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Review

Quantifying Nature Positive

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Abstract: To become mainstream, nature-positive development needs positive messaging, measures and metrics to guide, plan and assess urban outcomes. With the accelerating climate crisis and negative messages getting the upper-hand, it's important to avoid paralysis by bad news. Whilst striving for a nature-positive world, more effort should be on moving beyond zero to qualify and quantify benefits, gains, and regenerative outcomes instead of around damage and loss sticking points. Life Cycle Benefit Assessment (LCBA) methods measure gains in accelerating restoration and climate security that enable a good news focus. Its reach beyond the negative quantifies and shows positive gains beyond zero loss outcomes. The paper aims to clarify concepts, challenges and quantitative methods then review real-world third-party-certified case studies. Climate security, human wellness and resource viability gains inside safe operating space within planetary boundaries are quantified as positive benefits. Contrary to conventional Life Cycle Impact Assessment LCBA assigns damage and loss as negative debts and benefit as positive gains. It concludes that LCBA offers urban design a new tool, with research needed on economic and other outcomes.

Keywords: nature-positive, quantified benefit assessment, security, wellness, viability, gain

1. Introduction

The media has recently begun to convey more "positive chatter" including e.g positive energy in an Australian Federal Government advertising campaign. The authors find most of such positive chatter fixated on reducing negatives to zero and rebounding to less depleted states. This chatter ignores expanding the development space to restore natural climate and habitat security to states they were in before industrial development. Despite some forest loss around European cities, most global anthropogenic forcing of climate change, habitat degradation and biodiversity loss began before C1750.

Despite masquerading under positive banners some initiatives, remain fixated on negative outcomes. Furthermore, Life Cycle Assessment (LCA) – by attributing positive signs to all damage and loss and negative signs to all benefits and gains from e.g., sequestration, offsets and credits – obfuscates meaning for its practitioners and clients as well as the public.

Only Positive Development (PD) is genuinely counting positive space for nature to its true extent. PD is defined as physical development that achieves net-positive impacts during its life cycle over predevelopment conditions by increasing economic, social and ecological capital [1]. This paper reviews the authors' life cycle benefit assessment (LCBA) method to quantify many, but not yet all, outcomes of PD with scientific rigor to support, test and verify the design process.

When UN and leading sustainability practitioners limit their work to the range negative loss to zero and feeble rebounds and call it positive sustainability, associated communications and reporting fails basic math, science, accounting and logic. This paper discusses barriers and solutions to such absurdities that must be addressed in urban design and development.

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2. The negativity problem threatening humans' home planet

Why unsustainability practitioners working, messaging and reporting in the negative range - loss to partial repair, ignore the positive range - net gain to restored pre-urban natural productivity is explored. Such practices applied to attain sustainability fail to be unbiased and defy logic. Absurdities and barriers that must be addressed and many solutions for adoption are discussed considering competitive advantages such as PD offers urban design.

Understanding that huge gains are essential to compensate for three centuries loss of naturally regulating feedback loops is the first step to resolving rampant climate and extinction problems. Transforming the reach of tools and numeracy involved is the next step. Positive messaging to generate hope and public engagement is step three. Balanced assessment supporting PD in every economic sector and across urban and regional development has the capacity to deliver successful transformations in the few decades left.

3. Objectives

The paper aims to show why practitioners have become locked into the futility of reducing loss from industrialisation damages whilst ignoring gains from restored habitat richness climate security and biodiversity. By contrasting negatively framed barriers in communications, assessment and quantification versus positively framed solutions for urban design the authors aim to clarify new sightlines and pathways to invigorate strategic planning. LCBA quantification methods are reviewed to facilitate understanding applicable to broader fields of work and certified case studies to offer proof of concept.

4. Background

The conclusions drawn by the latest 2021 report of the Intergovernmental Panel on Climate Change (IPCC) have erased previous doubt that most climate forcing is from human technology [2]. At the 2021 UN Climate Change Conference of the Parties COP26 summit in Glasgow global governments, leaders, business and non-government organisations (NGOs) agreed on the urgency for human action to mitigate global climate change's ensuing human health damages and biodiversity loss [3].

Previously at the 2020 UN General Assembly and Biodiversity Summit, global NGOs and business organisations urged leadership to set a clear and global goal to create an "equitable, carbon-neutral, nature-positive world" [4]. This Global Goal for Nature seeks to stop damages from climate change and biodiversity loss.

Figure 1 depicts 3 measurable biodiversity objectives to achieve a nature-positive world: net zero loss from 2020, net gain beyond zero by 2030 and full gain recovery by 2050 [5]. Th**is** chart shows nature-positive as rebound after loss stops at zero. **T**he 20**5**0 rebound called full gain is not to natural pre-industrial levels.

While such goals are not necessarily net-positive, other agreed positive world measures include reafforesting 350 MHa and revegetating 20% native flora as well as protecting >30% land, ocean and freshwater communities from further degradation and losses [3]. These are in addition to the 17 UN Sustainable Development Goals (UNSDGs) including enhanced nutrition, employment, wellness, education and economies.

Climate security demands that abatement and sequestration must exceed global warming emissions [2]. In other words, it must to add more gain than loss**,** by reducing emissions contributing to the greenhouse effect forcing extreme weather events [4].

Also, youth and people worldwide involved in the Extinction Rebellion movement, are now regularly calling for net-positive climate and biodiversity security outcomes. A global survey in 2021 found that while 60% of youth were worried or very worried about the future, their addiction to new gadget and electronic equipment use had skyrocketed despite "climate anxiety" [6].

