, and transparency are pre-conditions of a sustainable economy. Democracies maintain stability by channeling conflict into peaceful, open, and participatory public

processes. However, voting means little without individual resource security, access, freedom from coercion, or fear campaigns about the economy. If these resources and emotions can be manipulated, there can be no real democracy. Markets provide superficial lifestyle choices but break down in crises. People must then rely on charity, governments, or military aid. Eventually, unmet needs tend to lead to violence.

Do the standards:

- Create direct universal access to natural systems and eco-services that provide means of survival, enable self-reliance, and prevent military, government, or market monopolies on supplies to deprive citizens of genuine political or basic life choices?
- Ensure public education and transparency about existing decision frameworks so that there is full public awareness of tacit anti-ecological biases in many decisions concerning environmental issues—since these decisions affect everyone?
- Expand community involvement in major land-use and building decisions through public adversarial debates that can expose the long-term implications for public interests, including their redistributive outcomes and environmental impacts?
- Require that referendums and the like concerning development issues (sub-divisions, rezoning, etc.), or major new developments, provide public fact sheets on pro and con positions that are agreed to by opponents and refer to further sources of information?

7.2.3. Governance Standards

Governmental decision making regarding development should create constitutions and decision-making processes for eco-governance that can create net-positive outcomes. Governance is sometimes regarded as the fourth pillar of sustainability. However, government systems were not designed to deal with ecological issues [2,76]. Today, checks and balances are needed where irreversible environmental decisions may occur, not only between judicial, executive, and legislative decision-making functions, but between governments and corporations. Both private and public sector developers have shown little regard for nature. Some corporations have more money and influence than some national governments, and both have destroyed whole bioregions [77]. In recent years, some countries modified their constitutions to include nature. However, legal recourse is often too late in the case of ecosystems and threatened species.

Do the standards:

- Make sustainability and maintenance of future options a fundamental human right, since it affects every individual's and family's future, and make corporate and government sectors accountable for decisions irreversibly damaging the natural environment?
- Convert development approval systems from rule-based processes and reductionist assessment tools that often concern only energy and resources (economics), to proactive frameworks that can address the ecological and ethical dimensions of sustainability?
- Ensure that sustainability reporting, public information, and community participation processes are sufficient to prevent environmental decisions being made 'informally' through subtle (yet not illegal) forms of corporate and government collusion?
- Consider revising constitutions to require more sustainable governance, planning, project approval, and standards, along with diverse citizen jury processes for resolving controversial issues or proposals adversely affecting the natural environment?

8. Net-Positive Planning Analyses

Many practitioners have said that they are not interested in critical analyses or system design thinking. Some would prefer simple templates, such as the 'hard' tick box approaches used in most green building rating tools or the 'soft', elastic principles of sustainable design paradigms. However, if sustainability did not require hard work in analyzing soft systems, things would already be sustainable. Conventional planning analyses and strategies do not take into account the reality that planetary *limits* have been exceeded (population growth and consumption, pollution and waste, atmospheric and oceanic carbon levels, forest and wetland destruction, extinction rates, etc.). Net-positive

planning therefore provides open-system planning analyses that consider the bioregion or planet. They are summarized below and detailed elsewhere [1] (pp. 155–200). They will be included in the 'STARfish' net-positive design app, discussed later, to facilitate better visualization, prediction, and measurement.

The following planning analyses are missing from most if not all city planning and urban design frameworks and processes. The aim of these analyses is to expose locality-specific sustainability deficits that planning can resolve or mitigate. They cover planning issues at different scales of urban design, from the building or project scale to the level of urban governance. The questions cannot be prioritized, since urban planning and design are always unique to the site, social context, bioregion, and so on. They may appear burdensome, but urban planners are accustomed to examining land use issues through many conceptual overlays. These analyses can be applied on a conceptual or technical level. For instance, depending on project size, these analyses can be conducted as simple mind-mapping exercises in community design workshops or in expert-led Big Data analyses.

