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Quantifying Nature Positive

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Abstract: The needs for environmental reporting to include positive outcomes considering differences between creation of less harm, benefits and net benefits are explored. 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 oscillating around damage and loss sticking points. Life Cycle Benefit Assessment (LCBA) is a method to measure gains in accelerating restoration and climate security. It enables a good news focus as its reach is to quantify and show positive gains beyond the negative and 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 (LCIA) LCBA assigns damage and loss as negative debts and benefit as positive gains. It concludes that LCBA offers business and design a new environment assessment tool, with research needed on economic and other outcomes.

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

1. Introduction

Human development and all living things depend on naturally integrated ecosystems and regenerative sustainability creates wellness via reciprocal relationships between buildings and their ecosystems [1-13]. For five decades environmental quantification and reporting of actual damages and real harm reduction has lacked core capacity to sight and report positive benefits and net gains. Design blindness remains in architectural practice and science still seeks more definitive net-positive principles, baselines, benchmarks, boundaries and timeframes [12-14].

The media has recently begun to cite goals and plans from the United Nations https://www.naturepositive.org/ and e.g., Australian Federal Government https://www.positiveenergy.gov.au/ sites. "Positive chatter", around reducing damage and depletion is quieter on restoring natural climate and habitat security. Restoration goals must reflect pre-urban carrying capacity before most anthropogenic forcing of climate change and biodiversity loss accelerated.

The paper discusses barriers to and solutions for urban design and development. It queries why, despite masquerading under positive masks and banners, most such chatter is more about less harm than added benefit. The authors examine if Environmental Product Declarations (EPDs), Life Cycle Assessment (LCA) and Life Impact Cycle Impact Assessment (LCIA) attributing positive signs to loss and negative signs to gain is confusing. They also query if despite best intentions, sustainability practitioners, working in negative to zero or weakly positive range fail basic math, science and accounting logic.

Positive Development (PD) that counts space for nature to its true extent, does report beyond zero loss to environmental net gain. PD is physical development that achieves net-positive outcomes during its life cycle over pre-urban conditions by increasing economic, social and ecological capital [12]. This paper reviews quantification to ascertain PD outcomes with scientific rigor including the authors' life cycle benefit assessment (LCBA) to support, test and verify the design process.

2. The negativity problem threatening humans' home planet

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The problem explored is why practices applied to attain sustainability have a negative bias that lacks reach to increase ecological capital for adding positive gains beyond zero loss. Why practitioners, work in the negative range - loss to partial repair, but ignore the positive range - net gain to restored pre-urban natural productivity is examined. Absurdities arising, barriers to overcome and solutions for adoption are uncovered offering competitive advantages such as for PD and urban design.

3. Objectives

The paper aims to clarify needs for environmental reporting to include positive outcomes, benefits and net benefits beyond zero harm. It aims to explain the futility of why practitioners locked into reducing loss from industrialisation ignore gains from restoring climate and biodiversity security. The authors aim to clarify new sightlines and paths for strategic planning by contrasting negatively framed hurdles and positively framed solutions for urban design. They cite positive communications, assessment and quantification methods to facilitate understanding in broader fields of work.

LCBA case studies are shown to offer proof of concept. It aims to show that rectifying climate and extinction rates depends on understanding that huge gains are essential to compensate for two centuries loss of naturally regulating feedback loops. Transforming tools' positive reach aims to generate hopeful messaging, inspired engagement and balanced metrics and measures supporting PD to secure urban habitability.

4. Background

Conclusions of the 2021 report of the Intergovernmental Panel on Climate Change (IPCC) erased previous doubt that most climate forcing is from human technology [15]. At the 2021 UN Climate Change Conference of the Parties COP26 summit in Glasgow global leaders, governments, business and non-government organisations (NGOs) agreed on the urgency for action to mitigate global climate change's ensuing damages to human health and biodiversity loss [16]. Earlier leaders at the 2020 UN General Assembly and Biodiversity Summit set a goal to create an "equitable, carbon-neutral, nature-positive world" [17]. This global goal for nature is to stop loss of viable climate and biodiversity.

Figure 1 depicts measurable biodiversity objectives to achieve a nature-positive world: net zero loss from 2020, net gain by 2030 and full recovery by 2050 [18]. Nature-positive biodiversity can include genetic-habitat diversity, indigenous species richness, total diversity range and or introduced species activity to improve ecological functionality. This chart shows a nature-positive rebound after loss passes zero but that rebound called full gain by 2050 is to warming <1.5^{0}C and not to natural pre-urban levels.

The 17 UN Sustainable Development Goals (UNSDGs) that include enhanced nutrition, employment, wellness, education and economies are not necessarily net-positive. But other agreed positive world measures include reafforesting 350 MHa, revegetating 20% native flora and protecting >30% land, ocean and freshwater communities from further degradation and loss [17-19]. The worldwide Extinction Rebellion (XR) youth movement now regularly calls for net-positive climate and biodiversity security outcomes [20].

And a 2021 global survey found that 60% of youth, had "climate anxiety, worried or very worried about the future" [21]. Thompson T. reported in the Nature Journal that of 10,000 young people surveyed in 10 countries about climate change only 5% were not worried, 68% were afraid and 68% sad, 63% were anxious and 58% angry, while 57% felt powerless and 51% felt guilty about it [22].

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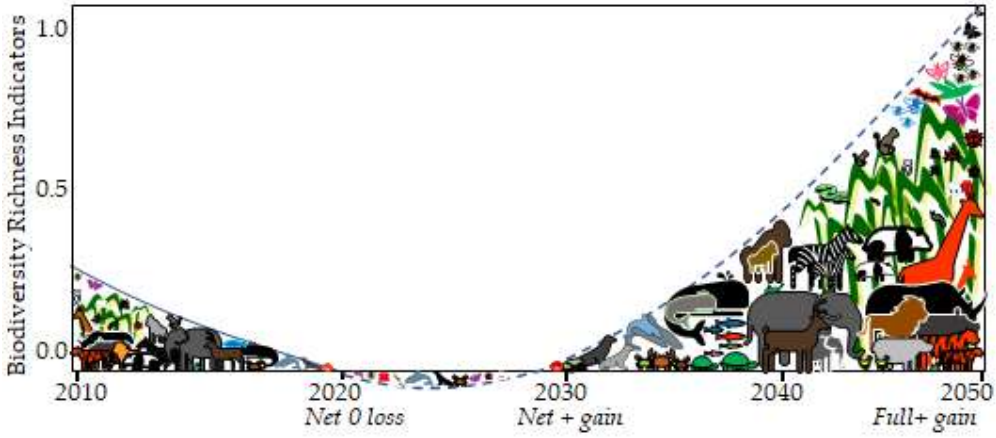

Figure 1. From 2010 to full nature-positive gain by 2050 Adapted from [18].

