[ECOLOGICAL BOUNDARIES]
Local Ecosystems Integration in Architectural Design

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Catarina Isabel VITORINO DOS SANTOS

Kuma Laboratory, Department of Architecture, Graduate School of Engineering, The University of Tokyo, JAPAN
[cat.vitorino@gmail.com]

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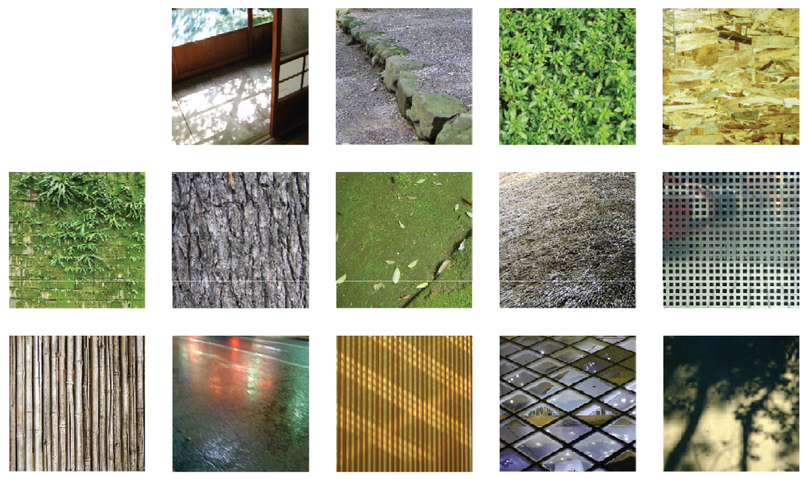
ABSTRACT

Integration of local ecosystems is one fundamental characteristic of future green architectural design, encompassing potential synergies at diverse environmental sustainability parameters, and it is envisaged, in regenerative design paradigm, as a symbiotic cooperation between ecosystem and architecture. However, the conditions and strategies for local ecosystems integration within architectural design process entail further systematization and design development.

The aim of the present paper is to propose a conceptual framework, to systematize, visualize and support further design research, regarding the possible dynamic interactions between local ecosystem valorization and the whole architectural quality parameters. Through a comparative analysis of architectural and ecosystem assessment methodologies, relevant indicators were selected, in order to express interconnectivity potential both to architectural design and local environmental regeneration. The possible identified synergies imply often an expanded perception of the built-system, and highlight the potential ecosystem collaboration, beyond environmental performance, with further design quality parameters.

Keywords: *integration of local ecosystems, architectural design quality parameters, regenerative design, ecological services and functions*



1. INTRODUCTION

In Japanese architecture, the term kyokai [boundaries (境界)] is used to address the multiple layering and intermediate spaces that characterize the ambiguous limits of its building envelope [1], dematerializing a clear frontier between interior and exterior. Accordingly, the distinction between architecture and nature is, in Japanese architecture tradition, tenuous and fluid, as between two inextricable elements, integrating concepts as shakkei [borrowed landscape (借景)].

In the present research, the term ecological boundaries, represents in a similar concept the integration of local ecosystems within architectural design, referring to the extents where the built-system limits could be envisioned and unfolded, in order to achieve this cooperation. The integration of local ecosystems within architectural design is here considered as the integration of the necessary design strategies to provide restoration and enhancement of the local ecosystem, and the symbiotic dynamic interactions established between local ecosystem valorization and architectural quality parameters.

The objective of the present paper is to systematize, visualize and provide a basis for further exploration regarding the possible dynamic interactions between local ecosystem valorization and architectural quality parameters, in order to promote design research in potential development areas, as a need for innovation is stated, both as methods and design tools [2], regarding ecosystem integration within architectural process.