8.1. Design Issues at the Building or Project Scale

Avoiding upstream and downstream waste:

- Designed Waste (DW) Analysis: Are the likely waste and impacts caused during product usage that result from design anticipated or assessed?
- Ecological Waste (EW) Analysis: Are the likely restoration time and space that specific ecosystems need to recover quantified or factored in?

Increasing positive public purposes:

- Development Functions (DF) Analysis: Is the 'social waste' inherent in developments or products that have negative public purposes weighed into approvals?
- Hierarchy of Innovation (HI) Analysis: Are the public (social and environmental) values of innovations or designs assessed against ethics-based, versus economic, criteria?

Maximizing natural systems and ecological spaces:

- Passive Maximization (PM) Analysis: Are the benefits of supplementary passive and natural systems in reducing renewable (mechanical) energy systems examined first?
- Multifunctional Space (MS) Analysis: Is the potential for mixed uses in cities to increase social and ecological benefits and future adaptability assessed?

8.2. Urban Planning Issues at the Mmunicipal or Regional Scale

Prioritizing preventative actions:

- Resource Security (RS) Analysis: Are the best locations for adaptable emergency facilities, environmental amenities, and services identified to ensure universal security?
- Risk Avoidance (RA) Analysis: Is the amount to be invested in preventative or corrective safety measures based on the worst-case scenario, rather than a gamble?

Mapping opportunities for public benefits:

- Negative Space (NS) Analysis: Are the long-term impacts of the transfer of public space to private control (or vice versa) analyzed and considered in urban policies?
- Highest Ecological Use (HU) Analysis: Are the ecological deficiencies of the wider area that the site development could correct considered and addressed?

Site planning for ecological gains:

- Ecological Transformation (ET) Analysis: Is the ecological evolution of regions from pre-urban to present times examined to identify appropriate species and ecosystems?
- Ecological Space (ES) Analysis: Is the amount of space needed to provide more ecological carrying capacity than in pre-settlement times to offset consumption considered?

8.3. Decision Making at the Development Assessment Scale

Setting whole-system baselines (time and space):

- Reverse Sunk Cost (SC) Analysis: Is the full 'share' of costs, benefits, and risks of fossilized production systems that are reinforced by developments counted in decisions?
- Source of Energy (SE) Analysis: Are the negative impacts caused by fossil fuel-based or nuclear 'sources' and the type of energy used factored into decisions?

Ensuring whole-system accounting:

- Costs of Change (CC) Analysis: Are the costs of retrofitting new (even 'green') development projects into more sustainable structures as standards increase counted?
- Benefits of Action (BA) Analysis: Are the 'costs of inaction' considered, including lost opportunities for positive actions after construction or the benefits of urban nature?

8.4. Governance Issues at the Regional or National Scale

Charting impacts of governance systems:

- Institutional Design (ID) Analysis: Do the performance indicators only reflect trends or exclude comparisons relative to the remaining 'total' resource stocks and nature?
- Cumulative Decision (CD) Analysis: Is the original charter and legislative intent of agencies compared to agency policies, actions, or on-ground outcomes?

Assessing socio-economic independence:

- Democratic Impact (DI) Analysis: Are the ways that built environments affect distributive justice, social choice, and the ability to participate in democracy scrutinized?
- Economic impact (EI) Analysis: Are the long-term costs of ecological losses and resource depletion upon the economy itself (not just financial costs) reported?

Ensuring equitable outcomes:

- Resource transfer (RT) Analysis: Is the transfer of wealth and resources embodied in physical structures and property values adequately examined?
- Green Optimum (GO) Analysis: Does the basic decision rule, the Pareto Optimum, rationalize developments that provide little or no public benefits?