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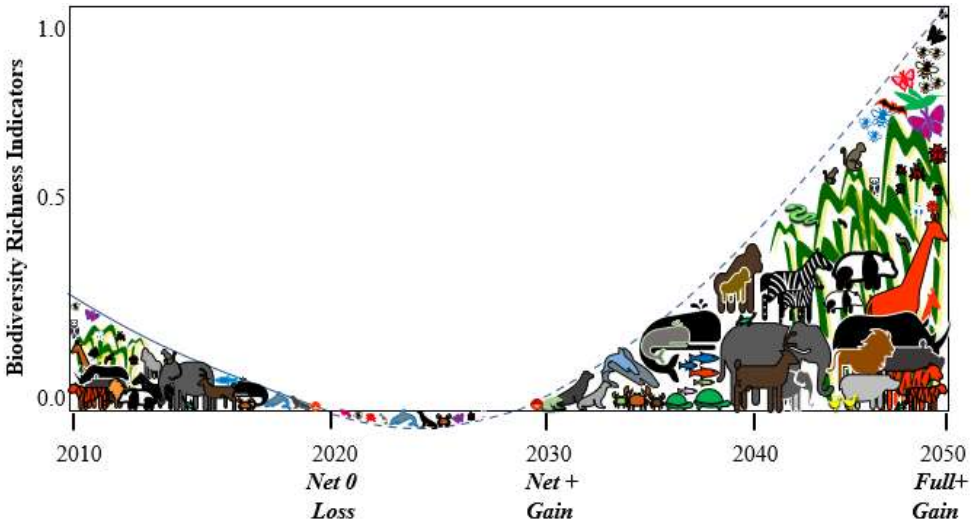

Figure 1. From 2010 to full nature-positive gain by 2050

4.1. Positive development

In 2007 Birkeland wrote that "If we are serious about 'sustainability', then, it is necessary that development work increase the Earth's ecological health, resilience and carrying capacity, and protects biodiversity in order to meet even the legitimate demands of existing populations" [7]. Urban green space for gardens on ground-level, roof-tops and vertical walls can improve biomass production and ecological carrying capacity [8]. Such positive social and ecological development strategies offer human and planetary wellness.

Modifying buildings, infrastructure, landscapes and products can improve capacity for natural, social and economic services [7,8]. Urban positive development concepts to enhance food growth, air quality, insulation, local amenity, profit and ecology from Birkeland 2007 include:

- food production frames, wall with shutters, shelves, aquaponics, hutch, bird cages,
- converting organic waste into fertilisers using bacteria,
- creating green space and landscapes to support wildlife [8], and
- use of an onsite green roof enhances biodiversity, cleans air and draws down CO_2.

4.2. Urban Development use of LCA

In 2015 a PD-framed building design employed a carbon amortization performance method on top of Life Impact Cycle Impact Assessment (LCIA) [9]. Cole cited it as a world first in quantifying carbon drawdown over the building life cradle-to-grave [10].

LCA is typically used to develop Environmental Product Declarations (EPDs) that enable building owners, designers and specifiers to evaluate greener choices [11]. Conventional LCAs and EPDs are limited to declaring damaging to zero loss outcomes. Damages include Depletion of Human and Ecosystem Health and Resources.

Life Cycle Benefit Assessment (LCBA) was developed to quantify positive outcomes and net-gain. LCBA assesses positive as well as net-positive naturally restorative benchmarks delivering ecosystem recovery, restoration, renewal and resilience outcomes. Vital C1750 ecological examples include recovered marine habitats, regenerated pollinator species richness, renewed soil carbon density and drought resilient land.

All such restoration assessments include global supply chains and affected ecosystems beyond product, building or infrastructure outcomes. LCBA has been used in third-party-certified EPDs to clarify and enable ecologically beneficial choice for stakeholders since 2016 [11]. It also defines net-positive benchmarks for climate security, human wellness, ecosystem repletion and resource viability benefits.

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5. Communication

At this critical stage in human development, communicating needs and outcomes is vital. Balanced framing of literacy and numeracy to facilitate sustainable development is lacking. Such framing is essential to overcome barriers to solutions and prevent technical absurdities railroading efforts of urban designers and developers seeking truly positive outcome. This next section discusses negative and positive framing of messaging.

5.1 Negative framing

Today most climate change and sustainability news stories are negatively framed around humanity's losses from damages caused by climate change [12, 13, 14]. And LCA feeds this negative framing. Conventional LCA was originally developed to quantify production systems causing worldwide bad-news of environment and human health damages. Figure 2 depicts the leading ReCiPe LCIA damage categories, for example [15].

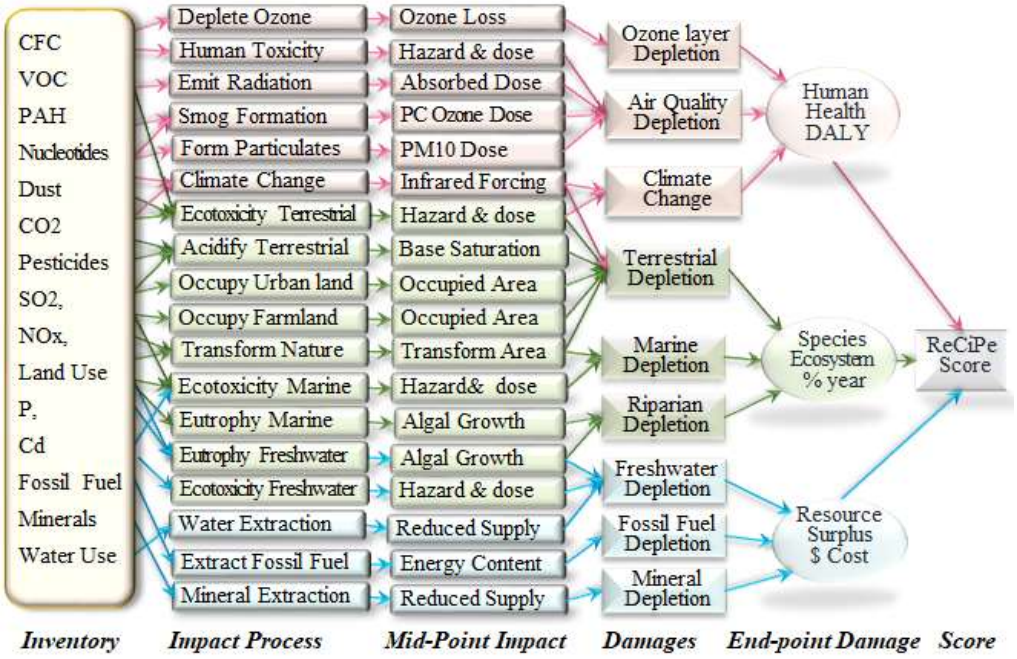

Figure 2. Schematic of ReCiPe 2009 LCIA Method.

