博士論文

Interpretation Patterns on the Design Integration of Local Ecosystem Services in Architectural Projects

（現代建築における敷地周辺の生態系サービスと建築物の統合パターンに関する研究）

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TI[L]ES:

Interpretation Patterns on the Design Integration of Local Ecosystem Services in Architectural Projects – A multi-criteria approach with insight at contemporary buildings within and without Japan [1990-2014]

（現代建築における敷地周辺の生態系サービスと建築物の統合パターンに関する研究）

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ABSTRACT

1. Object & Research Question(s)

In architectural design, Ecosystem Integration can be defined as the promotion of, and the collaboration with local ecological services and functions, through architectural projects. The concept of Ecosystem Integration implies a mutual cooperation between architecture design solutions and the site's natural elements, presenting an opportunity to increase both the quality of the built system and the local environment. While in the fields of urban planning and landscape design, comprising regional and macro scale projects, diverse methodologies and guidelines have been advanced towards the promotion and collaboration with natural systems, at the smaller scale of architecture projects, questions about application and evaluation methods and criteria remain essentially unanswered, requiring further research development. In order to provide more sustained design assistance and project guidance for ecosystem integration, the research aims to contribute to the field with insights on the development of a design assistance support method and criteria, to *reinforce and improve local ecosystem services integration in architectural design projects*.

Considering the importance of local provision and restoration of ecosystem services through architecture projects, particularly in urban areas, to increase community resilience and health of socio-ecological systems, the underlying question to the present research is: *how can the integration of local ecosystem services be improved at the scale of architecture?* The evaluation of the integration of local ecosystem services in architectural projects unravels in two different but complementary analysis perspectives: 1) *Environmental Assessment* (with predominance of Quantitative Analysis), focusing on the benefits of ecosystem services and functions promotion, measured through objective indicators – that can be expressed in absolute values, or relative to plot size, resource use or previous state; and 2) *Design Integration* (with predominance of Qualitative Analysis), and focusing on the mutual relational effects between ecosystem services and functions with architectural quality criteria - not strictly measurable through objective indicators but mostly by qualitative interpretations.

Focusing on the questions of Design Integration, the present research suggests an assessment methodology [or *observational lens*], that is aimed to be used as a tool for thinking, to identify opportunities and provide project guidance, and evaluate different possible solutions, within a specific project, within a site. This proposed structured approach, for evaluation of design integration with local ecology is developed, in correspondence with other accepted benchmark methodologies, as the Millennium Ecosystem Assessment, based on the concept of ecosystem services [the tangible and intangible benefits from nature human beings depend for their existence and wellbeing], and it is thus designated as Ti[l]es (Tool for Integration of Local Ecosystem Services). The idea encapsulated in this framework is that design integration could be represented visually, and interpreted through the number, diversity and range of these collaborative interactions between

local ecosystem services and functions and architectural quality parameters. Within the proposed concept of Ecosystem Design Integration, our working hypothesis associates these collaborative interactions to more resilient ecological built systems, and the improvement of the project, both in terms of architecture and local ecology. As such, the initial question is disaggregated into two complementing research interrogations: 1) *How collaborative interactions between local ecosystem services and architecture quality parameters are contemporarily perceived, interpreted, and attempted?* and 2) *How the proposed framework may contribute to its understanding and strengthened implementation?*

The research aims therefore to identify how the Design Integration of local Ecosystem Services has been and is presently referred and represented in contemporary architecture projects, focusing on the time period between 1990 and 2014, following the dissemination of environmental assessment methodologies and the ongoing paradigm shift from mitigation to neutralization and into regeneration. It attempts to clarify in what ways the Integration of ecosystem services might be perceived and interpreted by design teams (including architects and environmental consultants), and explores the potentialities and limits of the application of the Ti[l]es framework [and the parameters within it] to specific project targets and by multiple users.

2. Methods

The followed research methodology entails qualitative and quantitative methods, with a structured approach and diverse interdisciplinary processes of inquiry, including case study and documental analysis, interviews and surveys, and direct observation onsite. In order to investigate the application of the proposed design integration framework, the employed methodology, based on data triangulation, is unfolded in three stages: 1) the constitution of a reference database – multiple project analysis, 2) the application of the framework to specific case study targets –single project analysis, and 3) the application of the framework by multiple users with different qualitative perception – multiple user analysis. The thesis examines 240 general reference study cases, including projects and systems within international background, from which 162 are contemporary building projects. With an insight to architectural building projects situated within Japanese context, these general referenced cases comprise 60 collaborative interactions samples in Japan, from which 3 specific case study targets are selected for experimental application of the Ti[l]es framework. The data obtained with these observations is then complemented and confronted with qualitative data surveys to an inquired panel of 30 design professionals and stakeholders, from where interpretation patterns on the design integration of local ecosystem services in architectural projects are finally derived.

3. Structure and Findings

The structure of the dissertation is organized into 4 parts: Part 1 – Ecosystem Integration in Architecture {CONTEXT}, Part 2 – Research Design Methodology {METHODS}, Part 3 – Collaborative Interactions {RESULTS}, and Part 4 – Interpretation Patterns {DISCUSSION and CONCLUSIONS}.

The present research builds up on critical background review, of theoretical, historical and methodological sources, from where it derives the *Context* of this dissertation. On Chapter 1, the constellation of terms and knowledge fields that concur to form the concept of ecosystem integration operated within the thesis are clarified, entailing the interpretation of several associated notions in the fields of Ecology and Architecture, including: Ecosystem Services and Functions, Design Integration, and Environmental and Architecture Quality Indicators.