9. The Net-Positive Design App

Green building rating tools are not design tools and do not assess impacts. They can only be used when a design is fairly complete. Although used primarily for certification, most rating tools can stifle creativity because their performance thresholds are based on typical or best practice buildings—which are not sustainable. They use specific dimensions or quantities and thresholds that encourage incremental improvements relative to current norms. Others are too subject and merely emulate traditional design review processes. In contrast, the opensource net-positive design app, STARfish, is a design tool, not a rating tool, but it can assess, compare, or certify impacts when the design is complete. However, unlike rating tools, EIAs, and LCAs, STARfish can be used long before it is too late for major changes.

Rating tools lack transparency, whereas STARfish is completely open. Users must record their reasons for where they place the various impact factors on the sliding scales between stated negative, restorative, and net-positive benchmarks. The benchmarks in the STARfish tool are based on whole-system outcomes, not rules pertaining to conventional building components. That means impacts are estimated against fixed benchmarks that are based on sustainable, not current, conditions. The users must also provide reasons for weightings as well. The total transparency enables others to point out design or reporting errors or make positive suggestions.

The appropriate data and their availability are problems in all building assessment tools, including STARfish. This is because data and statistics were traditionally collected to serve the needs of business and industry, not sustainability. This explains why most of the current indicators for the SDGs (the United Nations Sustainable Development Goals) have

little relevance to sustainability goals—let alone nature [78]. Although EIA and LCA tools stimulated the collection of data sources from 1970, only negative (or less negative) impacts were quantified, and they used systems boundaries, which concealed cumulative and remote impacts [1,2]. STARfish will hopefully drive the collection of data that is relevant to genuine sustainability.

Data is not essential in the design and reasoning stage, as the app provides benchmarks based on the positive logic of PD. It offers a means of assessing social and ecological impacts in real time during the design process and in supply chains. Initially, impacts are estimates, sufficient for preliminary design, based on the commonsense benchmarks. As the design solidifies, scientific data can be added to the spreadsheet as in other digital tools. Negative, regenerative, and net-positive impacts are entered separately and permanently so, unlike rating tools, design failures are not hidden behind remedial or compensation measures.

The app reverses all aspects of current design and assessment tools [79]. It can be downloaded from http://netpositivedesign.org (for free). The tool itself has embedded instructions. The website and video also have instructions, and one can ask questions on the website or consult the book chapters that describe the app [1] (pp. 335–369). Section 10 compares the STARfish app to typical rating tools. Figure 1 illustrates the net-positive design app and shows how 'satellite' diagrams can be added *infinitely* by users to expand the level of analysis. Rules for benchmarks are provided so any added benchmarks are transparent. A couple of projects currently testing STARfish have committed to providing papers for this special issue.