4.1. Positive development

Modifying buildings, infrastructure, landscapes and products can improve natural, social and economic service capacity [23-24]. 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" [12]. This is because urban green space for gardens on ground-level, roof-tops and vertical walls adds more biomass production and ecological carrying capacity than barren space does [23].

Birkeland's urban PD concepts aim to enhance food growth, air quality, insulation, local amenity, profit and ecology. They include food growth frames, roofs and walls with shutters, shelves, aquaponics, hutches, bird cages and bacteria converting organic waste into fertilisers. Creating green space and landscapes supports onsite wildlife enhancing biodiversity, clean air and CO_{2e} drawdown [12]. Such positive social and ecological development strategies offering human and planetary wellness is only net-positive, however, when new ecological space outweighs accumulated impacts of development.

4.2. Urban Development use of LCA

Over 300,000 companies worldwide use UN Environmental Economic Accounting System (UNSEEA) frameworks and International Standards Organisation (ISO) ISO 14044 methods to assess their systems. Overarching UNSEEA reference frames cover benefits from direct use of environmental inputs but exclude indirect benefits from ecosystem services such as carbon, water and biomass storage [35]. UNSEEA and ISO environmental management system frameworks for LCA, LCI, LCIA and EPD cover borrowings of natural capital, costs to nature and damages to supply, habitat and health [34, 35].

In 1993 the promise of a Green Games and world-first public building LCA helped Sydney win the 2000 Olympics bid. Guided by Dr Ian Boustead and Dr Chet Chaffee from overseas seven New South Wales (NSW) scientists including one of the authors compiled Australia's first national LCI [35]. They modelled Stadium Australia's product supply chain cradle-to-grave. The Games LCA legacies include environment planning laws, the BASIX building sustainability index, LCIA software and a free OzLCI database [35].

EPDs enable greener environmental choices by owners, designers and specifiers [25-35]. Using ISO14025, ISO21930 and EN15804 standards compliant LCA methods, EPDs show LCIA of lost human and ecosystem health and natural resource access [34]. Since 2014 LCBA has been used in third-party-certified EPDs to clarify ecologically beneficial choices for stakeholders [25-35]. All such assessments include global supply chains and affected ecosystems beyond product, building or infrastructure outcomes.

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4.3. *Damage and loss categories apposing benefit and gain categories*

Positively framed LCBA covers benefit and gain whereas negatively framed LCIA covers damage and loss. Evah developed LCBA to define and quantify positive outcomes and gains from recycling, recovery, restoration, renewal and resilience strategies to net-positive climate security, human wellness, ecosystem repletion and resource viability benchmarks [25-35]. Examples include recovered marine habitats, regenerated pollinator species richness, renewed soil carbon intensity and PD building design [25-35].

LCIA methodology categories include loss of human health, ecosystems and resource availability. Loss is due to damage from air, land and water pollution, forcing climate change and depletion of the ozone layer, biodiversity, freshwater, minerals and fossil fuel [41]. Figure 2 depicts the leading ReCiPe 2008 LCIA descending from full capacity damage to zero loss versus Evah 2020 LCBA ascending from zero to full capacity gain.

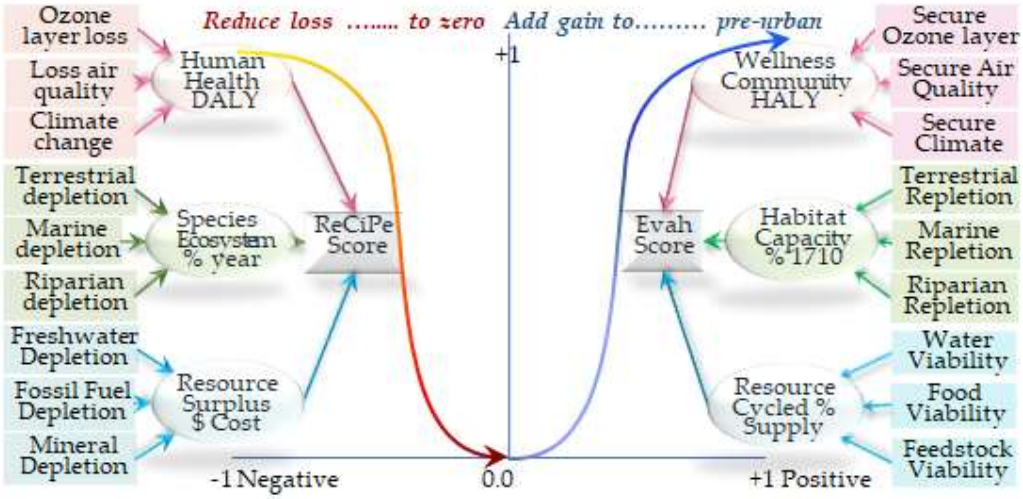

Figure 2. LCIA Negative Versus LCBA Positive Score

5. Negative and Positive Messaging in Communications

This section discusses negative and positive framing of messaging. Positively framed literacy and numeracy is lacking for communicating needs to accelerate sustainable development. Such framing is essential to show ways to solutions around barriers diverting efforts of urban designers and developers seeking truly positive outcomes.

5.1 Negative framing of messages

Today most climate change news stories negatively frame urban losses from damages caused by unprecedentedly extreme winds, flash-floods, sea-level rise, storm-surges, blizzards, heat-waves, droughts and wild-fires [36-39]. And LCIA originally developed to quantify production systems causing worldwide environment and human health damages and more or less loss, is also negatively framed. In LCA, most such LCIA is entirely fit-for-purpose to show loss outcomes and also to report bad-news.