In Chapter 2, it is analyzed how diverse forms of ecological collaborative approaches have been addressed in the course of art, architecture and broader social contexts. Focusing on the convergence to the integration of local ecosystem services within architectural practice, it is observed through a thematic organization of authors, how it might follow a rise, consolidation and finally the transition signs of a shift of environmental architecture towards regenerative design during the 20th century. An insight to the context of Japan is also provided, though a brief discussion of local key environmental issues, approaches to architecture, culture and ecology, and procedures towards ecosystem services and biodiversity conservation. The period from 1990 to 2014, covered by the present research, is characterized by the launch and generalization of building environmental assessment methodologies, and an ongoing theoretical transition from environmental mitigation benchmarks to neutralization, and lastly, into regeneration, particularly noticeable within the U.S. and U.K.

An overview of existing design assistance methods and potential resources for the application of ecosystem integration in architectural design is provided on Chapter 3. The significance of the integration of local ecosystem services is emphasized within urban systems, where ecological disturbance factors may be interpreted as regeneration priority areas to orient the focus of collaborative design. Existing methodological processes employed by relevant ecological approaches towards site restoration and local ecology integration, both used in landscape and architecture design, are also examined. Finally, a discussion and comparative analysis on commonly and prospective tools and indicators for assistance and assessment of environmental architecture and design, unveils its non-uniform character in addressing factors related to local ecology, and the difficulty of embracing qualitative appreciation within them, although it is noted an increasing tendency among many of them to provide visualization outputs that highlight its role as interpretation and thinking support.

The development of the research design methodology employed within the present thesis is explained in *Methods*. Addressing the underlying objective to *potentiate a collaborative integration of local ecosystems in architectural design*, Chapter 4 explains the general adopted methodological approach of the dissertation and explains the development of the analysis framework designated by Ti[l]es (Tool for Integration of Local Ecosystem Services). The objective of the proposed methodological framework is to clarify, identify, and interpret the reciprocal relations between architectural design and local ecology aspects. The method is projected as a potential design assistance tool, providing project guidance, identifying opportunities and evaluating different possible solutions, being based on a multi-criteria matrix diagram, or correlation framework, that references ecosystem services and architecture design quality parameters. In order to investigate the application of the Ti[l]es framework, the research design methodology comprises three methodological steps, described in Chapter 5: 1) the constitution of a reference database [multiple project analysis], 2) the application of the framework to specific case study targets [single project analysis], and 3) a qualitative data validation through the application of the framework [by multiple user analysis].

On the third part of the thesis, are presented the obtained *Results* within these analysis. In Chapter 6, the identification of collaborative interactions in multiple project reference database provides criteria and background for subsequent analysis of single specific projects and application of the tool. Chapter 7 observes the design integration within landscape and envelope surfaces of local ecosystem services and functions in specific individual projects, comparing the results obtained *inter se*, with the cumulative results of reference database, and with local ecology assessment parameters. Chapter 8 complements the precedent analysis, observing multiple user qualitative variations, and consistency verification in the use of the Ti[l]es framework, through interviews and surveys targeted to design teams and architecture field related professionals.

The possible causes and implications of the results are object of *Discussion* at the light of previously introduced topics. In Chapter 9, the inferences obtained from the 3 complimentary analysis stages, and the overall combined assumptions resultant from them, as well as the attempts to encapsulate suggestions for integration criteria and guidelines result in the subsequent *Conclusions*. The unveiled Interpretation Patterns on the Design Integration of Local Ecosystem Services indicate that to reinforce and improve local ecology integration in architectural design projects, broadly and transversally, a true necessity lies on the provision of ecological literacy instruments and on the adjustment of the mental framework of its agents.

While the design integration of local ecosystem services in architectural projects, - for its focus and reinforcement on local resources - is a promising mean to reinforce local community resilience and hazard protection in urban areas, contributing to establish positive economic synergies, the change that it proposes into architectural design is also exciting, as the attempts observed within contemporary architectural projects seem to indicate. As such, the scientific development of design assistance resources, as the proposed Ti[l]es framework, combining decision making and information functions, may contribute in the future to a full ecosystem integration, which for now is still an open possibility.

Summary of Contents

Table of Contents

List of Tables and Figures

LIST OF TABLES

LIST OF FIGURES

Note: All images by author, except where otherwise stated.

LIST OF APPENDIX

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INTRODUCTION

00. INTRODUCTION

0.1 Background

"Dwelling is the manner in which mortals are on the earth." (Heidegger, 1971, p. 3).

Our collective of humans, *dwell* now in a world where the global ecological footprint of developed countries is greater than the planet earth's biocapacity (WWF, 2008; WWF, 2010). We as well assist to an increased demand and decline of world ecosystems functions and services, essential to human well-being (MEA, 2003), and an escalation of scarcity issues, paralleled by a rising growth of urban population and of urban vulnerability trends.

Presently, urban population is "for the first time in history, more […] in urban areas than anywhere else" (Hosey, 2012, p.8). The forecasts of total urban world population in 2040, presented by the United Nations (UN), are of more than 80%, while "The UN predicts that the global population will grow from 6.9 billion in 2010 to more than 8.2 billion by 2030" (Grant, 2012, p. 52). As stated by Rogers (2001), at the turn of the millennium, it seems logic that if the consumption of natural resources lays inherently to feed these hegemonic urban systems, it is also in the city that lays the possibility of inverting its depletion.

Regardless of the sustainability awareness that superficially traverses the architecture field and the public society, the consumption of natural resources, waste and pollution concentrations, and the depletion of biodiversity and farming land, has not inverted their global intensification trends (WWF, 2008; WWF, 2010). Presently, 80% of arable land is already in use. It is estimated that by 2050, to feed the expected world population it would be necessary more approximately the surface of Brazil [2,1 billion acres] as new agricultural land. Considering the environmental impact of the construction sector and the growth rate of the world's population, by 2050 a 90% impact reduction would be necessary, requiring building sustainability benchmarks to shift from neutral to regenerative.

