Positive LCA Factoring Planetary Boundaries

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Objectives

The aims of this work are to show and quantify:

- Ecologically sustainable development needs go beyond low & zero impact .
- LCA's reach into ecopositive life cycle benefit assessment (LCBA).
- Recovery & regeneration of safer operations within planetary boundaries.

Conclusions

LCA science, methodology and tools with a negative impact focus exclude positive benefits as well as real potential for sustainable development. Considering safe operating space for humanity, uptake of balanced ecopositive LCA theory and methods may enable envisioning and measuring sustainable development goals, gaps and gains. Preindustrial periods offer regeneration benchmarks even for urban spaces where redevelopment can yield ecosystem service equivalents for comparable territory e.g species richness and ground water retention.

Balanced LCA requires LCIA as well as ecopositive LCBA. LCBA is vital to quantify gains in human wellness, ecosystem reparation and natural capital regeneration.

Background to Problem

To sustain carrying capacity, society must ensure safe operating space distant from planetary boundaries [1]. Life cycle assessment (LCA) literature rarely considers potential for increased ecological carrying capacity addressed in fields such as Architecture [2,3]. LCA must evolve beyond impact assessment to assess architecturally 'Positive Development' in 'eco-retrofitting of the vast urban fabric we already inhabit' it. [4]

Current ISO LCA methods can address impacts of pollution and resource use [5]. Application focuses on impact, risk and loss not benefit, opportunity and gain. Typical life cycle impact assessment (LCIA) reach is negative to zero loss . Human wellness, ecosystem repair and resource regeneration is excluded. LCIA may quantify ecologically unsustainable but not sustainable development. This work extends LCA to quantify sustainable development.

Introduction to Solutions

Uptake of ecopositive LCA theory and methods may facilitate envisioning and measuring safe operating space for humanity goals, gaps and gains . LCBA is proposed to quantify gains in human wellness, ecosystem reparation and natural capital regeneration. New LCBA methods and metrics supplement established LCIA ones [7, 8 & 9]. This work was undertaken in generating Type 1 ecolabels and Environmental Product Declarations in 2016.

Scope and Methodology

The scope of LCBA extends from zero to positive outcomes e.g safe operating space outcomes or preindustrial benchmarks of C1750 [1].

Together LCIA and LCBA can produce the balanced scientific approach essential to avoid skewed LCA ignoring bad or good outcomes. Table 1 shows the Evah2020 LCBA applying to quantify:

- Hale human health adjusted life years restored improved health via avoided environmentally induced illness or disability/area/year
- Positive ecosystem replenishment formed new species, habitat, biodiversity, urban, air-shed and watershed fractions /area/year
- Supply energy & resource viability shares of renewable and recyclable supply in surplus renewable energy units/area/year

Results and Discussion

The scope of LCBA extends from zero to positive outcomes e.g safe operating space outcomes or preindustrial benchmarks of C1750 [1].

Cradle to grave, phases include manufacture, installation, floor space, operation, recovered recyclables, and repair plus end-of-life disposal for reuse and landfill.

Table 2 summarises results from LCIA and LCBA of a garbage chute servicing 4 units of 2 residents each of an 8 level apartment block. It lists loss impacts from manufacture versus gainsdiverting recyclables from landfill and floor space/chute for 60 years use.

Overall results show the system's positive gains to be far greater than negative burdens.

Balanced LCA is possible by modelling negative LCIA alongside positive LCBA. Both LCIA and LCBA are needed to conduct eco-balanced LCA (eLCA)

Further concepts, methods and metrics to assess positive benefits, goals and benchmarks are needed.