In other words, LCA was loss-framing to show negative outcomes. ReCiPe end point damages include all damages to human health, ecosystems and resource availability. Mid-point damages include:

- Ozone Layer Loss, Toxic Air Quality and Climate Change,
- Depletion of Terrestrial, Marine and Freshwater biodiversity, and
- Limited availability of Water, Fossil Fuels and Minerals.

C2C certifies planet-positive products considering safety, wellbeing, renewability, climate, water, soil, equity, circularity and innovation stewardship [22].

The Blue Economy facilitates low carbon, resource-efficient economies that largely allow nature to do the work using renewable practices - just as ecosystems do. Positive social and environmental outcomes include healthier space for local flora, fauna and human communities and natural habitats, oxygenated airsheds and carbon storage for climate abatement, cleaner air and water, reduced rain runoff plus job creation [23].

Evidently, with hundreds of case studies online, these good news stories got people, manufacturers and policymakers activated to invest in sustainability.

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5.2 Gain-framing versus loss-framing

Both gain-framing and loss-framing methods can be useful when trying to galvanise popular actions. Loss-framing conveys adverse losses of inaction, while gain-framing conveys beneficial gains of action [25]. Both methods can be effective but which has most power is often situation-dependent. Much research has been done in psychology on gain-framing vs loss-framing in general as well as in journalism and politics on positive vs negative stories.

In journalism, research suggests that while negative news is more attractive, it leaves people more distressed. Negative news media and televised articles also negatively influenced how people felt about unrelated personal issues. Negative articles with positive perspectives however, left viewers more interested in the topic, with fewer negative emotions often reading further [26].

Research on gain-framing versus loss-framing in the climate change field comes to similar conclusions. Research done in Tehran, a city affected by high air-pollution, found that positively-framed messages to citizens left them more inclined to change modes of transport from car to bus or bicycle to improve air pollution [27].

Another study by Vatanen et al found increased recycling rates in response to advertising new products made from recycled material and not avoiding virgin material or landfill [28]. Studies by Linden et al and Spence et al generally suggests loss-framing stimulates changed behaviour for risky outcomes whereas gain-framing is better for surer outcomes [25-26].

As the popular media considers climate change a certain outcome; humanity has a good overall idea of contemporary rising sea levels and increased extreme storms, heat waves, drought, and wildfires despite their unpredictability in time, place and severity. Therefore gain-framing should be expected to stimulate more behavioural change [12].

One guide by Norris adds that strategies need alignment to create long-term, positive impact to be environmentally restorative [29]. The guide is used to assess what it calls net positive impacts for any organization to actively reduce resource consumption, land use change and replenish habitat loss, water systems etc, and create long-term, sustained and absolutely regenerative impact not just reduce negative impact. The guide does reach to natural predevelopment outcomes.

Some researchers also argue that to reach a net positive world by 2030 it is more important to maximise positive benefits than minimise damages [30 to 32]. Generally, as benefits do not override risks of serious damages this approach would be too dangerous, i.e., responsible development is not about new green roofs while increasing toxic waste. So, it is equally vital to track, measure and report both system damages and benefits.

6. Pros and cons for LCA including benefits

Quantification of net-positive benefits is vital as it shows gain framing of opportunity, advantage and hope to contribute to recovery of nature to pre-industrial revolution benchmarks. Considering the previous section, it becomes clear why gain-framing used for Circular Economy, C2C, Blue Economy and recently also Handprint Analysis enabled them to quickly gain momentum [21-23, 29 -31]. LCA, meanwhile, continues using loss-framing and having an unpopular image.

6.1. Progress

Nevertheless, while Environmental-LCA (E-LCA) is lagging, Social-LCA (S-LCA) methodology does already include some positive benefits [17]. About this inclusion Di Cesare says that, among other things, positive impacts are meant to encourage performance beyond compliance [17]. This ignores why even the best but flawed urban planning standards, codes and regulations have not accelerated sustainability in 50 years.

Also "In order to increase the relevance of S-LCA for policy support, the development of indicators addressing both negative and positive impacts is fundamental." He

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then adds that "addressing these social positive impacts help communities to identify development objectives and ensure that positive developments are maximized" [17]. But the lack of meaningful urban biodiversity laws, codes or rating tools is another reason why LCBA may help quantify how positively things must change.

Similar arguments apply for including benefits into E-LCA now when people from the youth to elders in the Extinction Rebellion movement and all nations at the UN COP26 summit show it is vital to create a net-positive regenerative society. All must be able to quantify system benefits alongside with damages. LCBA can incentivize manufacturing to design for such a society and stimulate consumers to invest in regenerative lifestyles.

6.2. Challenges

Adding benefits to the LCA framework has potential risks including double-counting, ethical objections and greenwash [32].

6.2.1. Double-counting

Double-counting whole or part of the benefit must be avoided. Allocating reuse or recycling as an avoided burden while for example also counting it as a benefit is double-counting. What is classed as a benefit must be clearly defined.

Because double-counting is equally a risk in conventional LCA it too must also be avoided. For these reasons it is not necessarily an extra risk for LCBA.

6.2.2. Ethical objections

Ethical objections arise when benefit outcomes in one category offset damages in another category, location or time in any system. For example, can smog avoidance in Western Europe relate to such emissions in South-East Asia or can any short-term benefits or damages relate to those benefits long-term?

As such considerations already abound in LCA, the onus is on decision-makers to deal with them consistently and transparently. So, whilst benefits and damages are declared separately as well as net, ethical issues in LCBA and LCIA are comparable. Such challenges arise in environmental LCIA and LCBA but arise more so in S-LCA [32, 33].

6.2.3. Greenwashing

Where product marketing conceals impacts but promotes benefits greenwashing arises. This is a certain risk of declaring only net-benefits after subtracting damages. It can lead manufacturers, distributors and users to put more effort in maximising their benefits instead of minimising their impacts.