The depletion of ecosystems and the demand of ecological functions and services has awaken the necessity of considering in parallel with the conservation and mitigation of environmental impacts in remote areas, the restoration and provision of these same service within urban limits.

Because of it, biodiversity is a re-emerging theme in building's environmental sustainability, which has been led in the previous years by a central focus on energy, and more recently, water. As formulated by Williams (2010), "Biodiversity is not an additional option in an ideal world, but a fundamental need [...]" in urban centers and neutral buildings. In fact, some studies (as of White *et al,* 2010), stress the central role of biodiversity in assisting other ecosystem services and provide the conditions that concur to ecosystem health.

As the impact on biodiversity is intrinsically connected to other macro-scale environmental factors [as energy and atmospheric emissions, water and materials intensity and flow cycles], the micro-scale impacts on biodiversity are also co-dependent on other inputs to local ecological processes and functions, as soil formation, nutrient and water cycling, photosynthesis and primary production. The United Nations Convention on Biological Diversity signed by 153 nations at the Earth Summit, Rio de Janeiro, acknowledged officially, under the form of an international legally binding document, the universal need for the conservation of biological diversity [biodiversity], and the sustainable, equitable and fair use of its resources. Recently, 2010 was decreed the International Year of Biodiversity, and the present decade, from 2011 to 2020, has been declared by the UN, the UN-Decade on Biodiversity.

However, the decline of urban and non-urban biodiversity continues to be registered, locally. Williams (2010) refers for instance the decline of migration birds (swifts) by 29% between 1995 and 2007 in the United Kingdom. Urban ecology and urban biodiversity represent fundamental aspects of the sense of time and the sense of place [and therefore related with, and part of, "responsive" architecture and urbanism]: cicadas and swifts in summer, etc., and roles in local ecosystem functions and services. "Swifts screaming round the rooftops must be one of the most evocative sounds of summer." (Helen Phillips in foreword to Williams, 2010, p. vii)

Along with bioregional and ecological network planning, on-site landscaping and open green naturalized spaces are necessary to regenerate local urban ecologic systems, although, sometimes, as referred by Grant (2012), there is not even space "for street trees". Such is the case of "the City of London (the historic core of London) [where] a combination of narrow, often medieval streets and modern underground services means that frequently the only opportunities for greening are on walls and roofs". (Grant, 2012, p. 122). "This approach leads to a blurring between the public and private realms, especially at street level, and an increasing reliance on the buildings as the platform for urban greening." (Grant, 2012, p. 122) and demands for new solutions in architectural and planning projects.

Simultaneously, ecological thinking, and sustainable design, might be considered to remain marginal in the framework of current architectural practice. While the role of the architect is changing, and the contours of the profession restructured, as the need for new construction is decelerating in European, and other developed urban centers, demanding more of participative processes, refurbishment of the existing and other more “immaterial” interventions (Coelho, 2012), and as result of parametric design, regenerative design, and others, resulting in an increasing role of the architect as an agent, or facilitator.

Conceptual approach and affiliation

The changing character of the binomial relations human-nature, culture-nature, city-nature, and architecture-nature, result from intrinsic philosophical perspectives, that are rooted on the observation of the results of human societies to the natural context, and of the sense of contrast and sometimes loss [found for instance in the essence of the concept of heritage, both natural and cultural, as stated by Françoise Choay (2001)]. “Art and architecture have in the course of their long histories repeatedly had recourse to nature as paradigm for their activity.” (Mateo, 2007, p.1) The same can be said about nature as context, particularly in architecture but also in other artistic expressions. The present research assumes nature as paradigm, but inherently as context, not only of architecture but of whole human existence and activities.

An important driving force of the research project is rooted on the paradigm shift, within built environment sustainability, purported by regenerative design [which concept “[…] relates to approaches that support the co-evolution of human and natural systems in a partnered relationship. […] by the ways that the act of building can be a catalyst for positive change within the unique ‘place’ in which it is situated.” (Cole, 2012a, p.1). Consequently, it is embedded in regenerative design concepts, notions, and approaches. Based on the concept of humanity as integrant part of nature, an important key input of regenerative paradigm into architectural design [as compared to conventional green and sustainability perspectives] is to aim for effective positive contributions from architecture to nature [instead of seeking a mitigation of impacts], in a co-evolutionary partnership (cf. Reed, 2007; Cole, 2012a; and Du Plessis, 2012).

The research assumes that human systems are inherent part of nature, and cities itself constitute socio-ecological systems, as summarized by Du Plessis (2012), and others. This perspective presuppose as well an holistic approach towards the vision of triple bottom line of sustainability as concentric circles [nested bottom line], presupposing an overarched hierarchy and connectedness, where economic and cultural spheres exist within the social human sphere, which exists, depends on, is part of, and interacts within global environmental natural sphere.

In this sense, ecosystem services and functions, although being essentially an anthropocentric concept, represent in essence the *ties* that connect us, with the remaining elements of what we call nature. Underlying the philosophy of the present thesis is also the concept of resilience. Aware of the vulnerability risks encapsulated in technology dependent solutions and societies, and of distant resource sourcing, the thesis is also sustained on the importance of local, and site specific approaches.

Architectural integration

Among the motivations of the present research lays the need for a design integration of ecosystem functions and services in architectural projects that respects the multiple facets of architecture quality, including the aesthetics or the conceptual. As referred by Lee (2011), aesthetics oriented design research is still, within the field of sustainable architecture, very limited and represents a short intersection segment.

Explorations of specific sustainable building materials and technologies, as PV solar panels, have been motive of experimentation for aesthetic oriented design architects, and academic work and institutional research regarding the possible aesthetic and functional integration of these elements have been carried, as the example of the European Energy Agency SHC solar tasks. Likewise, the discourse of sustainable building design and ecological architecture has been focused in the last decades in very specific topics, as energetic conservation and atmospheric emissions issues, carrying with it the development of new materials and systems. As the discourse and efforts of sustainable development and nature conservation shifted from local degradation to global impacts, as referred by Grant (2012) and Edahiro (2011), the valorization of local ecosystems, within aesthetical, conceptual and perceptive orientation, has been waning relevance.

