



**THIRD WORLD SYMPOSIUM  
ON SUSTAINABILITY  
SCIENCE AND RESEARCH**

Sustainability Futures: Challenges  
and Opportunities Towards a More  
Sustainable World

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# **Relating the metrics of the Living Building Challenge and urban ecosystem services for regenerative design**

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# OBJECTIVES OF THE PAPER

To quantify environmental strategies and to define metrics and indicators for architectural and urban design towards a regenerative pattern for transforming cities into ecological balanced systems.



# OBJECTIVES OF THE PAPER

## SPECIFIC OBJECTIVES

1

To relate architecture and city with nature based on the approach of urban ecosystem services (UES).

2

To analyze the Living Building Challenge (LBC) in relation to the UES.

3

To identify the UES that are addressed by the LBC and how they are quantified.

4

To define a support system for architectural design that aims an efficient and regenerative performance based on the provision of UES.

# APPROACH USED

Relating the LBC 4.0 imperatives and the UES

Living Building Challenge		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
		Ecology of Place	Urban Agriculture	Habitat Exchange	Human Scaled Living	Responsible Water Use	Net Positive Water	Energy + Carbon Reduction	Net Positive Carbon	Healthy Interior Environment	Healthy Interior Performance	Access to Nature	Responsible Materials	Red List	Responsible Sourcing	Living Economy Sourcing	Net Positive Waste	Universal Access	Inclusion	Beauty + Biophilia	Education + Inspiration		
Urban Ecosystem Services	Food																						
	Raw Materials	*																					
	Water	*																					
	Medicinal Resources	*																					
Provisioning	Renewable Energy	*																					
	Carbon Sequestration and Storage																						
	Moderation of Extreme Events	*																					
	Air Quality Regulation	*																					
	Water Quality Regulation	*																					
	Global Climate Regulation	*																					
	Local Climate Regulation	*																					
	Pollination																						
	Regulation of Water Flows	*																					
	Noise Reduction																						
	Disease and Pest Regulation																						
	Waste Treatment	*																					
	Erosion Prevention and Soil Fertility																						
	Cultural	Social Cohesion and Sense of Place	*																				
		Spiritual Experience																					
Mental and Physical Health																							
Cognitive Development		*																					
Recreation		*																					
Aesthetic Appreciation and Inspiration		*																					
Education and Learning		*																					
Active Living		*																					
Supporting	Habitat for Biodiversity	*																					
	Genetic Diversity	*																					

Legend:

- Required and linked to nature.
- Acknowledged and linked to nature.
- Indirectly mentioned and not linked to nature.
- Not mentioned.
- \* UES evaluated with two or more "R"