Greenwashing and marketing on benefits alone, however, threats in LCIA are not new. No net-benefit result should be declared independent of gross damage in any category. As negative results are essential for ecological, human and workplace health due diligence none should be ignored.

Comparing such risks only confirms that both LCIA and LCBA equally need transparent communications.

6.2.4. Defining positive benefits

A net-benefit is defined as a gain that exceeds system damages. Benefit quantification with traditional LCA is important to show gain-framing from systems qualifying and quantifying opportunity, advantage and hope to contribute to restore in nature and well-being. As this concept is often confused in literature and in other methods, however, we must stress the importance of understanding that whilst reduced damage is a relief, it is not the same as a positive benefit.

Handprint assessment, for example, describes results as "the positive climate impact of a product" [28, 29]. They do so by subtracting a product's negative impact result from

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those of a worse product, thereby only measuring reduced negative damages, not positive benefits or net-positive outcomes to any natural wellness threshold or end-point.

7. Evah LCBA methodology

Evah LCBA was developed to quantify positive outcomes in Climate Security, Hale Human Health, Ecosystem Replenishment and Supply Viability [12, 19]. Figure 3 depicts LCBA flows and categories

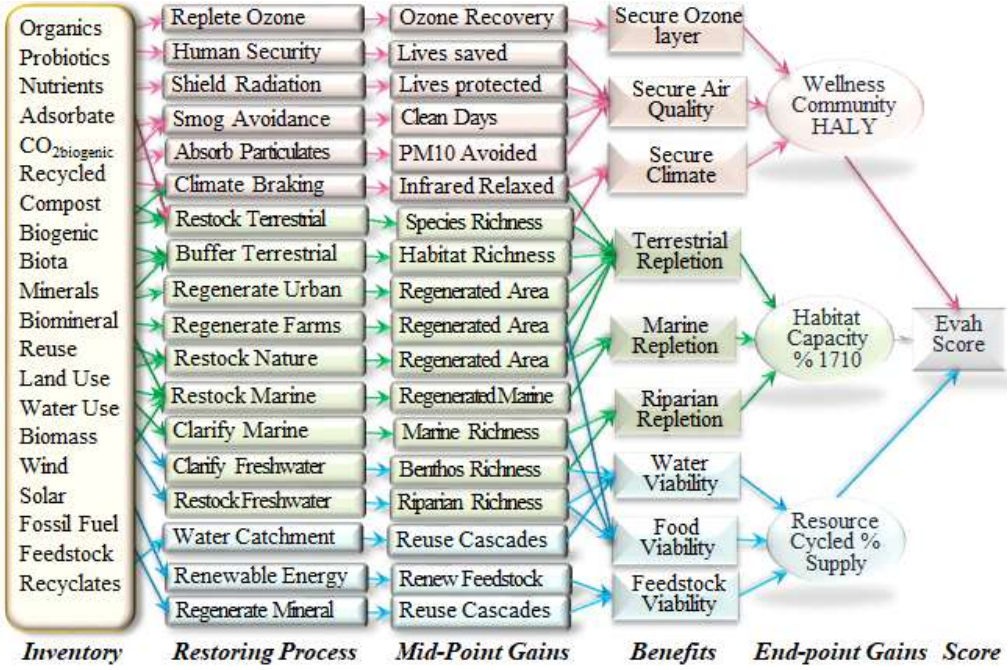

Figure 3. Evah 2022 LCBA Method Schema

They all oppose conventional LCIA previously defined in Figure 2 on purpose. The reason is that Evah benefit categories were developed to address and or offset LCIA impact categories, for example including:

- Climate Security versus Climate Change,
- Hale Human Health Years versus Damage to Human Health,
- Positive Ecosystem Replenished Formation versus Damage to Ecosystems, and
- Supply Energy & Resource Viability versus Damages to Resource Availability.

7.1. Benefits versus gains

As Figure 4 depicts Evah LCBA 2022 is modelled from zero to gain capacity whereas e.g., ReCiPe 2008 LCIA is modelled from damage capacity to zero loss. In most but not all layers each benefit has direct damage off-sets except where units do not yet align. This will require further research.

Where they have a direct off-sets, for transparency, conventional LCA damages versus LCBA gains can be declared in the same table or graph. Conversely, where damage categories lack a direct benefit category off-set and vice versa, net-damage and net-benefit cannot be calculated in a balancing set but damage and benefit can be reported in their different categories.

7.2. LCBA categories

LCBA categories can include LCBA categories can include:

- Climate Security: climate safety brakes, carbon banks and ozone layer repair,

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- Hale Human Health Years: gains free of environmental illness and disability,
- Positive Ecosystem Replenished Formed: species richness and habitat security, and
- Supply Energy & Resource Viability: feedstock renewability and circularity.