Simultaneously, the disconnection, in part brought by environmental sustainability assessment ratings, with other design quality areas, has for long concerned designers and critics. Architecture is a multidisciplinary field, and builds up with the inputs of several specialists, where the architect more and more develops as a role of a facilitator. As referred by Grant (2012, p. 62) "Those of us who have promoted the universal importance of green infrastructure or ecosystem services will be familiar with the difficulties faced when dealing with specialists who feel that such issues are outside the scope of their work or irrelevant to their task." In other cases, it is left to the environmental consultant, the ecologist, or the landscape architect to deal alone with these tasks, and sometimes as antagonism to all other design fields. The chances of achieving quality design integration results in these cases becomes much more reduced, as also Williams (2010), refers to the importance of considering local ecology factors, as biodiversity, earlier during design process. What is proposed in the present thesis hopes to help overcome these barriers, by providing a communication and thinking tool, during design work plan, that is specifically centered on design integration of local ecosystem parameters.

Knowledge gaps in Ecosystem Integration

The identification of a knowledge gap in local ecosystem integration is already stated by Grosskopf & Kibert

(2006), as a need for innovation, both as methods and design tools, and of fully developed examples, in practice, of local ecosystem integration in architecture. Concurrently, the terms in which local ecosystem integration and collaboration may be accomplished and assessed are not sufficiently systematized, and the whole range of potential synergies was not systematically explored. The conditions and strategies for a collaborative integration of local ecology within architectural design demand, then, further systematization and design development.

The need for systematization and research development in this area is particularly noticeable for micro urban scale (building, building envelope and immediate site) interventions. Collaborative design with natural systems has been object of study, particularly within the fields of landscape design and planning - as in Design with Nature (McHarg, 1969), Regenerative Design (Lyle, 1994) and Ecosystem Design (Lyle, 1985) -, and mainly related to interventions at bio-regional and macro scales. Several theories and methodologies for ecosystem site analysis and planning design were also acknowledged - including the Sustainable SITES Initiative (2009) -, but an adequate transposition of those methods to single building scale has yet to be identified and consolidated.

Although a macro-scale approach is fundamental for regenerative and up-cycle design, and urban planning and neighborhood strategies are required in order to achieve certain environmental benchmarks, there are many reasons why ecology integration must and should be thought at micro scale, as well. First, because micro urban scales correspond to the most frequent, and numerous, property units and project development dimensions in urban environments, as urban transformations occur frequently within individual property.
Second, because of their micro scale characteristics, they result in a bottom-up, self-organizing approach towards ecology integration that under certain conditions, might be faster to implement or grant results. As result, design options incorporated in architectural projects of micro urban scale (building, building envelope and immediate site) present relevance potential to contribute positively to local ecology, in a bottom-up approach – as proposed by Lerner (2003) in Urban Acupuncture, regarding the impact of small functional interventions in city's socio-ecological system.

0.2 Object, Objectives and Method

Ecosystem Integration, in architecture, is defined, within the present dissertation, as the simultaneous promotion and collaboration of local ecological processes, services and functions, with architecture design aspects, namely assisting and being of assistance to increase performance aspects of the built system. The concept of Ecosystem Integration entails, thus, a mutual cooperation between architecture design quality and sustainability criteria with onsite natural resources, presenting global and local environmental benefits.

Consecutively, ecosystem integration encompasses, at the same time an opportunity to improve architectural projects, while increasing the local ecological base within cities and built environments, contributing to urban resilience and human wellbeing.

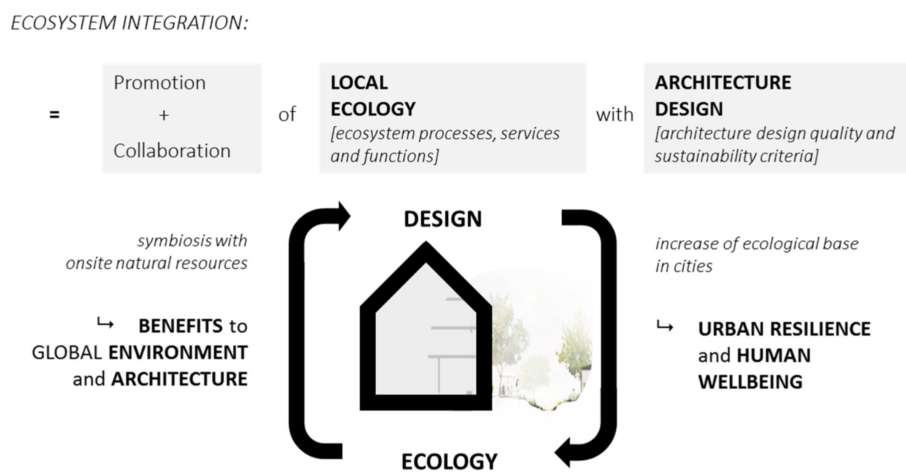


Figure 1. Ecosystem Integration

Considering the background importance and the research need towards this topic, the underlying objective of the dissertation is to contribute to *reinforce and improve local ecosystem integration in architectural design projects*. Namely, the research aims to contribute to the field with insights on design criteria, methods and guidelines, and in the absence of substantiated specific frameworks for its analysis, the consequent first question of the research (*how can the integration of local ecosystem services be improved at the scale of architecture?)* leads to another problem: *how is it possible to assess the level of ecosystem integration within a project?*

The evaluation of the integration of local ecosystem in architectural projects might be unravelled in two different but complementary analysis perspectives:

1) *Environmental Assessment* (with predominance of Quantitative Analysis), focusing on the benefits of ecosystem services and functions promotion, measured through objective indicators – that can be expressed in absolute values, or relative to plot size, resource use or previous state;

2) *Design Integration* (with predominance of Qualitative Analysis), focusing on the mutual relational effects between ecosystem services and functions with architectural quality criteria - and not strictly measurable through objective indicators but mostly by qualitative interpretations.