5.2 Positive framing of messages

Positively framed good news and assessment tools include Cradle to Cradle (C2C), Blue Economy, Handprint and Net Positive. Hundreds of their online good news case studies got business and policymakers investing in sustainability [43-52].C2C certifies planet-positive products considering safety, wellbeing, renewability, climate, water, soil, equity, circularity and innovation stewardship but does not show net-positives [43-45].

The Blue Economy facilitates low carbon, resource-efficient economies that largely allow nature to do the work like ecosystems do [47]. Positive social and environmental

outcomes include healthier space for local flora, fauna and human communities and natural habitat, oxygenated airsheds and carbon storage for climate abatement, cleaner air and water, as well as reduced rain runoff to partial or full natural capacity. Handprint describes assessment results as "the positive climate impact of a product" [48-50]. Their subtracting a product's negative impacts from those of a worse product, only measures reduced negative damages excluding positive or net-positive outcomes.

The 'Net Positive Project' guide stresses long-term strategies need alignment to create environmentally restorative outcomes [51]. It shows how to assess reduced negative impacts of resource depletion, land use change plus replenishment of habitat loss, and water sources [51-52]. But it does not reach natural pre-urban carrying capacity outcomes.

5.3 Outcomes of gain-framing versus loss-framing

Loss-framing conveys adverse losses of inaction and gain-framing conveys beneficial gains of action [36-39]. Both can galvanise popular action but which has more power is often situation-dependent. Much research has been done in psychology on gain versus loss-framing and in journalism and politics on positive versus negative stories [36-37].

Journalism studies show negative news attracts more views but leaves people more distressed. Negative news and televised content also negatively influence how people feel about other issues. But negative articles with positive perspectives leave viewers with fewer negative emotions, often more interested in the topic and reading further [37-39].

Environmental research comparing gain and loss-framing has similar conclusions. In air-polluted Tehran, Mir et al found positive healthier-air messages persuaded citizens to change transport modes from car to bus or bicycle [40]. Winterich et al also found recycling rates increased more when advertising that recyclate was to make new products rather than to save virgin material and landfill space [41]. Linden et al [36] and Spence et al [38] suggest loss-framing stimulates changed behaviour for risky outcomes but gain-framing is better for surer outcomes.

As 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, popular media considers climate change a certain outcome [36, 39-41]. Therefore gain-framing is expected to stimulate change to more climate-secure behaviour. Some researchers argue, however, that to reach a net-positive world by 2030 it is more important to maximise positive benefits than minimise damages [54-55].

But as benefits may not override risks of serious damage this approach is too dangerous, i.e., responsible development is not about new green roofs while increasing toxic waste. So, it is wise to track, measure and report both system damages and benefits. Indeed, LCIA use remains as essential, if not more important than ever before in history.

6. Pros and cons for LCA adding positive benefits and gains

But while LCA using loss-framing suffers an unpopular image, gain-framing used for Circular Economy, C2C, Blue Economy, Handprint and Net Positive analysis enabled them to quickly gain momentum [43-52]. Gain framing net-positive quantification offers hope, and opportunity for recovery of nature to pre-urban benchmarks.

6.1. Progress in LCA to data

While Environmental-LCA (E-LCA) is lagging, newer Social-LCA (S-LCA) methods already include some positive benefits [53-56]. Di Cesare et al says positive impacts are meant to encourage performance beyond compliance and "to increase the relevance of S-LCA for policy support, the development of indicators addressing both negative and positive impacts is fundamental" [55]. And "addressing these social positive impacts help communities to identify development objectives and ensure that positive developments are maximized" [55].

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Similar arguments for including benefits into E-LCA apply for people from youth to elders calling for nature-positive regeneration. Both the UN COP26 summit of nations and the XR values agree on the need to create a net-positive regenerative society and culture [20, 16]. And by enabling nature-positive design development LCBA may help stimulate regenerative markets and lifestyles [25-35].

Perhaps the lack of positive metrics explains why even the best urban planning standards, codes and regulations have not accelerated sustainability in 50 years. The lack of meaningful urban biodiversity laws, codes or rating tools is yet another reason to sight, reach for and quantify positive change.

6.2. Challenges for LCA of damages versus benefits

Nevertheless, adding benefits to the LCA framework has potential risks including double-counting, ethical objections, greenwash and definition of positive gains [53].

6.2.1. Avoiding 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 LCA it too must be avoided but it is not an extra risk for LCBA.

6.2.2. Clarity around ethical objections

In any system ethical objections arise when benefit outcomes in one category offset damages in another category, location or time. For example, can smog avoidance in Western Europe relate to such emissions in South-East Asia or can any short-term result relate to long-term ones? As such issues already abound in LCA, the onus is on decision-makers to deal with them consistently and transparently. Comparable ethical issues arise considering separate and net-results in E-LCIA and LCBA but more so in S-LCA [53-56].

6.2.3. Reducing greenwashing

Greenwashing arises where product marketing conceals impacts but promotes benefits. This is a certain risk of declaring only net-benefits after subtracting damages. It can lead manufacturers, distributors and users to put more effort into maximising their benefits instead of minimising impacts. Greenwashing and marketing on benefits alone, however, are not new threats in LCIA.

As negative results are essential for ecological, human and workplace health due diligence none should be ignored. So, no net-benefit result should be declared independent of gross damage in any category. Comparing such risks only confirms that both LCIA and LCBA equally need transparent communications.

6.2.4. Defining positive benefit

A net-benefit is a gain exceeding system damage. LCA needs quantification to show if gain-framing to qualify and quantify hope, opportunity and advantage contributes significantly to restoration of nature and well-being. As this concept is often confused in the literature and in other methods, however, the authors must stress the importance of understanding that whilst less damage is a relief, this is not the same as a positive benefit.