2. BACKGROUND LITERATURE REVIEW

The integration with natural systems is a fundamental characteristic of future ecological architecture, providing combined assistance to material systems closed loops, maximization of passive design and renewable energy, optimization of hydrologic cycles and of indoor environmental quality [2]. Local ecosystems integration encompasses potential cost-benefit synergies, through collaboration with on-site resources, providing landscape assistance towards indoor comfort, water cycle management, amenities, local food production and resource distribution, cultural functions, and biodiversity [2]. The fact that the earth's regenerative capacity has been exceeded, in what concerns natural resources, depletion of biodiversity and farming land, and concentrations of pollution and waste [3], demands a progressive shift of architectural design practice, and building sustainability benchmarks to evolve from neutral to regenerative [4]. Furthermore, in Regenerative Design paradigm, local ecosystem integration is envisaged as a symbiotic cooperation between nature and architecture, as interconnected complex systems with mutual benefits [4-6].

Collaborative design with natural systems has been explored within landscape design and regional planning, as in McHarg's Design with Nature [7], and Lyle's Ecosystem Design [8], calling for interventions at macro-scale and bio-regional areas. Therefore, although several theories and methodologies of ecosystem site analysis and planning design were acknowledged [including the Sustainable SITES initiative [9]] an adequate transposition of those methods to the building scale has yet to be identified and consolidated. The urgency to materialize ecosystem integration in urban areas, and the conception of cities as socio-ecological systems [10], however, serve as strong support to envision the implementation of ecosystem cooperation within architectural design at micro-local scales, even at single building scale. This perspective is supported by Janis Birkeland's concept of design for eco-services, advocating the increase of ecological base in urban areas [11]. The enhancement of local ecosystems, through means of architectural design, is also expected to act as measure to reduce urban vulnerability caused by external dependency, providing tools to increase community resilience by immediate access to ecosystem services, in cities [11].

Even though an integrated perspective of ecosystem regeneration should be referenced to macro-scale structures, since more frequent urban transformations occur within individual property, building envelope and immediate landscape strategies acquire relevance to contribute positively to local ecology. Consequently a systematization of ecosystem regeneration strategies applicable to micro-local scales, is needed to provide an explorative support to potentiate these strategies in terms of architectural design.

3. CRITERIA CONSTRUCTION FOR ECOLOGY AND ARCHITECTURAL DESIGN

An ecosystem is a complex adaptive system, formed by biotic [living organisms] and abiotic [physical and chemical] elements, and their relationships intra and inter se, within a territorial unit [12-14]. While ecosystem boundaries constitute essentially conceptual limits, multiple nested ecosystems coexist within earth's global ecosystem, sharing flow inputs and outputs, processes and interactions. The purpose of integration of micro-local ecosystems within architectural design is therefore two-folded, as it aims to intervene within the immediate ecosystem, by means of restoration and regeneration, with macro-scale repercussions to the global ecosystem.

Building's environmental sustainability benchmarks, are usually constructed upon the assessment of negative impacts, rather than in potential benefits to the local or global ecosystem, not encouraging design practice into regenerative or ecosystem integrative levels. [The Living Building Change Standard, launched in 2006 by the International Living Building Institute and Cascadia Green Building Council, is an exception to the overall rule.] However, scattered individual researches, during the last decades, approached the possibility of valuing positive contributions to the ecosystem, as the checklist for design assistance, developed in 1969 by Wells: Wilderness-Based Checklist for Design and Construction [15].

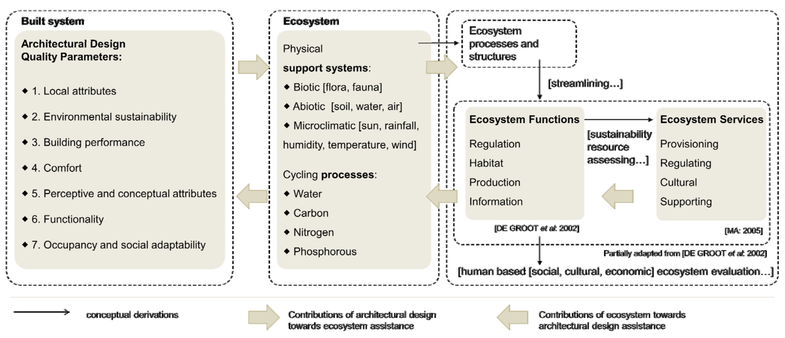
4. INTEGRATION OF LOCAL ECOSYSTEMS IN ARCHITECTURAL DESIGN

The proposed approach to local ecosystems integration aims to reach a symbiosis between the natural system and the nested built system, resulting in positive contributions from and to local ecology, while guaranteeing environmental sustainability at macro-scale. The suggested conceptual framework is thus derived from criteria resultant from: 1. design quality and sustainability assessment indicators; and 2. ecosystem services and functions.