Focusing on the Design Integration of Local Ecosystem Services in Architectural Projects, and in response to the enunciated questions, the present investigation attempts to deliver a methodological framework to translate this intrinsically qualitative information, into a shareable and operative analysis support format, that is used as observational lens into the research, a Tool for Integration of Ecosystem Services (Ti[l]es).

ENVIRONMENTAL ASSESSMENT:

QUANTITATIVE:
measures the promotion of ecosystem services and functions [expressed by objective indicators]

DESIGN INTEGRATION:

QUALITATIVE:
expresses the relation of ecosystem services with architectural quality criteria [expressed by subjective evaluation]

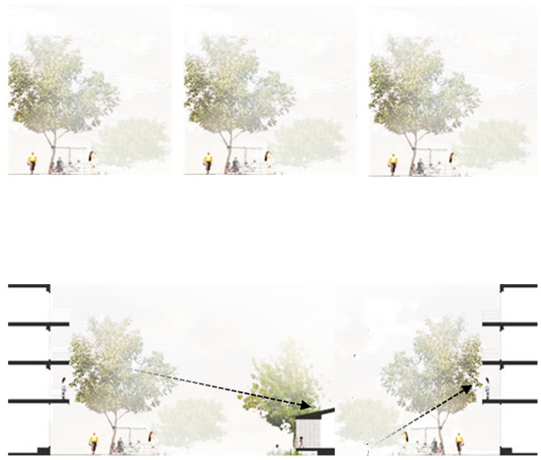


Figure 2. Ecosystem Integration – Levels of Analysis

In this framework, each of the architectural design quality parameters is related to each of ecosystem functions and services, in order to identify possible collaborative interactions [positive connections established between the promotion of local ecosystem and architectural quality criteria]. Within the proposed concept of Ecosystem Design Integration, our working hypothesis associates these collaborative interactions to more resilient ecological built systems, and the improvement of the project, both in terms of architecture and local ecology.

As such, in relation to the purpose of the research - the improvement of the integration of local ecosystem services at the scale of architecture - two complementing central questions emerge:
1) *How collaborative interactions between local ecosystem services and architecture quality parameters are contemporarily perceived, interpreted, attempted?*
2) How the proposed framework may contribute to its understanding and strengthened implementation?

Other secondary research questions addressed in the present research include also the following:

- Which patterns can be presently found between local ecosystem services and architecture quality parameters, through representation in contemporary projects and individual qualitative perception?
- What influence local ecosystem integration performs at architectural design level?
- What associations exist between the *quantitative* support of local ecosystem services, and the *qualitative* relations established with architectural parameters?
- What are the differences, major obstacles and opportunities in the perception and communication of ecosystem services and functions integration within different stakeholders (architects, consultants, landscape designers)?
- What are the present opportunities and barriers for the integration of local ecosystem functions and services in architectural design?

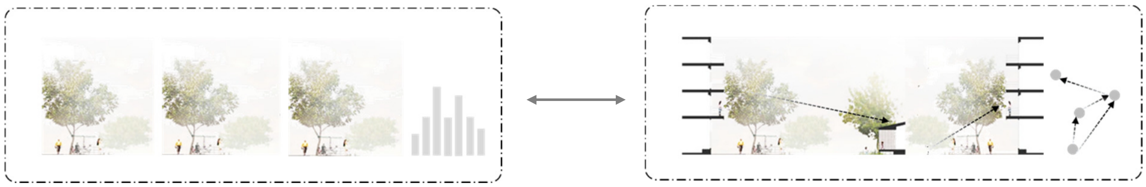


Figure 3. Relations between Ecosystem Integration Quantitative and Qualitative modes

The scope of the present thesis is essentially exploratory in its objectives and approach. The followed research methodology entails qualitative and quantitative methods, with a structured approach and diverse interdisciplinary processes of inquiry. In order to investigate the application of the proposed design integration framework, the employed methodology, including case study and documental analysis, interviews and surveys, and direct observation onsite, is unfolded in three stages: 1) the constitution of a reference database, 2) the application of the framework to specific case study targets, and 3) the application of the framework by multiple users with different qualitative perception.

In the first stages, the focus of analysis is drawn on projects, through documental sources. The proposed framework is used to examine the design integration of local ecosystem services in architectural projects, particularly during the time frame between 1990 and 2014. This particular chronological period is chosen, as it entails the widespread mainstreaming of sustainable architecture and environmental policies, the launch and consolidation of voluntary and market building environmental assessment methods, and finally the imminent conceptual revision of the ecological architecture benchmarks and directions, namely expressed through the regenerative design paradigm.

Among the international reference case studies, a specific insight is there drawn onto the context of Japan, where specific target projects are examined through the application of the proposed Ti[l]es lens, substantiated with field survey. The selection of this particular country is justified for different inter-related reasons, among which we highlight: as one of the prominent economies and developed countries in the world, Japan is regarded too as one of the leading nations in sustainable construction research. CASBEE is widely recognized amongst Sustainable Building researchers to particularly give attention to large scale systems, extending environmental assessment to the relationship established between the building itself and the surroundings, to urban development or existing areas. The role of Japan in sustainable building commitment is identified too by local legislation frameworks, like Tokyo Green Plan, including mandatory bills towards heat island mitigation that instigate the installment of green roofs, besides being supported by extremely advanced technology and research. On the other hand, modern, post-modern and contemporary architecture in Japan presents an exceptional ground of authors and theories, with a significant international projection and admiration. Also, fully founded or not, Japanese architecture and Asian culture, have long been referred in the 20th century, for its traditional philosophies and contemporary integration towards nature, which is mirrored in the regenerative design concept of human beings as stewards of earth ecological systems, and of which the *satoyama* and *satoumi* settlement organization and the developed research on socio-ecological landscapes, ecosystem services and human wellbeing carried by Japan Satoyama Satoumi Assessment is an encouraging example.