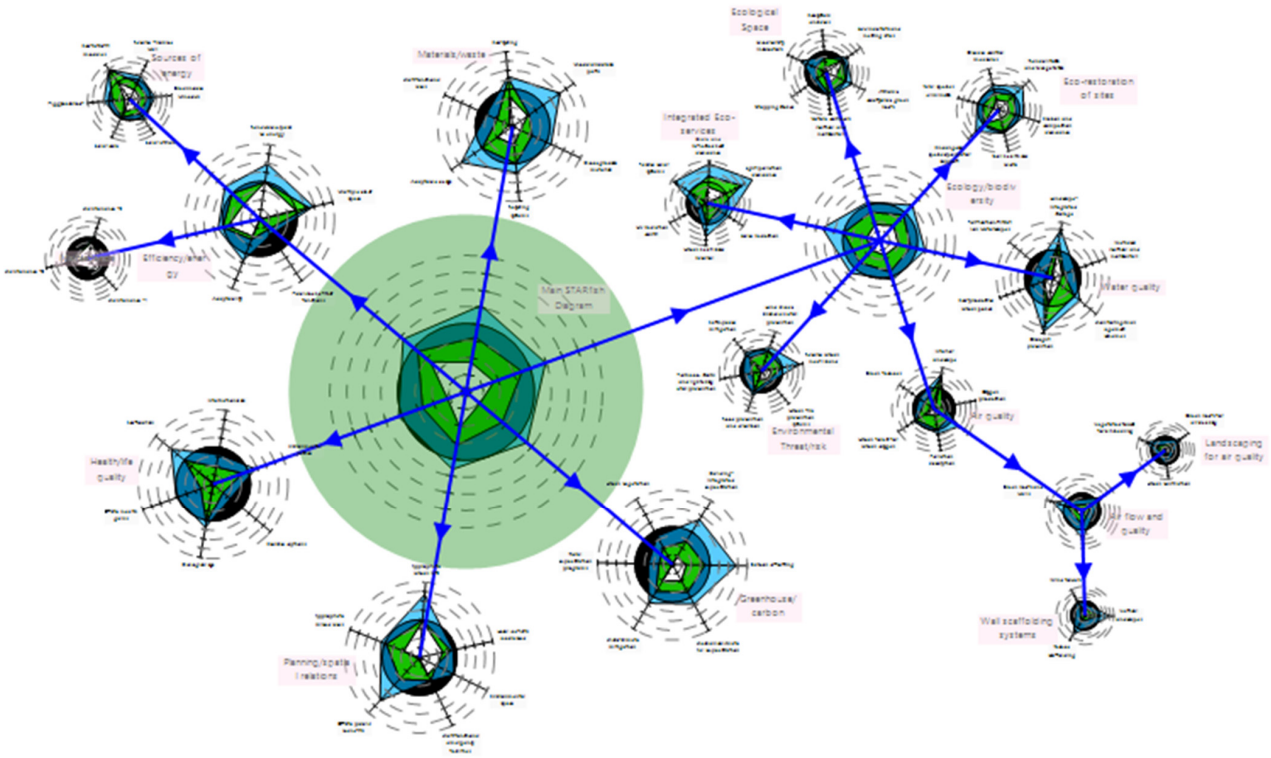

Figure 1. Illustration of the STARfish net-positive design app.

10. Criteria for Evaluating Design and Assessment Tools

Assessment tools tend to be judged by their uptake or market penetration, instead of whether they make the built environment, as a whole, more sustainable or not. Although green building rating tools are not yet used by most builders and developers, they are influencing the design of 'exemplar' projects that aim for sustainable design awards. Some tools are being adopted by municipalities, so their reductionist framework is increasingly being locked in. This has adverse implications for sustainability. The following are questions

for interrogating green building assessment, certification, or rating tools. STARfish is also compared against these criteria.

10.1. Questions Regarding Reduction and Efficiency versus Design

Does the assessment or rating tool:

- Serve as a design tool or only as a decision tool that aids in choosing among building products or in scoring projects after too much time and effort was invested to enable changing the design? STARfish emphasizes iterative design over retrospective accounting activity. It estimates impacts in real time, with data added as the design progresses.
- Encourage using pre-conceived single-function design elements that are considered to be good practice but leave out unique site-specific opportunities? STARfish can credit all socio-ecological losses and gains to stimulate synergistic design that multiplies the private and public benefits of resources, while prioritizing natural and passive systems.
- Encourage cross-disciplinary consultation or help to integrate designers with social and biological scientists in finding ways to meet sustainable priorities? STARfish supports collaboration among the social and physical sciences, community, building users, and designers in the early stages, especially through the new forensic planning analyses.
- Allow meeting performance standards by simply adding on more efficient commercial equipment instead of requiring passive and solar systems to reduce the overall embodied and operating impacts of buildings? STARfish begins by determining the highest ecological needs in site planning before basic forms, products. or equipment are selected.
- Use a prescriptive approach that can be operated by specialists without much design skills and, therefore, fail to credit innovative design and reward innovations regardless of actual impacts? STARfish credits the outcomes of innovations, and designers can add new positive impacts to the app if they follow the benchmarking principles.
- Appear scientific because it is numerical, but only measure what is easy to assign numbers to or avoid goals that buildings have not already achieved? STARfish uses criteria that could, in combination, achieve net-positive public gains, based on actual conditions and outcomes—instead of standards based on past industry conventions or codes.