A framework of architectural quality parameters was set upon existing Quality Indicators, Key Performance Indicators, and Sustainability Performance Indicators, critically gathered from design process tools and assessment methodologies [BREEAM, CASBEE, DGNB, DQI, Green Star, ISO21931, LEED, LIDERA, Living Building Challenge, SPEAR, and SBTOOL], that reflect the concepts in force associated with design quality and performance, including environmental sustainability. In the referred methodologies, it was observed that impacts towards local ecology are partially included, but frequently are fragmented through the diverse tool parameters, and/or comprehend a limited set of prescriptive topics, not favoring a structured comprehension of the whole local ecosystem relations.

The need of an ecosystem based assessment criteria is referred in “The application of ecosystems services criteria for green building assessment” [16], and a possible framework of architecture interaction with local ecosystems has been systematized by Suzanne Charest [13], as Ecosystem based Design. The conceptual framework to value ecosystem functions and services, developed by Constanza, De Groot et al [14, 17], and conveyed by Millenium Ecosystem Assessment [18], thus confers a comprehensive communication tool, and a simplified, analytically segmented structure, of ecosystem complex processes. Consequently, the resource to systematized ecosystem functions and services, to address both assessment and design criteria, presents relevant potential to local ecosystem integration, and has been recently analysed as a possible design basis, either to regenerative built environments [19] and landscape architecture [20].

Ecosystem services, tangible and intangible benefits human beings extract from nature, result of an ecological economics approach [12], and the possible impacts [both negative and positive] of the built system to the micro-local ecosystem don't act directly on functions or services but rather on ecosystem processes and structures [Figure 1].



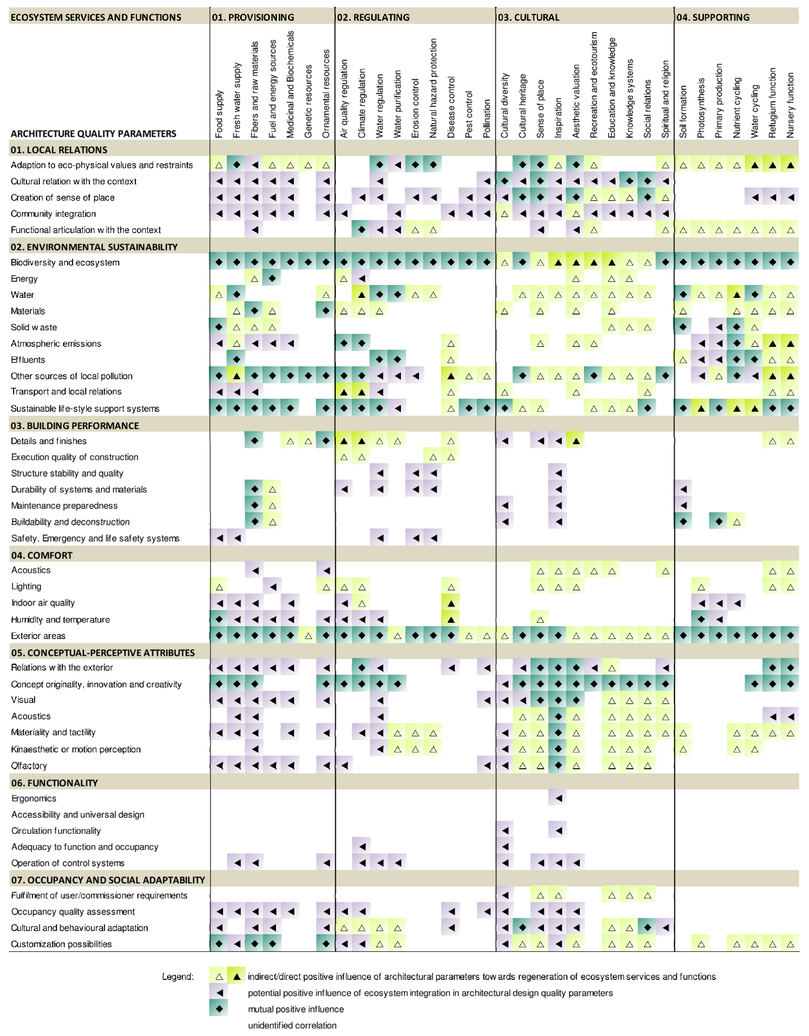
[Figure 1]. *Architectural Parameters and Ecosystem Criteria*