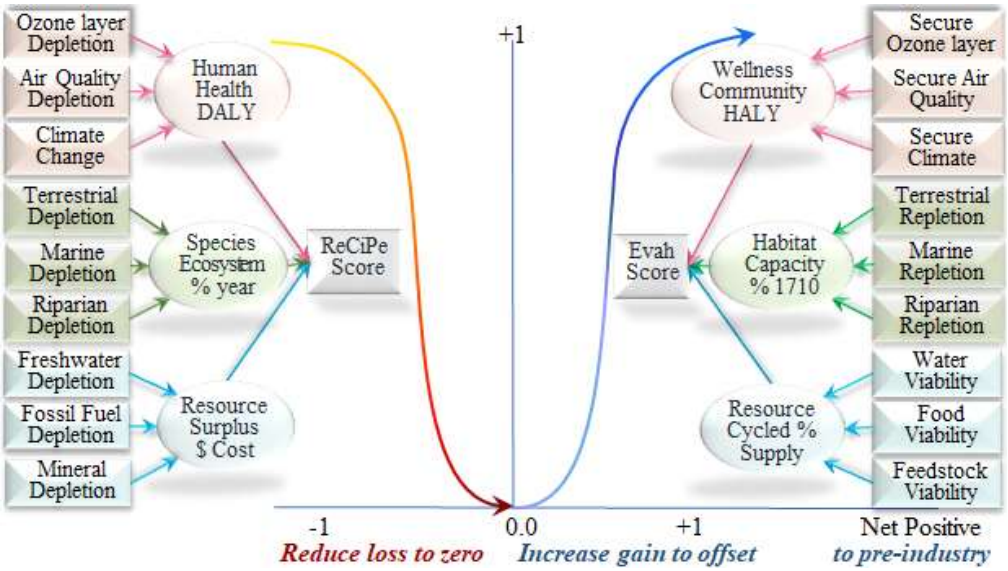

Figure 4. LCIA Negative Versus LCBA Positive Score

Table 1 shows beneficial flows reflecting designated restored or exceeded security, wellness, replenishment and viability outcomes [11, 12, 19, 35]. It lists categories, divided into benefit layers, units, circularity scores and climate braking factors. Tabled in each category are regional benchmarks such as defined by pre-industrial natural ecosystems, World Health Organisation (WHO) wellness limits or safe operating space within planetary boundaries.

As the literature shows climate forcing emissions escalated since C1750 LCBA uses pre-industrial benchmarks for climate security, ecosystem replenishment and resource viability categories [34]. On the other hand, considering advances in modern medicine and urban sanitation versus entrenched inequity, poverty and pollution, the Hale Human Health category employs WHO wellness limits or safe operating space within planetary boundaries.

Planetary boundaries research maps worldwide forecasts of safe operating space with very low risk regional pollutant levels within long-term global ecological carrying capacity [19, 36]. It also offers near-term trends of high-risk pollutant levels approaching global ecological carrying capacity thresholds. Maps measured pollutant levels exceeding ecosystem capacity and tipping point show where a small change makes a big difference and changes the global state.

This threshold value is a tipping point beyond which a tiny increment in a control variable triggers larger incongruous changes in response feedbacks in the natural Earth System itself. Exceeded climate insecurity thresholds lie in the Amazon rainforest, the West Antarctic ice sheet and the Gulf Stream system.

7.3. Charting net-benefit and net-damage

Charting from unsustainable to sustainable and to restored summed and partial results is also practical according to an Industrial Ecology thesis [33]. Figure 5, an extract from this work, charts results for hypothetical products A, B and C. Its hypothetical carrying capacity threshold depicts a threshold for net-negative damage.

Considering positive benefits minus negative damages it shows A with a net-positive benefit but B and C have net-negative damage.

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Table 1. Evah LCBA Benefit Categories & Circularity Metrics.

Benefit Layer	Positive Outcomes per Jurisdiction	Unit pa	Circularity
Climate security (CLIMES)		CLIMES /kg	%
Climate Brake	Near Term Carbon Drawdown	kg CO_{2e20}	Brake GWP
Climate Layby	Near Term Carbon in Product	kg CO_{2e20}	Sink GWP
Climate Bank	Far Term Carbon in Product	kg CO_{2e100}	Life GWP
Soil Carbon	Far Term Carbon bank in soil	kg CO_{2e100}	Soil GWP
Oxygen Safe	Photosynthetic Oxygen generated	O_2 kg CO_{2e100}	O_2 GWP
Ozone Repair	Avoided ozone depleting chemicals	CFC_{11e} kg CO_{2e100}	O_3 GWP
Hale Human Health Years (HALY)		HALY/capita	% HALY
Fresh Air	Oxygen free of particulates outdoors	kg O_2 @ C1750	Fresh Air
Clean Air	Oxygen free of NMVOCs indoors	IAQ	Clean Air
Potable Water	Rain & potable water for hydration	m^3	Water
Nourishment	Accessible affordable fresh food	kJ	Food
Local Shelter	Household shelter Gross Floor Area	m^2	Housed
Dignity of Work	>30hrs per week paid work	Weeks	Jobs
Positive Ecosystem Replenished Formation (PERF)		PERF/Ha@C1750	%PERF
Wildlife Safe	Wildlife corridors as refugia range	t Verge Biome	Wild Verge
Terrestrial Stock	Terrestrial species richness & range	t Terra stock	Wild Land
Aquatic Stock	Aquatic species richness & range	t Aquatic stock	Aqua stock
Marine Stock	Marine species richness & range	t Marine stock	Mar stock
Urban Bounty	Area range & natural carrying capacity	t Urban biomass	Green Urban
Recreation Area	Area for 2 days pp week capacity	t R&R biomass	R&R space
Nature Reserve	Scarce reserves restocked	t Reserve stock	Regen Scarcity
Supply Energy & Resource Viability (SERV)		SERV/person km	%SERV
Viable Air	Acess to chemical and dust-free airshed	O_2 kg	Oxygen
Viable Water	Refill of locally accessible reservoirs	m^3 water	Water
Viable Food	Reliance on locally accessible fresh food	kJ food	Food
Viable Supply	Replenish locally accessible resources	kg feedstock	Supply
Viable Fuel	Reliance on local renewable fuel supply	MJ fuel renew	Biofuel
Viable Mineral	Restocked accessible mineral reserves	MJ Mineral	Mineral
Viable First Aid	Accessible Paramedic & Medical Care	Minutes to Aid	Nurse

Product:

- A's net-benefit to regenerated nature C1770 is a restored nature-positive outcome,
- B's net-damage within carrying capacity reflects sustainable development, and
- C's large net-damage beyond C2020 carrying capacity is unsustainable.

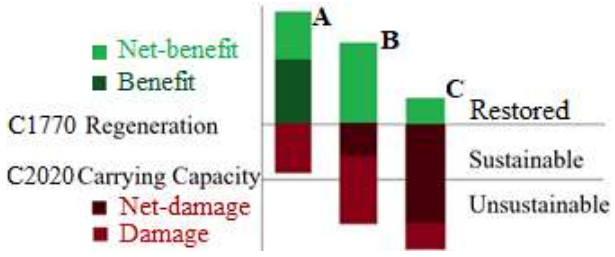

Figure 5. Charting Progress from Unsustainable, Sustainable to Restored C1770 Nature-Positive.