7. LCA methods for adding positive LCBA to negative LCIA

Figure 3 depicts the ReCiPe LCIA method mid-point damages of pollution, climate forcing as well as depletion of ozone, biodiversity, freshwater, minerals and fossil fuel leading to end-point losses of human and ecosystem health and resource availability [42]. Figure 4 depicts LCBA climate, supply wellness and habitat security gain categories to counteract LCIA loss categories [25-35].

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Potential off-sets are to allow transparency in declaring LCIA loss versus LCBA gain in the same table or graph. Conversely, where categories lack direct off-sets, net-damage and net-benefit cannot be calculated but damage and benefit can still be reported in their different categories. In layers where units do not yet align further research is required.

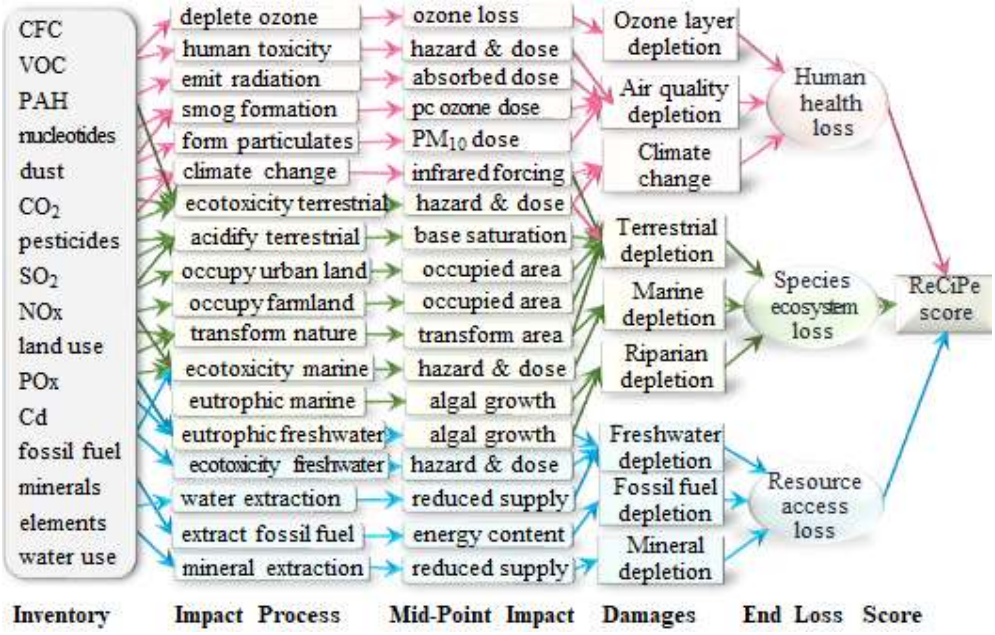

Figure 3. Schematic of ReCiPe 2009 LCIA methodology adapted from [42]

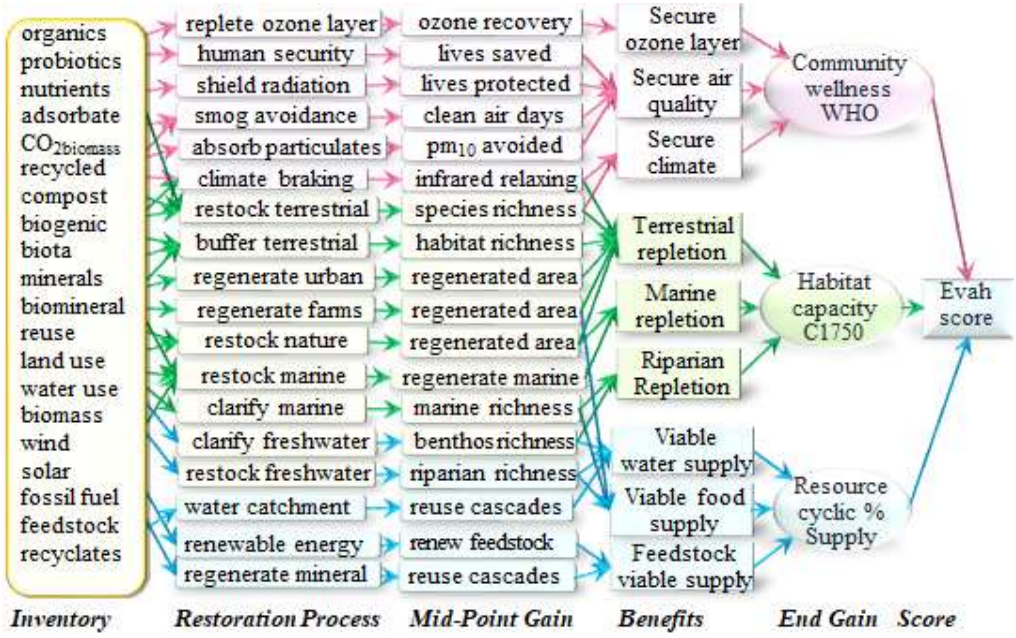

Figure 4. Schematic of Evah 2020 LCBA methodology

Direct alignment for off-sets includes:

- Climate security that addresses greenhouse emission forcing climate change
- Wellness that avoids loss of human health in death and disability lost years
- Positive ecosystem formation that replenishes ecosystem damage and loss
- Supply energy & resource viability that avoids losing access to essential resources

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7.1. *LCBA categories for assessing positive gain*

Table 1 details LCBA for viable climate security, community wellness, habitat restoration and supply security. It categorises benefit layers, factors, units and circularity scores. LCBA's Climate security (CLIMES) category includes carbon drawdown, carbon brakes, carbon banks and ozone layer repair. Hale human health Years (HALY) is time free of environmental illness and disability. Positive ecosystem replenished fraction (PERF) counts species richness and habitat security and Supply Energy & Resource Viability (SERV) counts feedstock renewability and circularity.

In natural ecology, as energy cannot be destroyed but only transformed circularity of material and energy flows is vital. Circular economies need metrics to count such flows e.g from cradle to manufacture, use, reuse, recycle, reuse, compost to cradle. Linear economy flows are from cradle quarry to manufacture, use to landfill grave.