In subsequent methodological stages, the methods of analysis for qualitative data survey and research methodologies are inductive from cross comparison and the identification of answer patterns, in individual analysis of specific case studies. Rather than testing a pre-formalized hypothesis, this analysis follows an explorative approach towards the results, centered on the issues of reliability [consistency], and variability, permitting the identification of degrees of reliability, case by case. The results of the combined analysis intend to provide answers, and the formulation of guidelines, for a more informed and reliable application of the Interpretation Tool, and of design integration of local ecosystem services.

0.3 Significance and Limits of the Research

The present thesis distances itself from precedent studies on architecture and nature, environmental architecture, and regenerative design, by focusing on synergies with local ecology, and its specific design implications, for a potential implementation in urban areas, on micro-urban scale. The systematization of the symbiotic interactions between local ecosystem regeneration and architectural quality parameters provides an opportunity to collect an unprecedented set of specific architectural case studies that hadn't been related or gathered together, and studied under the perspective here presented, proposing a new reading on existing projects, and the possibilities of ecosystem integration in them.

The analysis tool developed by the research project also permits to highlight potential unexplored synergies for project development in the future, and perform as a tool for thinking during design process. As previously identified in literature review, the present study is designed to fill the identified knowledge gap, regarding symbiotic integration of local ecosystems within architectural design, at micro urban scale, and the need to regenerate ecosystem services and functions in urban areas, as mean to increase urban resilience and contribute to regenerative built environments.

The research's significance also addresses social and practical problems, providing support for the regeneration of local ecosystem services and functions in urban areas. Developing tools to minimize urban vulnerability and external dependency, contribute to increase community resilience, health and well-being, lower ecological footprint in cities, and influence the perception of resource use limits and ecosystem inter-dependency to urban populations.

The originality and significance of the thesis to the research field includes its contribution to fill the identified knowledge gap, regarding local ecosystem regeneration within architectural design at micro urban scale, and presents a distinction from other precedent studies on architecture and nature, environmental architecture, and regenerative design, by focusing on a design perspective. The relevance of the present thesis to the profession and practice of architecture is to provide design assistance methods and systematized information for a more effective integration of local ecology, suggesting guidance for an emerging topic, not yet satisfyingly addressed in the field.

The conceptual point of departure of this dissertation proposes a perspective to look at architecture as a nested piece within a local socio-ecological system. Its methodology suggests a [re-]definition of ecosystem design integration as an architecture of relationships [as a complement or rather than an architecture of quantification]. Lastly, the present thesis and its ecosystem integration assessment methodology proposes a different concept of looking at ecology and architecture - that is based on local relations, on the rehabilitation of local ecological structure, and on the promotion of local ecological services and functions. It is a method that links directly local ecology concerns with architecture quality parameters, through a perspective of design integration, highlighting the existing interdependence and beneficial relations between them.

Scope and Limits of Analysis

The focus of the present research looks at the collaborative interactions established between ecosystem services and architecture performance, at local scale, with incidence during building lifecycle operation stage [as sketched on Figure 4]. The spatial and operative limits of the research object, - even though attending to broader ecosystem macro-scale influence - are drawn on design solutions and synergies, that are relevant at micro scale, focusing on building, building envelope and immediate site.

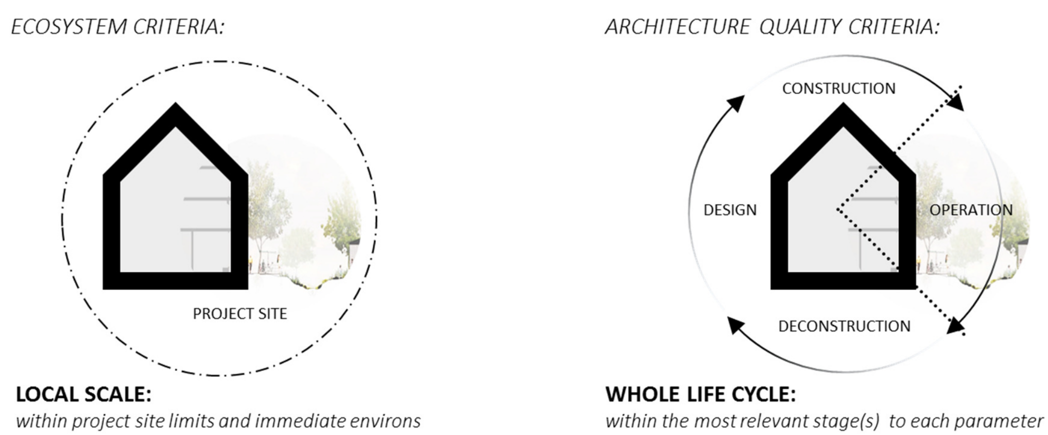


Figure 4. Research Boundaries and Scope of Analysis

The present research doesn't substitute bioregion and neighborhood scales to sustainable development, or other possibilities of architectural enhancement or environmental performance of buildings. Nor doesn't intend to provide a methodology for regenerative design or constitute a design assessment or rating tool, but to offer a possibility to inform and provide assistance into the design thinking process. The focus of the research aims to analyze how architectural design [and in particular different architectural design parameters] respond to its given ecosystem context.