7.4. Safe operating space within planetary boundaries

Some authors argue that such planetary boundaries concepts are incompatible with damage-based LCIA [36]. They see the main purpose of such boundaries is long-term

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forecasting of tipping point issues. Many past forecasts remain so uncertain that they should not be used as targets in LCIA.

Recent evidence reported in the popular media, however, of already breached and imminent tipping points is so strong that it offers benchmarks for LCIA [1-3]. The precautionary principle advises heeding such warnings.

Improvement studies using LCIA focus on reducing damages as low as possible near zero [12, 16]]. Whereas studies using LCBA focus on system generation beyond zero of as much benefit as possible to facilitate restoration to C1750 ecosystem outcomes before they were depleted. Here the authors argue that the focus for LCA system improvement should be on regenerative C1750 rather than less of currently depleted carrying capacity.

For safety and to inspire hope rather than greenwashing, it is vital to show net and total damages along with net and total benefits. It is equally vital to clearly define if a flow is a benefit or avoided burden within or beyond a system boundary to avoid double-counting.

7.5. Accounting and mathematical logic

In LCBA practice, as in real-world, mathematics, science, accounting, and logic, a damage or loss is a negative outcome and a benefit or gain is a positive outcome. In LCBA benefits are designated positive signs representing gains in security, wellness, habitat and supply. This is the converse of conventional LCIA where damages are designated positive signs despite representing loss of climate, health, species and supply.

In LCIA sequestered carbon is designated a negative emission flow irrespective of it producing biomass. LCA can become more balanced by supplementing LCIA with LCBA. LCA needs to be unbiased and offer balance such as from risk benefit analysis to reveal good versus bad approaches, accounting of gain versus loss for investment and auditing balance sheets plus versus minus flows for transparency.

8. Case studies

The case studies are compliant with relevant ISO methodology. All input, output, product, burden and benefit shares throughout are allocated on their chemical, biological, physical and thermodynamic share of contributions. All system flows leaving at end-of-waste boundary are allocated as coproducts.

Evah has also developed more advanced methods for durable biomass products carbon drawdown [35]. These factor on-site fuel use, fire history, prior land-use and service life [35,37-38]. Selected examples depict a range of damages and benefits of durable:

- US corn feedstock Polylactic Acid (PLA) polyester fibre in-wall thermal insulation;
- Queensland forest fibre particleboard sub-flooring installed in a base building;
- Residential high-rise chute for occupants to divert recyclables from garbage, and
- Queensland Brisbane Showground Interpretive Centre building.

With a few applications they show many LCBA result types. The authors have tested LCBA in LCA of urban systems, infrastructure, buildings, events, gardens and novel products. These include main roads, metro systems, city desalination systems, sewerage systems, public hospitals, schools, TAFEs, university dormitories, lecture theatres, office towers, an opera house, supermarkets and residences. Despite its damage focus and data limits making LCA on net-positive systems rare the authors have assessed renewable microbial products such as mycelium panels, foam and fabrics.

8.1. Biopolymer case study

Polylactic Acid is a very common biopolymer made from corn, sugarcane or cassava. PLA's properties vary with glass transition and melt temperature comparable with Polyethylene Terephthalate (PET), Polypropylene (PP) and or Polystyrene (PS). During growth the corn plant takes up carbon dioxide and converts some into sugars and then starch feedstock.

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Post-harvest, part of the carbon dioxide the corn sequestered remains in the roots as soil carbon. Factories make polylactide polymer from corn starch feedstock through continuous lactide polymerisation. Figure 6 depicts molecular changes from corn starch to a polylactide (PLA) that all comprise chains of carbon, oxygen and hydrogen.

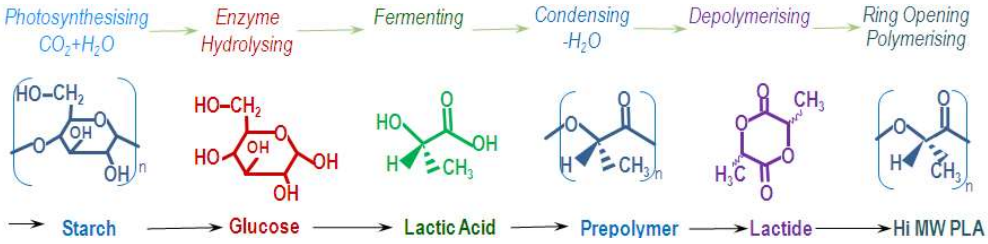

Figure 6. Starch, Glucose, Lactic Acid Lactide and PLA Microstructures.

First water is removed in a continuous condensation reaction of aqueous lactic acid to produce low molecular weight prepolymer. Next, this is catalytically converted into the cyclic dimer lactide and vaporized. This lactide mix is then purified via distillation before melt crystallisation occurs [39].

Finally, high molecular weight PLA is produced by ring-opening lactide polymerisation. Impurities are removed and meso lactide is separated by distillation [36]. The longer a PLA product is used, the longer its feedstock carbon is retained within. Built-in PLA polyester insulation remain in place as long as the building does so that carbon storage is a benefit from >20 to >100 years.

Evah modelled the global warming damage and climate braking benefit/ m2 of PLA polyester insulation fabric blend of 91% dextrorotatory PLA (PDLA) 9% levorotatory PLA (PLLA). The cradle-to-grave study compared insulation fabricated in South Korea (SK) **and** New South Wales (NSW) Australia, New Zealand South Island (NZSI) and Victoria (Vic) Australia. The Victorian grid is brown-coal-reliant, South New Zealand grid is hydro-reliant. More typical South Korean and New South Wales grids are 10% to 30% renewable black-coal-reliant [40].

Table 2 show negative damage and positive benefit results for this insulation. In polyester insulation fabric production melt-spinning of fibre from pellets uses most energy. Energy type use was the most significant contributor to Global Warming Potential. SK and NSW made insulation emits more CO_{2eq} than PLC biomass retains yielding a net damage total. However, because NZSI-made PLA insulation used mostly renewable power it has a net benefit.

Table 2. PLA Insulation Global Warming Potential (GWP) (kg CO_{2eq100}).