Nevertheless, the systematized ecosystem functions and services offer a comprehensive communication tool, and analytical structure of ecosystem complex processes. Plus, ecosystem functions and services present a high degree of equivalency, so both criteria systems were combined.

In the resulting diagram [Figure 2], architectural design quality parameters and ecosystem functions and services are correlated, in order to establish existing or possible synergies, to each factor. The diagram analyses the potential symbiotic interactions between architectural quality analysis topics and their prospective contribution to ecosystem regeneration. While some of the identified interactions might be accomplished by acknowledged green, bioclimatic, or vernacular architectural forms, others might be achieved by emerging or yet realized technologies.

The analysis highlights the possible mutual dynamic symbiotic interactions not only to environmental sustainability parameters but to other design quality aspects, and several correlations are possible to observe. 02.Environmental sustainability and 04.Comfort parameters, present a high degree of potential cooperation, either in ecosystem and architectural assistance directions. Simultaneously, the diagram also points up how 01.Local relations, 05.Conceptual and Perceptive Attributes and 07.Occupancy and social adaptability can perform to enhance ecosystem cooperation, either by developing customization possibilities that beneficiate local ecology or by potentiating the role of local ecosystem services into architectural aesthetics.

The possible strategies applicable to each case are micro-local specific, disabling the study of detailed solutions in the present study. However, several connections established with 01.Local Relations and 04.exterior areas indicators stress the dependency on macro-areas planning, to assure hydrologic and soil balance. Strategies that use the building envelope surfaces to provide additional ecosystem natural areas [vertical wetlands, window terrariums, green walls and roofs, and integrated living systems [11]], deserve attention from architecture practitioners to explore how these technologies may be potentiated design wise, and adapted to different micro-local specificities. Creative architectural solutions that deal with the diverse and successive layering of the building envelope, and elevate it to new quality standards and architectural aesthetics, are required, as predictably the frontiers between landscape design and architecture, interior and exterior, architecture and nature, merge.



[Figure 2]. *Correlation diagram of architectural design parameters and ecosystem functions and services*

5. DISCUSSION AND CONCLUSIONS

The present analysis constitutes a preliminary framework proposal of the possible dynamic interactions between local ecosystem valorisation and the whole architectural quality parameters. The present results are based on ecosystem services and functions, and in existing assessment methodologies, but other complementary parameters may be applied. The proposed framework constitutes an attempt towards integration of micro-local ecosystems within architectural design process, and is subject to future development. Considerations of the possible contributions to and from the ecosystem may vary according to user, and to the environmental context.

The difficulty of visualizing the many interdependent connections, as several qualitative and quantitative indicators are interlinked, constitutes one of the major issues to improve in future steps, as intervention scales and design strategies should be embedded. At the present stage, the proposed framework may act as a creative tool, to enhance ecological boundaries awareness, and reveal uncharted relations between local ecosystems and the built environment. It highlights the creative possibilities and the quality potential of ecosystem integration to architectural design process, which extends beyond environmental sustainability parameters.

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