10.2. Questions Regarding Flexibility and Adaptability

Does the assessment or rating tool:

- Use rigid rules based on typical sites, practices, or buildings and, therefore, lack the flexibility to cover differing site conditions or contexts, so new tools are created for different building types? STARfish allows major new impact factors to be added where appropriate to the project (streetscapes, transport, building management, etc.).
- Fail to encourage design for mixed or multiple building uses to avoid buildings being demolished early due to their inability to adapt to changing needs or new economic or technological forces? STARfish rewards novel means of adaptability to accommodate changing needs, reduce embodied resources, and increase building lifespans.
- Prescribe solutions and allow variances from standards by giving users a choice of ways to score enough points to cross thresholds, even if called 'performance based'? STARfish encourages design for disassembly by crediting demountable, re-useable components or modular structural elements that allow buildings to expand or be moved.
- Encourage design for future retrofitting so that buildings can be upgraded to higher standards easily, or fail to prioritize retrofitting even though this generally does less harm than new buildings? STARfish makes it harder to obtain higher scores

by constructing new buildings, and it can identify deficits in existing buildings for eco-positive retrofitting.

- Neglect to provide adequate space for multifunctional benefits, unanticipated future demands, or climate change adaptation, since points are limited to traditionally or easily measured features? STARfish can theoretically credit all impacts to encourage symbiotic design, including contributions of interior–exterior spaces to public health.

10.3. Questions Regarding Omissions and Transaction Costs

Does the assessment or rating tool:

- Require a consideration of alternative locations, site plans, building forms, or sites to ensure that the basic design has minimal negative impacts overall? STARfish allows for quick quantitative comparisons of basic schematics, using many variables, based initially on experience and knowledge but which can be gradually refined as the design solidifies.
- Entail paperwork or transaction costs that are expensive to develop and use, yet not very relevant to increasing design capacity or assessing their outcomes? Design education is a precondition of sustainable cities. STARfish therefore creates a 'game' in which designers learn by competing with themselves for the most sustainable outcome.
- Apply to the majority of projects, or fail to modify harmful building designs that do not seek certification, which leaves a big gap since codes only set minimal standards and rating tools are voluntary? STARfish can apply to any type or scale of project and does not rely on designers first changing developers' values or consumers' preferences.
- Encourage the use of LCA and BIM tools as separate processes, although these tools center on efficiency (reduction of negative impacts) and marginalize design? STARfish, being a digital tool, could be linked to other LCA tools or BIM tools to make users of those tools consider core sustainability issues as well as impacts and costs.
- Distract from regional and global ethical issues such as animal extinctions, poverty, and inequity or the extraction of labor from poor communities and raw materials from nature? STARfish enables wider socio-ecological issues, such as impacts on environmental and social justice, to be analyzed and compared at local, regional, or global scales.

10.4. Questions Regarding Social Issues

Does the assessment or rating tool:

- Incentivize or assess a sense of place, community, or belonging, as well as social needs, cultural issues, or local priorities, when adopted and modified for other countries? STARfish criteria are relative to local conditions, unique contextual issues, and special social circumstances, although PD also provides generic design guidelines.
- Exclude community input in tool development, or, if the criteria are developed by experts and ratified by industry, are the rules and ratings subjected to public hearings? STARfish explains the design rationale, so lay citizens can learn, see the impacts of controversial projects, make constructive suggestions, or even challenge the benchmarks.
- Count only the benefits to stakeholders and treat social benefits to owners and occupants as 'public' gains, even if the project concentrates wealth or reduces neighborhood amenities? STARfish uses social benchmarks based on contributions to the public good or corrections to social deficits in the surrounding region, not just stakeholder interests.
- Contribute to genuine social transformation or, by purporting to implement sustainability, actually slow down advances in building codes that affect social sustainability? STARfish allows changes to be made quickly in response to feedback as it is a design tool—not an awards scheme controlled by the industry that it is meant to reform.