# APPROACH USED

UES identified with two or more requirements (R) by the LBC

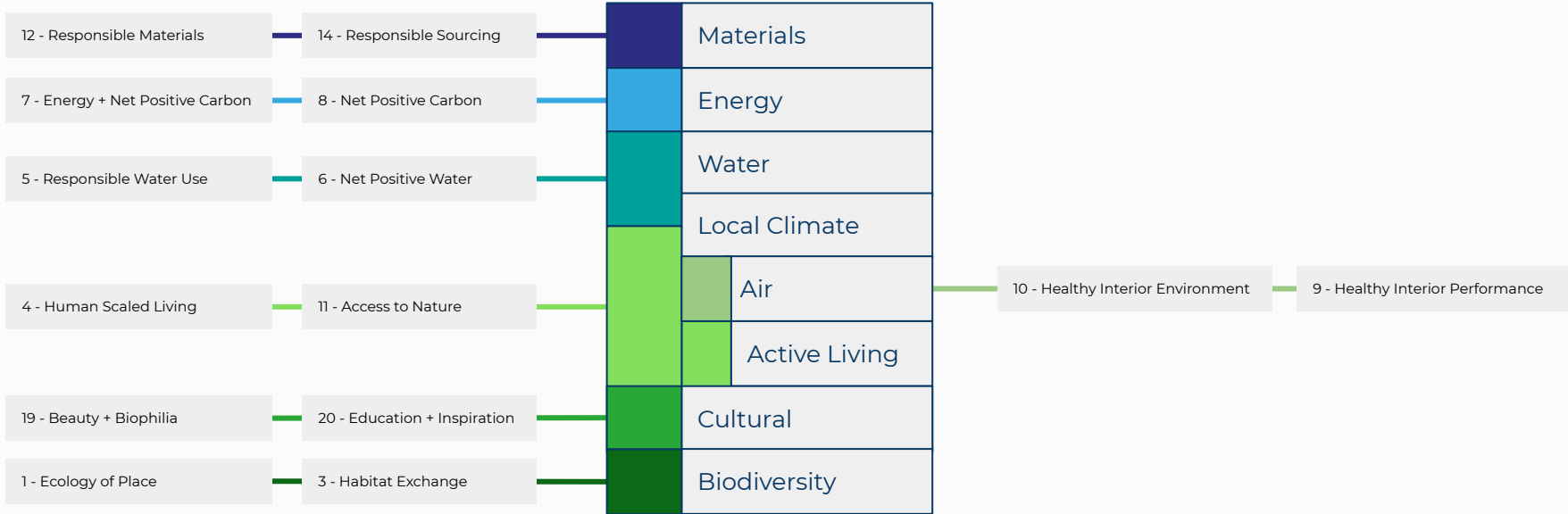
		Living Building Challenge																				
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<b>Urban Ecosystem Services</b>																						
Provisioning	Raw Materials	*																				
	Water	*																				
	Renewable Energy	*																				
Regulating	Moderation of Extreme Events	*																				
	Air Quality Regulation	*																				
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# KEY RESULTS

UES categories with the same requirements in the LBC



# KEY RESULTS

Design metrics for UES provision  
aligned with the LBC criteria

## Materials

The volume of wood and rocks; carbon dioxide (CO<sub>2</sub>) sequestration by trees (Gómez-Baggethun et al., 2013)<sup>1</sup>; account for the total embodied carbon emissions from construction through the utilization of carbon-sequestering materials and/or through a carbon offset purchase; 80% of the wood must be certified or recovered on-site and the remaining 20% must come from low-risk sources; ensure that at least 90% of new materials are Red List free; at least 20% of the materials must come from a radius of 500 km from the site, 30% must come from 1000 km from the site, 25% must come from 5000 km from the site and the remaining 25% can come from anywhere; must divert waste material from the landfill to the following levels, 100% of soil and biomass, 99% of metal, 99% of paper and cardboard, 95% of rigid foam, carpet and insulation, 90% all others, 80% of demolition waste.

## Energy

Quantify or reduction in annual energy use due to renewable sources (kWh / year or%) (LAF, 2018)<sup>2</sup>; 2 electric vehicle charging station or 1 per 30 spaces, whichever is greater; reduction in the total net annual energy in 70% in new buildings, 50% in existing buildings and 35% in interior designs, compared to existing buildings with the same typology; in new buildings combustion is not allowed and existing buildings and interior design must have a plan for elimination of combustion; the project must use renewable energy to supply 105% of their energy needs and the energy used must be measured.

<sup>1</sup> Gómez-Baggethun, E., Gren, Å., Barton, D. N., Langemeyer, J., McPhearson et al. (2013). Urban Ecosystem Services. In T. Elmqvist, M. Fragkias, J. Goodness, B. Güneralp, P. J. Marcotullio et al. (Orgs.), *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities: A Global Assessment* (p. 175–251). Springer Netherlands, from [https://doi.org/10.1007/978-94-007-7088-1\\_11](https://doi.org/10.1007/978-94-007-7088-1_11)

<sup>2</sup> LAF (Landscape Architecture Foundation). (2016). "Landscape Performance Series", from <http://landscapeperformance.org>.