Table 1. Evah LCBA categories, units/annum and circularity metrics

Benefit Layer	Positive Outcomes per Jurisdiction	Unit	Circularity
Climate Security (CLIMES)		CLIMES/kg	% CLIMES
Carbon drawdown	Near Term Carbon Drawdown	kg CO_{2e20}	Drawdown
Carbon Brake	Near Term Carbon in Product	kg CO_{2e20}	Braking
Carbon Bank	Far Term Carbon in Product	kg CO_{2e100}	Banking
Soil Carbon	Far Term Carbon bank in soil	kg CO_{2e100}	Soil carbon
Oxygen Safe	Photosynthetic Oxygen generated	kg O_{2e100}	Oxygenated
Ozone Repair	Avoided ozone depleting chemicals	kg CFC_{11e}	Ozonating
Hale Human Health Years (HALY)		HALY/capita	% HALY
Fresh Air	Oxygen free of particulates outdoors	kg O_2	Fresh air
Clean Air	Oxygen free of NMVOCs indoors	IAQ	Clean air
Potable Water	Rain & potable water for hydration	m^3	Clean water
Nourishment	Accessible affordable fresh food	kJ	Nutrition
Local Shelter	Household shelter Gross Floor Area	m^2	Housing
Dignity of Work	>30hrs per week paid work	Weeks	Working
Positive Ecosystem Restored Formation (PERF)		PERF/Ha	% PERF
Wildlife Safe	Wildlife corridors as refugia range	t Verge Biome	Corridors
Terrestrial Stock	Terrestrial species richness & range	t Terra stock	Wilderness
Aquatic Stock	Aquatic species richness & range	t Aquatic stock	Aqua-stock
Marine Stock	Marine species richness & range	t Marine stock	Sea stock
Urban Bounty	Preurban natural carrying capacity	t Urban biomass	Greenspace
Nature Recreation	Area for 2 days pp week capacity	Ha nature R&R	Game space
Nature Reserve	Scarce reserves restocked	t Reserve stock	Reserves
Supply Energy & Resource Viability (SERV)		SERV/capita km	% SERV
Viable Air	Access to chemical & dust-free airs	O_2 kg	Clean air
Viable Water	Refill of locally accessible reservoirs	m^3 water	Freshwater
Viable Food	Reliance on locally grown fresh food	kJ food	Sustenance
Viable Supply	Replenish local accessible resources	kg feedstock	Autonomy
Viable Fuel	Reliance on renewable fuel supply	MJ fuel renew	Bio-fuelled
Viable Mineral	Restock accessible mineral reserves	MJ Mineral	Minerals
Viable First Aid	Access to Paramedic & Medical Care	Minutes to Aid	Medics

Each category has regional benchmarks defined by pre-urban ecosystems, by World Health Organisation (WHO) wellness limits or by safe operating space within planetary boundaries. As the literature shows climate forcing emissions escalated since C1750, LCBA uses pre-urban climate security, ecosystem replenishment and resource viability benchmarks. But considering advances in modern medicine, urban sanitation and entrenched inequity, poverty and pollution the LCBA Hale Human Health category uses WHO wellness and or safe operating space in planetary boundaries benchmarks [57].

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7.2. *Safe operating space avoiding toxic tipping points within planetary boundaries*

Planetary boundaries global research maps forecast safe operating space with very low risk pollutant levels within long-term regional ecological carrying capacity [58]. They also provide near-term trends of high-risk pollutant levels nearing local ecological carrying capacity thresholds. Maps of measured pollutant levels exceeding ecosystem capacity and tipping points show where a small change making a big difference changes the global state [58]. This threshold value is a tipping point beyond which a tiny increment in a control variable triggers larger incongruous changes in feedback response in natural earth ecosystems. Exceeded climate insecurity thresholds lie in Amazon rainforests, West Antarctic ice sheets and Gulf Stream oceanic current systems.

Weidema et al argue such planetary boundaries concepts are incompatible with damage-based LCIA as they see the main purpose of such boundaries is long-term forecasting of tipping point issues [59]. Many past forecasts remain so uncertain that they should not be used as targets in LCIA. Recent evidence reported by global media, however, of already breached and imminent tipping points is so strong that it does offer risk-appropriate benchmarks for LCIA [15-19]. The precautionary principle says heed toxicity warnings.

7.3. *Charting net-benefit and net-damage*

Improvement studies using LCIA focus on reducing damages to near zero [42-53]. But LCBA studies also seek system benefits beyond zero to facilitate restoration to e.g., pre-urban ecosystem benchmarks [14, 24-35, 60-63]. The authors argue that system regeneration should be to C1750 carrying capacities rather than to say C1950 depleted capacity. For safety and to inspire hope rather than greenwashing, it is vital to show net and total damages beside net and total benefits. To avoid double-counting it is also best to clearly define if a flow is a benefit or avoided burden in or beyond a system boundary.

And according to an Industrial Ecology thesis charting partial and total results from unsustainable to sustainable to restored is also practical [63]. 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 with net-negative damages. Product A's net-benefit to regenerated nature C1770 is nature-positive. B's net-damage within carrying capacity is sustainable and C's large net-damage beyond C2020 carrying capacity is unsustainable.

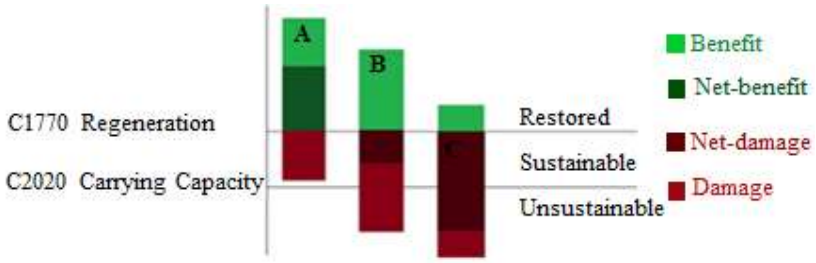

Figure 5. Charting Progress from Unsustainable, Sustainable to Restored Nature-Positive [63].