PLA Insulation made in	Vic	KR & NSW	NZSI
GWP sequestered in PLA	4.9	4.9	4.9
Insulation fabrication	-11.8	-6.8	-2.9
Net damage	-6.9	-1.9	
Net benefit			2.0

8.2. Forest product case study

Like corn plants, trees also drawdown carbon, oxygen and hydrogen from air and photosynthesise these into carbohydrates to store as food, feedstock and structural fibre in trunks, roots and soil [35]. Carbon sequestered in paper and lumber is stored over the near-term fitout and long-term building life.

Apart from remnant roots in soil, wood in buildings can store ≤1.8kg of CO_2/kg lumber used [34-35]. Building with timber has many advantages for shock resistance, thermal insulation and pleasant indoor climate. Until the world reaches zero Carbon targets

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biomass deposits banked in timber builds also offer time-critical climate braking opportunities to avoid imminent tipping points [11, 32, 34-35].

The Evah Institute LCBA method shows how to account for sequestered CO_2 in LCA. All sequestered carbon is a gain only after factoring 6 conditions. If the first 3 conditions are unmet then none qualifies, if the second 3 conditions are partly met then that part qualifies [11, 32]. These conditions include accounting for:

- 3 tree regrowth cycles,
- forest stewardship certification,
- reforesting countries,
- wild-fire and control- burn loss,
- renewable fueled processes, and
- >20-year applications.

Evah has carried out various timber LCAs including this particleboard example. Table 3 summarise gross negative damages and positive benefits of FSC certified 13kg/m2 particleboard flooring cradle-to-grave. This forest product was calculated to store 38kg CO2eq/m2. This carbon banking includes carbon retained in soil and feedstock not allocated to other co-products.

Table 3. Particleboard/m^2 Damages and Benefits.

Layer	Damage or Benefit	losses	gains	Unit
Climate	Ozone Depletion	-3E-08		kg CFC_{11e}
	Climate Brake near term		47	kg CO_{2e20}
	Climate Bank long term		38	kg CO_{2e100}
Habitat	Ecosystem Loss	-7E-05		m^2pa
	Forest Biomass Retain		452	MJ_{NCV}
People	Human Health Loss	-3E-04		HALY
	Hale Wellness		1E-4	DALY
Supply	Fossil Fuel Depletion	-12		MJ_{NCV}
	Mineral Depletion	-0.05		MJ_{NCV}
	Energy Renewal		75	MJ_{NCV}
	Matter Renewal		378	MJ_{NCV}

The fine root mass goes well beyond the drip line and far underground. Its carbon remains in that soil for >100 years even when the stump is torn out. These fine roots act as conduits across the forest supporting soil algal, microbial and fungal habitat and feed residual plants and trees throughout.

Despite trunks being removed, the larger mass of relic autotrophic and chemotrophic synthesizers remains in the underground habitat. Their function is retained particularly for water supply and chemosynthesis by bacteria and fungi in synergy with algae fixing nitrogen, hydrogen sulphur and carbon to make compounds such as sugar and carbohydrate feedstock and structural fibres.

8.3. Garbage diverter case study

The high-rise residential building garbage chute with diverter studied allows householders to send garbage and recyclables to separate bins unlike other single chutes sending garbage to one bin. By making recycling easier, the diverter stimulates recycling rates. As individual recycling bins per unit are unnecessary this also avoids weekly elevator trips to take them out for collection. Unnecessary recycling bin rooms reduces one room per level which is a significant financial saving.

This Evah LCA modelled an 8-storey apartment building chute use by 128 occupants in 64 units, with and without a diverter, over 60 years. The literature showed typical residential recyclate material mix in Australia as well as 22% higher single dwelling recycling than high-rise rates [38-44]. Damages of garbage bin only and benefits of 22% higher recycling bin share use were modelled.

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Garbage to landfill impacts versus added diverted recycling feedstock gains were estimated. Similarly, occupied recycling bin room damages versus benefits accruing from avoidance of building unneeded rooms were modelled for a typical new high-rise residential building cradle-to-grave.

Table 4 summarise garbage chute damages and benefits/m² gross floor area (GFA) building with and without the diverter for 60 years cradle-to-grave. Again, damages are reported as negative results and benefits as positive results. In all categories benefits with diverter were larger than damages without it. Overall, gains were most significant.

Table 4. Garbage Diverter Damages Versus Benefits.

Viable	Security Benefits	Units	Chute	Space	Recycled	Gains
Climate	Climate Brake	kg CO_{2e20}	-1.0E5	1.0E5	4.0E6	4.0E6
Habitat	Habitat Regain	m^2pa	-0.4	0.1	35	35
People	Hale Wellness	years HALY	-6.8	0.9	457	451
Supply	Energy Recovery	MJ	-6.7E5	1.1E5	9.4E7	9.3E7

8.4. Building case study

Baggs et al describes the author's cradle-to-grave LCIA and LCBA of an Interpretive Centre Design for the Ekka showground in Brisbane, Queensland [44]. Its build mass comprised local FSC forest products, steel and organic biomass with e.g., imported renewable ethylene tetrafluoroethylene (ETFE) Texlon roofing. While eutrophication called for mitigation in use to reach zero damages, no gross damage arose from:

- global warming forcing potential, stratospheric ozone loss or smog formation,
- particulates, ecotoxicity, acidification, ionizing radiation, and
- depletion of freshwater, fossil fuel, minerals, elements or natural land use.

Net-positive benefit gains outweighed all damage and loss. Whole-of-life annual benefits/m² GFA included

- 30kl water renewal viable supply security,
- 27kg feedstock renewal viable supply security,
- 42kg CO_{2e20} climate braking near term to avoid imminent tipping points, and
- 30kg CO_{2e100} climate bank long-term deposits in green wall and landscape fibre.