# KEY RESULTS

Design metrics for UES provision aligned with the LBC criteria

## Water

Improvement protocols in aquatic habitat to ensure water; improvements in the aquatic habitat; reduction in the sediment load (LAF, 2018); change in the chemical or physical properties of interest with sensors to monitor the parameters of the properties; soil infiltration capacity or the percentage of soil covered by asphalt or concrete in relation to the permeable surface (ha); calculation of minerals (phosphorus, potassium, magnesium and calcium, for example) in mg/kg compared to soil and water quality patterns; density of coverage of vegetation barriers that separate built-up areas from the sea (Gómez-Baggethun et al., 2013), lakes or rivers; percentages of water savings, in new buildings saving at least 50% of water in relation to other buildings of the same category, and in existing buildings or interior projects, 30; water must be managed based on local hydrology, preventing the flow of sheets outside the site; potable water can not be used for irrigation and non-potable uses; water treatment and purification must be done without chemicals; avoid chemical compounds on the Red List; supply 100% of the building's water requirement by collecting rainwater, recycling the project water or another natural closed system, if it is not enough, it can be connected with the municipal water system; treat 100% of the gray and black water by reuse, closed circuit system or infiltration, if it is not enough, it can be connected with the municipal water system.

## Local Climate

Reduction in air temperature (degrees or %) (LAF, 2018); 2 electric vehicle charging station or 1 per 30 spaces, whichever is greater; minimize parking lots with impermeable surface, they should be a maximum of 20% in the Natural, Rural and Suburban Area, 15% in the General Urban Area, 5% in the Urban Center Area and 0% in the Central Urban Area; reduction in the use of vehicles powered by fossil fuels, of at least 30% in relation to the usual; percentages of water savings, in new buildings saving at least 50% of water in relation to other buildings of the same category, and in existing buildings or interior projects, 30; water treatment and purification must be done without chemicals; water must be managed based on local hydrology; treat 100% of the gray and black water by reuse, closed circuit system or infiltration, if it is not enough, it can be connected with the municipal water system; the project must use renewable energy to supply 105% of their energy needs, without combustion; post-occupancy indoor air quality tests or maintain a system that continuously monitors the air; avoid products that emit VOCs and other products that use chemicals elements from the Red List; enable natural ventilation for at least 6 months a year and access to nature.



# KEY RESULTS

Design metrics for UES provision aligned with the LBC criteria

Air	<p>Polluting flow of gases present in the atmosphere (ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide) in (<math>g/cm^2/s</math>) multiplied by the tree cover (<math>m^2</math>) (Gómez-Baggethun et al., 2013); amount of air pollutants removed by woody vegetation (weight/year) (LAF, 2018); 2 electric vehicle charging station or 1 per 30 spaces, whichever is greater; minimize parking lots with impermeable surface, they should be a maximum of 20% in the Natural, Rural and Suburban Area, 15% in the General Urban Area, 5% in the Urban Center Area and 0% in the Central Urban Area; reduction in the use of vehicles powered by fossil fuels, of at least 30% in relation to the usual; the project must use renewable energy to supply 105% of their energy needs, without combustion; particle and toxin prevention system at entrances; prohibit smoking inside the building and within 7,62 meters of any opening; post-occupancy indoor air quality tests or maintain a system that continuously monitors the air; avoid products that emit VOCs and other products that use chemicals elements from the Red List; enable natural ventilation for at least 6 months a year.</p>
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Active Life	<p>Observation of the level of physical activity practiced; increased use of bicycles, public transport and hiking (number/day); reduction in vehicle mileage (LAF, 2018); dedicate a percentage of agricultural area in relation to the total area of the project or a smaller percentage with weekly community access to healthy food (5% or 2% with weekly access in the Natural Zone, 20% or 10% with weekly access in the Rural Area, 15% or 7% with weekly access in the Suburban Area, 10% or 5% with weekly access in the General Urban Area, 5% or 2% with weekly access in the Urban Center Area , 2% or 0% with weekly access in the Central Urban Zone); 2 electric vehicle charging station or 1 per 30 spaces, whichever is greater; minimize parking lots with impermeable surface, they should be a maximum of 20% in the Natural, Rural and Suburban Area, 15% in the General Urban Area, 5% in the Urban Center Area and 0% in the Central Urban Area; reduction in the use of vehicles powered by fossil fuels, of at least 30% in relation to the usual; have flexible options for work and learning; structure with a biophilic design uniquely connected to the place, climate and culture; access to external views and natural light for 95% of regularly occupied spaces and, for the remaining 5%, opportunities for people to move to compatible spaces during the day; residential projects must have operable windows for 100% of the project's occupants; post-occupation assessment of the health benefits of the project (natural light, fresh air and access to nature) through a survey of local perception; respect the current accessibility standards; simulations that prove that the project does not interfere in aspects of the adjacent buildings, such as the quality of fresh air and access to sunlight.</p>
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# KEY RESULTS