Simultaneously, the research doesn't intend to compare different micro-local ecosystem integration solutions or strategies as their effectiveness varies case by case, depending on site and project specific constraints and opportunities. The present thesis also abstains from discussing material construction questions or specifications, that cannot be anything but local or site specific. It focus on design integration and design assistance methods, that may provide overall guidance for ecosystem integration in early design stages, and set and communicate design priorities, not substituting as well the co-work with a local ecology expert within the design team. The research contributes to the knowledge on the subject by identifying, though, the interdependent role of a broad range of architecture design quality parameters towards the integration of local ecosystem services.

0.4 Summary and Structure

The structure of the dissertation is organized into 4 parts, that develop into 10 linked chapters the analysis and interpretation of local ecosystem services design integration in architectural projects, as follows:

- Part 1 – Ecosystem Integration in Architecture {CONTEXT}
- Part 2 – Research Design Methodology {METHODS}
- Part 3 – Collaborative Interactions {RESULTS}
- Part 4 – Interpretation Patterns {DISCUSSION and CONCLUSIONS}

Introduction. In the present section, it is exposed the overall research background, the motivations and need of the present study; the object, objectives, and method; the organization and structure of the dissertation, and the significance, scope and limits of the research.

Part 1. Part 1 [Ecosystem Integration in Architecture] presents the CONTEXT of the research. In Part 1, it is fundamentally presented the literature review, providing descriptions of critical key concepts and an overall contextualization of the research, including theoretical, methodological and circumstantial frameworks. Chapter 1 provides a roadmap to the concepts and terminologies where the formulation of Ecosystem Integration in Architecture takes root. Chapter 2 examines the contexts of emergence of integration of local ecosystems in architectural projects, analyzing key authors, theories and practices. Chapter 3 discusses precedent researches and existing auxiliary methods, providing a critical discussion on operative literature.

Part 2. Part 2 [Research Design Methodology] clarifies the METHODS of the research. In Part 2, it is described the methodology used in overall research design, data collection tools, and methods of analysis. Chapter 4 introduces the proposed model and criteria for Ecosystem Design Integration [Collaborative Interactions framework], from where the analysis of Design Integration of Local Ecosystems functions and services is derived including description and selection of ecosystem services and functions indicators, architecture design quality and performance parameters, and general application of the proposed method. Chapter 5 details the implementation of the research instruments and methods of analysis, through 3 sequential and complimentary research stages: reference database-multiple project analysis, tool application-single project analysis, and qualitative data validation-multiple user analysis.

Part 3. Part 3 [Collaborative Interactions] presents in detail the RESULTS of the research. In Chapter 6, the identification of collaborative interactions in multiple project reference database provides criteria and background for subsequent analysis of single specific projects and application of the tool. Chapter 7 observes the Design Integration of local ecosystem services and functions in specific individual projects, comparing it with local ecology objective parameters and with surface and envelope design. Chapter 8 complements the precedent analysis, observing multiple user qualitative variations, and consistency verification in the use of Ecosystem Design Integration framework.

Part 4. Part 4 [Interpretation Patterns] provides the DISCUSSION and CONCLUSIONS of the research. In Part 4, are discussed the possible causes and implications of the results, at the light of previously introduced topics. Chapter 9 introduces the inferences obtained from the 3 complimentary analysis stages, and the overall combined assumptions resultant from them. It also attempts to encapsulate suggestions for integration criteria and guidelines, derived from the precedent analysis. In Chapter 10, Conclusions, are summarized the main outcomes and findings of the thesis and provided an outlook for future research.

Appendix. In Appendix are presented, in complementarity to the dissertation, the detailed data collection tools and materials:

Appendix I. Catalogue of Reference Study Cases

Appendix II. Design Integration Reference Database

Appendix III. Specific Case Studies Data Records

Appendix IV. Pilot Questionnaire, Interviews and Final Questionnaire: Script, Information Materials and Raw Data

PART 1.

ECOSYSTEM INTEGRATION IN ARCHITECTURE
[CONTEXT]

01. CONCEPTS AND TERMINOLOGY

1.1 Key Concepts Outline

The present thesis focus on Ecosystem Integration in Architectural Design, building up on several keywords, concepts and expressions that constitute its theoretical background and basis. Understanding Ecosystem Integration in Architectural Design as a mutual promotion and collaboration between Local Ecology within Architectural Projects, entails the clarification of several associated notions in the fields of Ecology and Architecture, as well as bridging concepts that pertain to both fields. The fundamental key concepts implicit in the development of the thesis are defined in the present chapter, including the explanation of the proposed methodological framework, predominantly based on the ideas of Ecosystem Services and Functions, Design Integration, and Environmental and Quality Indicators. A roadmap of the connections between the auxiliary terms and knowledge fields implicated in *Interpretation Patterns on the Design Integration of Local Ecosystem Services in Architectural Projects* is depicted in the following Figure.