9. Discussion

While it is natural that people find bad news attractive it stresses and demotivates them. Children, youth and people everywhere involved in, for example the Extinction Rebellion movement, call for actions to generate nature-positive development. Contrasting negatively framed barriers in communications, assessment and quantification versus positively framed solutions for urban design the authors clarified blind spots and barriers to as well as new sightlines and pathways to invigorate strategic planning

However, increased positive chatter and banners was actually focused on negative to zero loss not replete natural outcomes. Positive banners typically belie less negative assessment. Most working under them are blind to restoring natural integrity to steady states before anthropogenic climate forcing and biodiversity loss began rapid acceleration. Explanations are offered for why most unsustainability practitioners

- work, message and report negatively on damages
- lock onto reducing loss to zero and reaching part repair
- exclude positive net gain to pre-urban climate security.
- offer weak negative instead of vital net-positive solutions

In the real world, science, math, logic and urban planning, a damage or loss is a negative outcome or loss whilst a benefit or gain is a positive outcome. Standard commercial LCA database practice, however, attributes positive signs to loss and negative signs to gains which obfuscates meaning for everyone. Consequently, most leading sustainability

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practitioners stuck on damaging gloss and blind to beneficial gain fail in even the most basic math, science and accounting. Applying such practices in any sustainability is illogically biased and that forms barriers and creates absurdities.

The paper suggest solutions for adoption in urban design considering competitive advantages of PD to recover space for natural feedback loops to regain climate control and biodiversity richness.

Like transparent, honest financial accounting systems counting both gains and loss, LCA needs to be capable of unbiased mathematics. In addition to urban system damages, it is vital to quantify benefits and gains to provide people hope about the future. LCBA methods were introduced to quantify many, but not yet all, outcomes of PD with scientific rigor to support, test and verify the design process.

Quantitative LCBA concepts were introduced to facilitate understanding applicable to broader fields of work. This was followed up by certified case studies shown to offer proof of concept. LCBA offers

- positive news on verified quantitative benefits to all stakeholders,
- information on product benefits as well as damages to markets and designers,
- unbiased picture of whole of life system gain vs loss to manufacturers and planners,
- decision support via unbiased whole of life gains vs loss declarations to purchasers,
- verifiable evidence of products being nature-positive to consumers and the law,
- encouragement to develop nature-positive systems to states, cities and industry,
- opportunity to develop nature-positive services for regional circular economies, and
- vision of benefits reducing damage and gains offsetting loss to service providers.

The paper shows methods and case studies to enable urban planners, designers and industry sectors to make use of LCBA to:

- report benefits may stimulate more nature-positive business strategies,
- quantify viable climate, wellness, habitat and supply security,
- offer service providers insight to contribute to net-positive regenerative outcomes,
- expose strengths, weaknesses, threats and opportunity for new and redevelopment.

The case studies show that benefit assessment can also offer a more holistic way of measuring a system's impacts. The biopolymer case study shows the importance of transparency, as the results are highly dependent of the renewables share in the electricity grid. It shows comparable products can have net-benefit or a net-damage outcomes.

This may seem obvious to designers and project management but is not necessarily understood by the general public. Transparency and displaying benefits alongside damages is vital to enhance decision making for good urban planning.

The forest product case study shows that within one product's results, there can be net-damages as well as net-benefits for different categories. As of late, climate change categories have received more attention and many consider it to be most important to track. Other categories that can be vitally important, however, should certainly not be ignored.

Although LCA is most often used for product systems, it can also be used to calculate whole of building life impacts as in the third and fourth case studies. Inclusion of benefits in whole-building studies can be vital for decision-making as shown in the garbage diverter case study. Here the main benefit from an expected increase in recycling rates would not have occurred if the garbage chute was unable to divert recyclables from general waste.

If only damages were calculated, a garbage chute without a recyclables diverter would have a preferable outcome since less material is used than a dedicated or dual-chute system. Only quantifying the damages distorts system outcomes so despite aiming for the opposite this can therefore contribute to unsustainable decision-making.

LCBA offers a way to:

- make damages more visible especially in infrastructure, town and building design,
- avoid greenwashing to market products or services,
- report net-benefits, real gains, positive and net-positive outcomes, and

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- report increased climate security for wildlife, cities, regions and infrastructure.

10. Conclusions

In the few decades left to resolve rampant climate and extinction problems essential direct sightlines and steps to take involve:

- understanding that only huge gains can restore planetary controls,
- transforming the reach of concepts, tools and numeracy involved,
- net-positive messaging generating hope and public effort, and
- unbiased assessment supporting PD throughout every sector.

The need to recognise that most positive chatter work under positive banners is done blind to restoring natural steady states climate and biodiversity integrity is vital. Most so-called sustainability practitioners exclude positive net gain to pre-urban climate security and vital net-positive solutions.

PD, positive design and nature-positive outcomes can be supported to a significant extent by scientifically verifiable LCBA quantification methods. These can quantify urban system benefits and gains in climate, wellness, habitat and resource security of products and built systems.

Conventional LCA work stuck on damaging loss and blind to beneficial gain is illogical, absurd, biased and obfuscates meaning that creates barriers for everyone considering sustainable development. LCA should become less biased by supplementing LCIA with LCBA and designating positive signs to beneficial gains in security and viability of climate, wellness, wildlife and supply. Acceptance of including benefits can be improved as many LCA practitioners still believe it facilitates greenwashing and distracts attention away from damage reduction. Despite countering such arguments more may need to be done to improve LCBA acceptance in the wider urban planning and LCA communities. As LCIA has taken decades to become what it is today, LCBA also needs further development. Categories can be further explored then tested to develop new standards

11. Recommendations

Positively framed solutions in communications, assessment and quantification for urban design can clarify new sightlines and pathways to invigorate strategic planning. All urban design solutions should consider PD's competitive advantage to recover space for natural feedback loops to regain climate control and biodiversity richness. Urban planning and design can be facilitated and enabled by adopting LCBA and PD concepts and assessment tools.

LCBA can quantify many, but not yet all, outcomes of PD with scientific rigor to support, test and verify the design process. LCBA concepts can facilitate broad understanding with certified case studies offering strong proof of concept. Evah LCBA scopes a more holistic unbiased approach than does conventional LCIA.

Unlike any other current quantitative method, LCBA offers the urban development field vital ways to quantify restoration of viable climate, habitat, biodiversity and wellness. Adoption of LCBA to facilitate PD in small pilot projects then iconic projects are next steps to consider.

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