Design metrics for UES provision aligned with the LBC criteria

## Cultural

Perception of security; perception of inclusion; perception of aesthetic values; scoring on an established visual quality scale; number of participants in educational events (number/year); quantity of cultural goods produced (LAF, 2018); participation, reification and external sources of socio-ecological memory; area of public green spaces (ha)/inhabitant (or every 1,000 inhabitants) (Gómez-Baggethun et al., 2013); dedicate a percentage of agricultural area in relation to the total area of the project or a smaller percentage with weekly community access to healthy food (5% or 2% with weekly access in the Natural Zone, 20% or 10% with weekly access in the Rural Area, 15% or 7% with weekly access in the Suburban Area, 10% or 5% with weekly access in the General Urban Area, 5% or 2% with weekly access in the Urban Center Area, 2% or 0% with weekly access in the Central Urban Zone); have flexible options for work and learning; access to external views and natural light for 95% of regularly occupied spaces and, for the remaining 5%, opportunities for people to move to compatible spaces during the day; residential projects must have operable windows for 100% of the project's occupants; post-occupation assessment of the health benefits of the project (natural light, fresh air and access to nature) through a survey of local perception; at least 20% of the materials must come from a radius of 500 km from the site, 30% must come from 1000 km from the site, 25% must come from 5000 km from the site and the remaining 25% can come from anywhere; respect the current accessibility standards; simulations that prove that the project does not interfere in aspects of the adjacent buildings (quality of fresh air and access to sunlight); provide educational materials available that describe the design and environmental characteristics of the project.

## Biodiversity

Abundance of birds, butterflies and other animals valued for their aesthetic attributes (Gómez-Baggethun et al., 2013); critical habitat area created, protected or restored for species of interest (area or percentage of total site); increase in continuous habitat area (area); increase in species richness for a taxon of interest and the abundance of a species of interest (number or %) (LAF, 2018); dedicate a percentage of agricultural area (which also attracts fauna) in relation to the total area of the project or a smaller percentage with weekly community access to healthy food (5% or 2% with weekly access in the Natural Zone, 20% or 10% with weekly access in the Rural Area, 15% or 7% with weekly access in the Suburban Area, 10% or 5% with weekly access in the General Urban Area, 5% or 2% with weekly access in the Urban Center Area, 2% or 0% with weekly access in the Central Urban Zone).

# MAIN CONCLUSIONS

- Relating the UES to design requires systemic and complex thinking.
- The LBC criteria can be used to quantify UES since the system includes the UES.
- The relationship between the metrics in the UES and LBC literature can be used as a support system for the architectural and urban design process, aiming at an efficient and regenerative environmental, social and economic performance based on the provision of urban ecosystem services.
- For future research, it may be considered the possibility to evaluate the applicability of the metrics proposed by this paper in local contexts and to compile local-based design solutions for UES provision.

# CONTACT DETAILS OF THE AUTHORS

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