7.4. *Accounting and mathematical logic*

Balanced LCA using LCIA and LCBA offers risk benefit analysis to reveal bad to good approaches and loss to gain accounts for investment as well as balance sheets for auditing. In LCBA practice, as in real-world mathematics, science, accounting and logic, a damage or loss is a negative outcome whereas a benefit or gain is a positive outcome. In LCBA benefits are designated positive signs representing gains in security, wellness, habitat and supply. But it opposes conventional LCIA where damages are designated positive signs despite representing loss of climate, health, species or supply. In LCIA sequestered carbon is designated a negative emission flow irrespective of it producing biomass.

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8. Case studies showing LCBA + LCIA results

The authors have tested LCBA in PD builds, passive homes' infrastructure, main roads, metro systems, desalination systems, sewerage systems, office, towers, public hospitals, schools, TAFEs, university buildings, an opera house, supermarkets, residences, forestry, agriculture, events and gardens. Because of its damage focus and data limits LCA on net-positive systems is rare but the authors have also used LCBA on novel renewable microbial products such as biopolymer roofing, textiles and foam and mycelium panels.

The following cradle to grave case studies show many LCBA examples depicting a range of damage and benefit result types. These durable applications increase in scale from a light textile, to heavy flooring, to an 8-story residential waste diverter chute to a 2.6-hectare PD design. All studies complied with relevant ISO 14025 and IPCC methodologies. All input, output, product, burden and benefit shares throughout were allocated on their chemical, biological, physical and thermodynamic share of contributions.

Firstly, renewable US corn feedstock Polylactic Acid (PLA) polyester fibre in-wall thermal insulation gains may be more or less than loss from fossil-fueled power use in factories [31-33, 62, 65]. Secondly a Queensland forest fibre board sub-flooring provides long-term climate braking from carbon drawdown banked in base building stock [26, 30].

Thirdly an Australian high-rise residential chute for occupants to divert recyclables from garbage offers far greater long-term gains than losses from capital works [25-35, 60, 66]. Lastly a Brisbane Interpretive Centre PD returns long-term gains on capital works investment via renewable energy and feedstock regeneration [10, 14, 23, 34-35, 60].

8.1. Loss vs gain in climate security benefit of biopolymer feedstock vs fossil fuel power use

Polymer textiles come from a range of renewable, recycled and fossil feedstock. PLA is a very common biopolymer made from corn, sugarcane or cassava. PLA properties vary with glass transition and melt temperature comparable with Polyethylene Terephthalate (PET), Polypropylene (PP) and or Polystyrene (PS). Figure 6 compares textile life cycles of PET made from fossil feedstock and PLA from renewable corn starch. Factories make polylactide polymer from corn starch feedstock through continuous lactide polymerisation.

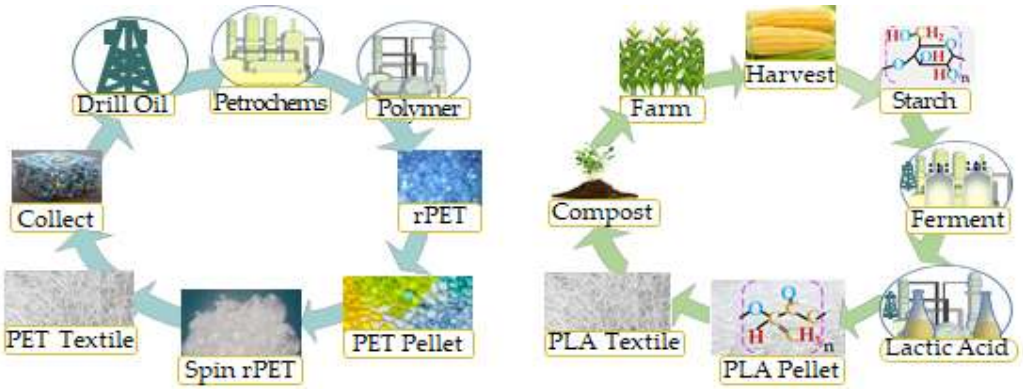

Figure 6. Textile fibre life cycles of fossil PET versus current PLA [62]

Firstly, water is removed in a continuous condensation reaction of aqueous lactic acid to produce a prepolymer that is converted into a cyclic dimer lactide and vaporised. This mix is then purified via distillation before melt crystallisation [31-32, 62, 65]. PLA is produced by ring-opening lactide polymerisation and lastly meso-lactide distilled off [65].

The growing corn plant absorbs carbon dioxide to make sugars and starch feedstock. Post-harvest, such carbon remains in the roots. The longer a PLA product is used, the longer its feedstock carbon is retained within. Built-in PLA polyester insulation stays in place as long as the building does so that carbon storage is a benefit from >20 to >100 years.

Evah modelled global warming potential (GWP) damages and climate braking benefit/ m^2 of PLA polyester insulation fabric cradle-to-grave. The study compared insulation

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fabricated in Victoria (Vic) Australia. New Zealand South Island (NZSI) and South Korea (SK) and NSW Australia. Vic grid is brown-coal-reliant and NZSI grid hydro-reliant. SK and NSW grids are black-coal-reliant with 10% to 30% renewable [31-33, 62].

Table 2 shows negative damage and positive benefit results for this insulation. In its production melt-spinning of fibre from pellets uses most energy. Grid energy use was the most significant contributor to GWP. SK and NSW made insulation emits more CO_{2eq} than PLA biomass retains so a net damage accrues. However, as NZSI-made product used mostly renewable power it has a climate security benefit from it braking global warming.

Table 2. PLA Insulation Global Warming Potential (GWP) (kg CO_{2eq100}) [33, 62]

PLA Insulation made in	Victoria	South Korea & New South Wales	New Zealand
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. Loss vs gain in climate, wellness, habitat and supply security in forest product

Like corn plants, trees also drawdown carbon, oxygen, hydrogen and nitrogen from air and photosynthesise these into e.g., carbohydrates to store as food, feedstock and structural fibre in trunks, roots and soil [62, 65]. 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 feeding residual plants and trees throughout.

Despite trunk removals, the larger mass of relic autotrophic and chemotrophic synthesisers remains in the underground habitat. Their function is retained for water supply and chemosynthesis by bacteria and fungi in synergy with algae fixing nitrogen, hydrogen, sulphur and carbon to make sugar and carbohydrate feedstocks and structural fibres [26-34, 57, 60-62]. In sustainably grown forest products, the sequestered carbon is also stored in fitout over the near-term and in building life over long-terms.