LCA cannot quantify beneficial outcomes without new data and algorithms to define native and built system gains in e.g. species richness and water retention

Table 1 EVAH 2020 Benefit Assessment Methodology & Metrics

Benefit Layer	Positive Outcomes	Unit
Hale Human Health Years		**HALY m²/yr**
Indoor Oxygen	Oxygen generation with carcinogen sequestration	IAQ m²/yr
Outdoor Oxygen	Make O_2 avoid pollutants to replenish species health	Ox m²/yr @ C1750
Low Allergen Air	Sequestration of dust, inorganics and allergens	Air m²/yr
Climate Braking	Carbon sequestration for safer climate with less damage	$CO_{2e\ 20\ year}$ m²/yr
Safe Water	Avoid toxics in effluent Toxin mg, rain Ml pp	Potable Ml pp/yr
Access	Secure food, water & rest Food kJ,H_2O Ml & Area m² pp	Access kJ Ml m² pp/yr
Household	Local supply shelter, food, water GFA, vkm work, MJ pp pa	Shelter MJ m²pp/yr
Positive Ecosystem Replenished Formation		**PERF*m²/yr**
Secure Space	Captured pollutants to protect corridors and habitat	Space m²/yr @ C1750
Bio-Stock	Balance toxins and replenish terrestrial aquatic biodiversity	Stock m²/yr @ C1750
Built Bounty	Building GFA converted to natural carrying capacity	Built m²/yr @ C1750
Urban Bounty	Urban land area converted to full natural carrying capacity	Urban m²/yr @ C1750
Secure Climate	Community soil & biomass sequester CO_{2e} & generate O_2	Clime @ C1750 m²/yr
Stock Habitat	Land native fauna, flora range biomass $O_{2\ carrying\ capacity}$	Habitat @ C1750 m²/yr
Stock Aquatic	Restock marine catchment fauna & flora range biomass O_2	Marine @ C1750 m²/yr
Secure Safety	Equity, recreation & aid crime rate+ Ha + Medical km pp pa	Safety/No 1 m²/yr
Supply Energy & Resource Viability		**SERV*MJ/yr %**
Viable Supply	Replenish concentrated & locally accessible resources	Supply MJ/yr
Viable Water	Replenish concentrated & locally accessible reservoirs	Water MJ/yr
Viable Fuel	Enhanced catchment or supply of renewable fuels	Fuel MJ/yr
Viable Reserve	Enhanced regeneration of scare material reserve stock	Reserve MJ/yr
Viable Mineral	Enhanced regeneration of finite material reserves & stocks	Mineral MJ/yr
Viable Food	Reliance on local Organic food Ha, tkm & MJ % pp pa	Food MJ/yr
Viable First Aid	Accessible Aid & Medicine Paramedic Ha, vkm% pp pa	Nurse MJ/yr

Table 2 Waste Diverter Chute Impact Versus Benefit Assessment Results

Outcomes	Security for	Units	Loss in Diverter Impact	Gains in		Gross Benefit
				Recyclate	Space	
Evah 2020 Benefits	**Score**	Points	-3,448	306,582	497	303,631
Hale Human Health Adjusted Life Years (HALY*)	**Human Wellness**	HALY	-6.8	457	0.9	451
	Dust Avoidance	kg PM_{10}	-0.09	6.28	0.02	6
	Healthy Airshed	g 1,4DBe	-0.01	7	0.011	10
	Organic Safe Air	g NM VOC	-0.03	7.8	0.02	10
	Ozone Layer Repair	g $R11_e$	-0.01	14	0.011	10
Positive Ecosystem Replenishment Fraction (PERF*)	**Climate Brake CO_{2e}**	kt CO_{2e100}	-0.07	3.8	0.01	3.8
	Water Clarification	T PO4 e	-2.00	159	0.3	157
	Ecotoxicity Avoided	t 1,4DBe	-0.15	21	0.03	21
	Ecosystem Recovery	PRF*m²*yr	-0.43	35.0	0.06	35
	Habitat Recovery	PRF*m²*yr	-0.01	0.77	0.001	0.8
Supply Energy & Resource Viability (SERV*MJ)	**Energy Recovery**	GJ surplus	-667	93530	110	92,974
	Water Recovery	Ml Reuse	-55	64877	76	64,899
	Fuel Recovery	GJ surplus	-337	4125	5.9	4,097
	Mineral Recovery	GJ surplus	-1.8	401	0.49	400
	Resource Recovery	MJsurplus	-6.0	760	1.0	755

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