- Address social fairness issues beyond the owner's existing legal liabilities, property lines, or supply chains and even reward 'not breaking laws' (slavery, codes, etc.)? STARfish will incorporate the planning analyses (Section 8) that consider ways to proactively increase community-wide gains, such as equity and environmental security.

10.5. Questions Regarding Ecological Issues

Does the assessment or rating tool:

- Count many things as 'ecological' benefits that only concern human health or comfort, such as indoor air quality (which has misled some to think that ecology or biodiversity issues are covered)? STARfish considers 'ecological uncertainty' to ensure that the basis of society—nature—is protected, and that ecological space is increased in absolute terms.
- Consider the highest ecological use of land since, within the limits of regulations, developers determine land uses based on economic factors, which often have huge public opportunity costs? STARfish determines the highest socio-ecological use of land first, and then attracts economic uses that are compatible with local needs and ecosystems.
- Aim to offset the full ecological footprint and increase ecological carrying capacity, or do offsets only restore the equivalent land area covered by the building or the spaces left over after construction? STARfish sets benchmarks based on biophysical outcomes, so land that is removed from nature is counted as a negative ecological impact.
- Encourage improvements to offsite land, water, biodiversity, and air quality, or are offsets only used to permit negative impacts or meet codes and not to increase net sustainability? STARfish credits actions that benefit the region's biodiversity but counts negative offsite impacts by using whole-system benchmarks.
- Consider the risks of exacerbating climate-related threats (potential floods, extreme winds, droughts, fires, etc.) and assess risks imposed indirectly upon nearby properties? STARfish gives credit for protecting the site and development itself from climate-related risks and reducing environmental crises in the surrounding area by design.

10.6. Questions Regarding Visualization, Communication, and Transparency

Does the assessment or rating tool:

- Provide transparency about how features are weighted or assigned a certain number of points or instead label 'best practice' (that which is currently achievable) as sustainable? STARfish allows tool users to modify secondary benchmarks and weightings to suit unique circumstances, since reasons for scores are recorded and can be challenged.
- Conceal negative impacts by only recording predicted impacts after promised mitigation measures are deducted, so there is little incentive for designers to rethink conventional building templates? STARfish makes both negative impacts and remedial measures visible, rather than just showing the percentage reduction.
- Score projects relative to typical impacts; that is, 'distance from unsustainability', not distance from sustainability? (A project can recycle all of its waste yet be a waste of resources.) STARfish calls for waste elimination by design, not simply better waste management, and counts lost resources (not just the portion of waste recycled, etc.).
- Use thresholds, which conceal impacts and represent percentage reductions as optimal, so there is no incentive to make design improvements or add more public benefits? STARfish rewards designs that add public benefits beyond the best practice and penalizes design for negative impacts—even if considered normal or code-compliant.
- Purport to disseminate innovations using case studies (usually promotional documents that advertise how 'less bad' a building is), rather than explaining how the design features work? STARfish automatically creates a Design Report, accessible to the

public, so other design teams can build upon the ideas—and acknowledge their originators.

10.7. Questions Regarding Complexity and Whole-System Impacts

Does the assessment or rating tool:

- Treat buildings as the sum of their parts, by assigning scores to design principles (even if lists are arranged in circles), as this clashes with synergistic design thinking? STARfish treats buildings as complex systems and helps to visualize the cumulative supply chain impacts, project lifecycles, and spill-over effects in different categories simultaneously.
- Prescribe solutions or techniques that are compatible with conventional building practices, rather than supporting design for creating new symbiotic relationships? STARfish does not dictate design elements and instead aims to expose opportunities to increase synergies among the different elements by design.
- Count design elements in only one category, when design should aim to increase human and environmental benefits in all aspects of a development and its surroundings? STARfish gives credit for actions that have multiple benefits in different categories but also requires additional public benefits to offset any 'unavoidable' adverse impacts.
- Exclude considerations of the embodied energy, water, and carbon emissions during resource extraction and manufacturing, although these impacts can exceed the operating impacts of buildings? STARfish makes cumulative impacts visible, and the fractal diagram expands to include new impacts that are not anticipated until later in the process.
- Refuse to certify a project that is on a sensitive site, yet does not prevent more harmful buildings from being built there that do not bother to obtain certification? STARfish includes all impacts, including site selection—based on positive and negative outcomes. There is no advantage to avoiding the new tool.
- Consider the damage caused by buildings relative to whole-system conditions, such as the scarcity of land or depletion of resource stocks (groundwater, fertile soil, native forests, etc.)? STARfish assesses impacts against fixed biophysical conditions, so it automatically responds and adjusts to total resource stocks and material flows.

11. Summary and Conclusions

In summary, contemporary sustainable buildings, at most, offset the added damage that they cause. They almost invariably leave the environment worse off than no construction at all and, despite any claims of being nature-positive, do net harm to nature. In a positive whole-system framework, less bad is negative, especially since planetary boundaries have already been exceeded. Regenerating land left over after manufacturing or construction is not nature-positive because it does not increase nature in real terms, let alone increase environmental security and justice. To be sustainable, buildings must increase *net* nature. Nature-positive outcomes must far outpace nature destruction even, where possible, that which is not caused by humans.

If people only look through microscopes or telescopes, they can see near and far, but not 'see' what is around them: built environment design. Many people do not yet see sustainability as a design problem. Therefore, it is incumbent upon informed and ethical designers to lead. Although demanding a change in thinking, design can by-pass politics and policy and begin to be implemented immediately. Countless design concepts already exist that, in combination, could retrofit cities for net-positive social and ecological gains. These could pay for themselves in narrow financial terms as well as in whole-system sustainability gains. Hence, there is no excuse for developers, planners, architects, or other designers to wait for directives from lay citizens or politicians.

PD theory supports this duty by providing comprehensive alternatives to DP or 'weak sustainability' for engagement, critique, debate, and collaboration. These include

different frameworks and standards, planning analyses, decision-making structures, design paradigms, and assessment tools, such as:

- An alternative positive sustainability theory that exposes and reverses the negative influence of the dominant paradigm in sustainable development.
- An explanation as to how open-systems design thinking can counteract the imbalances caused by reductionist, closed-system decision frameworks.
- An alternative design paradigm that addresses the limitations of each of the current sustainable design paradigms.
- Alternatives to outdated institutional frameworks of governance and planning that were enacted before there was any awareness of sustainability issues.
- New planning analyses to deal with fundamental sustainability issues and address serious omissions in city planning and urban design.
- Genuine sustainability standards and benchmarks that go beyond zero, as opposed to conventional green building criteria that aim or claim to do 'no harm'.
- An opensource, transparent, net-positive design app that can be used in real time to facilitate a collaborative, transdisciplinary design process.
- A means of assessing and improving net impacts, unlike rating tools that build upon, and reinforce, unsustainable industry norms.

To conclude, built environment design could be a silver sustainability bullet. Biophysical structures can address or solve most sustainability issues and make positive social change possible. However, built environments must do far more than current sustainable design paradigms, analyses, standards, and tools suggest. To combat nature depletion, urban overheating, sea level rise, congestion and sprawl, and so on, urban development must proactively build natural and social life-support systems. Structures can create ecological space for ecosystem nurseries and biodiversity incubators so that cities function like reefs that support their ocean bioregions and protect their inhabitants. This necessitates the multiplication of benefits for the general public and nature through net-positive design.

Questions, critiques and discussion are invited via nature.positive.building@gmail.com.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The author declares no conflict of interest.

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