Apart from remnant roots in soil, wood in buildings can store ≤1.8kg of CO_2/kg lumber used [26, 61, 62]. Building with timber has many advantages for shock resistance, thermal insulation and pleasant indoor climate. Until the world reaches zero carbon targets biomass deposits banked in timber builds also offer time-critical climate braking opportunities to avoid imminent tipping points [26, 30, 34, 57, 60-62].

Evah has done hundreds of forest product LCAs [26-34, 57, 60-62]. Evah's advanced LCBA methods show how to account for sequestered CO_2 for durable biomass products factoring carbon drawdown, prior land-use, fire history, site fuel use and service life [26, 29-35, 61-62]. All sequestered carbon is a gain only after factoring six conditions.

If the first three conditions are unmet then none qualifies, if the second three conditions are partly met then that part qualifies [61]. These conditions include accounting for three tree regrowth cycles, forest stewardship certification, reforesting countries, wild-fire and control-burn loss, renewable fueled processes and >20-year applications.

Table 3 summarises annual gross losses and gains of FSC certified 13kg/m² particleboard use for 60 years cradle-to-grave. Circularity scores show 95% reliance on renewable feedstock and 38% on renewable energy. They also show 34% reliance each on recovered fuel and 17% on recovered water, on-site rainwater tanks and bores.

The forest product was calculated to store 38kg CO_{2eq}/m² long term for 100 years cradle-to-grave even when some was in landfill. This is because Australian landfills are typically fairly dry and aerobic so decomposition of wood and paper is slower than e.g., in wet anaerobic soils. Overall results show added biodiversity security for biota, microbes, worms, flora, seeds, wildlife and pollinators in forest habitat, soil, roots and litter.

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Table 3. Particleboard flooring /m^2 losses and gains [26, 61, 62].

Climate	Result	Habitat	Result	Supply	Result
Ozone Layer Loss	-1E-10 kg R_{11}	Ecosystem Loss	-7E-05 m^2	Water used	-108 l
Carbon Brake 20yr	47 kg CO_{2e}	Habitat gain	450 MJ	Fossil fuel used	-211 MJ
Soil carbon 100yr	26kg CO_{2e}	Habitat gain	0.1m^2	Fossil fuel loss	-12 MJ
Carbon Bank 100yr	38 kg CO_{2e}	People	result	Mineral loss	-0.1 MJ
		Health Loss DALY	-2.2 hours	Biomass feedstock	378 MJ
		Wellness gain HALY	2.0 hours	Renewable energy	144 MJ

8.3. Climate, wellness, habitat and supply security of feedstock diverted from garbage

Unlike other single chutes sending garbage to one bin this high-rise residential building garbage chute with diverter allows householders to send garbage and recyclables to separate bins. It stimulates recycling rates by making recycling easier as no unit needs a recycling bin it also avoids weekly elevator trips to take them out for collection. this then avoids need for recycling bin room per level which is a significant financial saving.

The LCA modelled an 8-storey 64-unit apartment block chute for 128 occupants with and without a diverter, over 60 years [25]. Studies showed typical Australian residential recyclate material mix and single dwelling recycling rates 22% more than high-rise [66]. Damages were modelled for recycling bin rooms versus benefits of not building them.

Table 4 summarises cradle-to-grave damages for 60 years use/1.35t garbage diverter and chute. Table 5 summarises its damages and benefits for 60 years use/m^2 gross floor area (GFA) building with and without the diverter. Overall, gains were most significant, and all benefit categories with diverter were larger than damages without. [25, 34, 60].

Table 4. Damages over 60 years use/1.35t garbage diverter [25, 34, 60].

Damages	Units	Results	Damages	Units	Results
Global Warming	kg	-874	Depletion Fossil Fuel	MJ	-577
Stratospheric Ozone	kg CFC_{11eq}	-9.9E-07	Depletion Elemental	kg Sb_{eq}	-2.38
Photochemical Smog	kg C_2HO_{4eq}	-1.45	Depletion Water	kl	-9040
Acidification	kg SO_{2eq}	-10.4	Human toxicity	kg 1,4-DB_{eq}	-3.05
Eutrophication	kg $PO_{4\ eq}$	-0.46	Particulate Matter	kg $PM_{2.5eq}$	-65063
Land Use Change	m^2 pa	-9.6E-06	Ionising Radiation	kBq $U_{235\ eq}$	-8.6E-

Table 5. Damages versus benefits over 60 years use garbage diverter/m^2 GFA building [25, 34, 60].

Viability of	Security Category	Units	Chute	Space	Recycled	Gross net
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

For a typical new high-rise residential building cradle-to-grave garbage to landfill losses were estimated versus gains in 22% diverted feedstock to recycling. Annual supply chain gains/kg diverter included 1.5TJ energy and 1.1Gl freshwater. Some habitat was retained without 2.6t PO4e eutrophication or 0.4t 1,4DBe toxicity. Each year wellness was enhanced without 100g PM10 dust and 120 mg 1,4DBe toxicity [34].

8.4. Net-positive climate, habitat and supply security from a PD building design

In 2015 a PD design in Queensland applied a carbon amortisation performance method to quantify net-positive carbon drawdown [14]. Cole cited it as a net-positive building design exemplar [24]. Baggs et al [60] describe Evah's cradle-to-grave LCIA and LCBA of that Interpretive Centre Design with 2.6 hectares of gardens for Brisbane's Ekka

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showground [14, 24, 34]. Its build used local FSC wood, steel and organic biomass with renewable ethylene tetrafluoroethylene (ETFE) Texlon roofing. Net-positive gains off set all loss compared with C1770 site ecology before settlers made it into botanical gardens.

While eutrophication called for mitigation in use, no gross damage arose from forcing climate change or stratospheric ozone loss, smog formation, particulates, ecotoxicity, acidification and ionising radiation, or depleting freshwater, fossil fuel, minerals and natural land use. Table 6 shows whole-of-life annual benefits for that centre/m^2 GFA included supply security of 30kl freshwater and 27kg renewable feedstock.

Climate security gains added 30kg CO_{2e100} long-term climate banking and 42kg CO_{2e20} near-term climate braking to avoid tipping points. Green walls lignified biomass and soil carbon deposits gained 7kg CO_{2e} with green roofs, atriums, landscapes and roots gaining 6kg CO_{2e}. Those walls generated 5kg oxygen and the remaining greenspace 4kg oxygen adding to wellness and habitat security as well as ozone layer refill. An LCBA for Australian developers of an affordable passive house design is now underway.

Table 6. Annual security benefits /m^2 GFA building.

Category	Benefit	Gain	Units	Category	Benefit	Gain	Units
Climate	Braking	42	kg $CO_{2e\ 20yr}$	People	Wellness	0.05	year pp
	Banking	30	kg $CO_{2e\ 100r}$		Clean Air	25	kg O_{2eq}
Habitat	Biomass	13	kg $CO_{2e\ 100\ yr}$	Supply	Water Renewal	30	kl
	Fresh Air	9.0	kg $O_{2eq\ 100yr}$		Matter Renewal	27	kg

9. Discussion

The paper argues that it is vital to message and quantify benefits and gains beyond damage and loss to provide people hope about the future. It contrasts negatively framed bad news versus positively framed good news messaging and reflects on how people's attraction to bad news stresses and demotivates them. It finds children, youth and people in most nations expressing concern about the climate and extinction emergency. School children who began a global XR movement demand leaders urgently adopt a regenerative culture for nature-positive development.

Most positive banners and chatter was shown to be about reducing loss rather than any positive assessment beyond zero or gaining full pre-urban natural capacity. Instead of vital full net-positive solutions for pre-urban climate security they offer valid but weaker negative options. They do not asses regeneration to steady states comparable to before anthropogenic climate forcing and biodiversity loss began rapid acceleration.

But use of LCIA remains as essential, if not even more important than ever before in history to assess loss. The study explains why most LCA practitioners still work on negative flows, messaging and reporting damages, loss and reduced loss. As conventional LCIA was developed to assess damage its methods exclude net-positive gain, LCA practitioners seeing only damaging loss rely on tools that are blind to beneficial gain.

In real-world science, math, logic and urban planning applications, a damage or loss is assigned a negative outcome whilst a benefit or gain is a positive outcome. But commercial LCIA practice attributes positive signs to loss and negative signs to gains. The application of negative bias limiting sustainability assessment to loss accounting does not pass basic logic, math and science tests when it blocks positive assessment. Absurdities ensue where -4kt CO_{2e} is read as a bad result instead of 4kt of carbon dioxide in biomass acting e.g., as safety brakes on forcing climate change. For transparent accounting LCA needs to be capable of balanced math considering both gain and loss.

The authors also identified new sightlines and pathways to invigorate strategic planning for urban design solutions. The proposed quantification solutions to support urban design recover greenspace for natural feedback loops to regain climate control and biodiversity. Quantitative LCBA concepts were introduced to facilitate understanding

applicable to broader fields of work. LCBA methods can quantify many, but not yet all, PD outcomes with scientific rigor to support, test and verify the urban design process.

The case studies show how benefit assessment also offers more holistic ways of measuring product and whole building system impacts. Transparently displaying benefits alongside damages is vital to enhance decision-making for good urban planning. Comparable biopolymer products' GWP can show net-benefit or net-damage depending on renewable energy in electricity grids. While the climate change category has received most attention and many consider it to be the most important category to track, other vital ones should not be ignored. Forest product can have many different categories of net-damages and net-benefits that may be obvious to designers and managers but not stakeholders.

Although LCA is most often used for products, it can calculate built site outcomes. The garbage diverter study showed benefits in whole-building studies that can be vital for decision-making. The PD Interpretive Centre Design LCIA & LCBA showed net-positive benefits for that urban site considering pre-urban carrying capacity. Net-positive gains outweighed losses in climate, ozone, smog, dust, toxicity, acidification, freshwater, energy and minerals as well as habitat security for its land use. An LCBA for an affordable passive house design is underway to further test how it meets all legal planning codes.

In summary the case studies show proof of concept that LCBA can offer:

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

Overall, LCBA can enable and offer planning, design and industry quantification to:

- avoid greenwashing in specifying, marketing and purchasing products or services,
- expose damages and benefits in infrastructure, town and building design,
- reveal strengths, weaknesses, threats and opportunities for urban redevelopment,
- quantify viable climate, wellness, habitat and supply security,
- report net-benefits, real gains, positive and net-positive outcomes,
- offer service providers insight to contribute to sustainable outcomes,
- reveal benefits that stimulate more nature-positive business strategies, and
- increase climate security for wildlife, cities, regions and infrastructure

10. Conclusions

The paper clarified needs for environmental reporting to include positive benefits and net benefits beyond less and zero harm. A few decades are left to resolve accelerating climate and extinction problems. Direct sightlines reveal the next steps to take include for:

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

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. There is a need to recognise that most positive chatter about work done under positive banners is blind to restoring natural steady-state climate and biodiversity integrity. Most so-called positive assessment tools reviewed excluded positive net gain to pre-urban climate security and vital net-positive solutions.

While conventional LCA work remains stuck on damaging loss and blind to beneficial gain it has a negative bias. Considering sustainable development such LCIA creates barriers for every nature-positive and or regenerative initiative. LCA can be more

balanced by supplementing LCIA with LCBA and designating positive signs to beneficial gains in security and viability of climate, wellness, wildlife and supply.

LCA practitioner acceptance of adding benefits needs to be improved as many still believe it facilitates greenwashing and distracts attention 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. An affordable passive house design LCBA is underway to further test how it meets legal planning codes.

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 of PD concepts.

LCBA can quantify many 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. Coupled with LCIA, Evah LCBA scopes a more holistic balanced approach than does conventional LCIA alone.

Unlike other quantitative methods, LCBA offers the urban development field vital ways to quantify restoration of viable climate, habitat, biodiversity and wellness. LCBA to facilitate PD are recommended in planning codes, pilot projects and iconic projects.

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