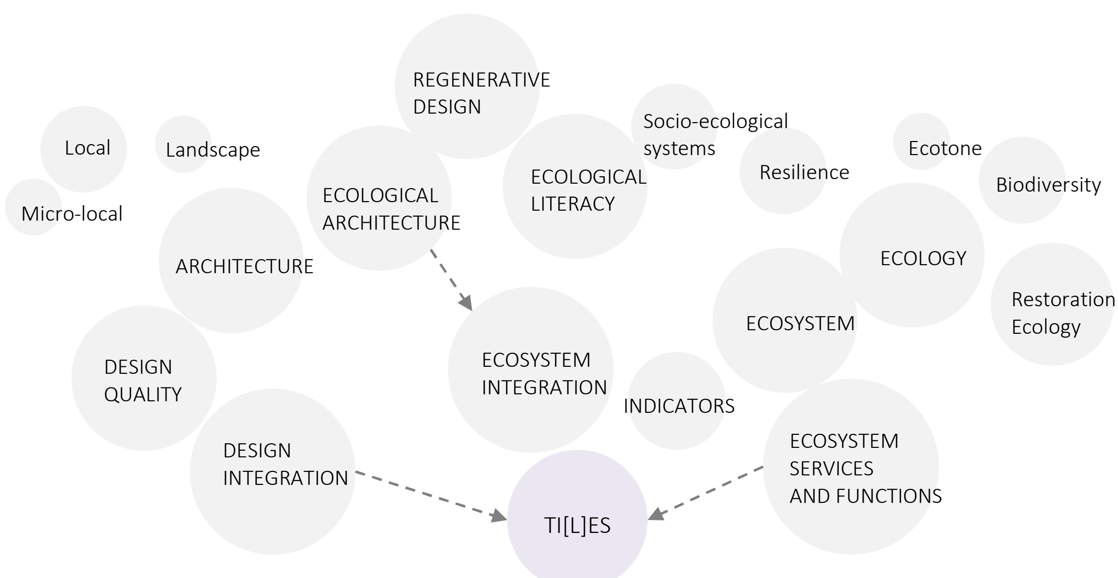


Figure 5. Keywords and terminology roadmap.

1.2 Ecosystem Integration and the TI[L]ES Framework

Ecosystem Integration.

The central proposition of Ecosystem Integration is the preservation and restoration of local ecological features, which in combination with adequate project design integration, contribute to increased performance in architectural quality.

The expressions *integration with local ecosystems* or *integration of natural systems* were used, particularly by Charles Kibert, to refer to the integration of specific site ecology and landscape features, *within architectural design* process, in order to establish positive synergies and upgrade environmental and overall performance (Kibert *et al*, 2002; Kibert, Grosskopf, 2006), although other ecological design authors also allude to the same idea under different terms (cf. Lyle, 1994; and McDonough, Braungart, 2002a). The integration of local ecosystems, is referred in *Radical sustainable construction: envisioning next-generation green buildings* (Kibert, Grosskopf, 2006), as a fundamental characteristic of future ecological architecture and one of the *"key strategies for radical green buildings"* (Kibert, Grosskopf, 2006).

As part of *construction ecology* (Kibert *et al*, 2002), *ecosystem integration* is and encompasses the possible advantageous landscape and local ecosystem assistance in heating and cooling passive processes, water cycle management, provision of environmental amenities, local food production and resource distribution, cultural functions, and biodiversity enhancement (Kibert, Grosskopf, 2006). It refers to the integration of specific site ecology and landscape features, within architectural design process, in order to establish positive synergies to improve the environmental performance of buildings.

The concept of *ecosystem integration* is formed in a context where the concerns over the depletion of natural resources, biodiversity and farming land, and concentrations of pollution and waste, demand a progressive shift of architectural design practice and building sustainability benchmarks, developed in the last decades, to evolve from neutral to regenerative (Reed, 2007), thus being ecosystem integration an integrant part of *regenerative design*.

In the present study, ecosystem integration is addressed simultaneously as the promotion and collaboration of local ecology with architecture design, referring to the implementation of strategies within architectural design that contribute to local ecosystem regeneration, and the reciprocal positive interactions established between local ecosystem aspects and architectural quality parameters. Consequently, a methodology for assessment of ecosystem integration in architecture implies both quantitative and qualitative analysis of the ecology-architecture collaboration system, and is here tentatively expressed through ecosystem services and functions, and architecture quality indicators.

In this interpretation, *ecosystem integration* is considered a fundamental part of deep ecological design although the architecture quality parameters to which it is linked are in fact broader than exclusively environmental performance assessment. As such, ecosystem integration stands as a powerful tool to reconcile architectural projects agenda with local and site-specific adequacy, ultimately contributing to improve the global sustainability and quality of our built environments.

TI[L]ES.

TI[L]ES stands as acronym of Tool for Integration of Local Ecosystem Services in Architecture, and it embodies the proposed methodological framework, representing the Design Integration of Local Ecosystem Services, as beneficial relations between the local provision of ecological processes and Architecture Quality Parameters. The designation of this framework alludes simultaneously to the word *tiles* [in the way it represents complex information in a tessellated structure], and also to *ties* [as links and connections between ecosystem and architecture elements], and emphasizes the *L* of *local* specificity and on-site ecological response and capacity.

Figure 6. Concept Reference of the TI[L]ES Framework [tiles of the Royal Alcázar of Seville].

The TI[L]ES methodological framework is used to translate intrinsically qualitative information [Design Integration of Local Ecosystem Services], into a shareable and operative analysis support format, that is used as observational lens into the research. The TI[L]ES framework is aimed to provide a design assistance instrument, or a tool for thinking, identifying opportunities or valuating different possible solutions, within a specific project, within a site. In the suggested method, selected ecosystem and architecture quality criteria are referenced in a matrix diagram, enabling subsequent analysis on how these parameters are linked to each other. In the resulting grid, positive collaborative interactions may be identified, when each of the design quality parameters is related to each of ecosystem functions and services in unidirectional or reciprocal positive manner. In this framework, the concept of *ecosystem integration* is tentatively interpreted and expressed by the number, diversity and range of collaborative interactions between local ecosystem services and functions and architectural quality parameters. As such, it is provisionally assumed that the greater collaborative interactions achieved, more resilient is the ecological built system, and increased the project performance, both in terms of architecture quality and local ecology.

1.3 Notions in Ecology, Design and Ecological Design

Ecology.

The term *ecology* was shaped by the naturalist and illustrator Ernst Haeckel [1834 - 1919] in 1869, to refer to the emerging studies on the interactions of biological species with their environment, the composition and stability of groups of species within geographic units, and of the exchanges and interactions (of energy, matter, and others) established between them. The word *ecology*, etymologically deriving from the Greek "oikos", meaning home or place, and "logos", meaning reason or plan and implying an overall order, infers to the meaning and organization of local, site-specific communities. As poetically referred by Hosey (2012, p.47), *"Ecology is rooted in home, and home is rooted in place."*

As a discipline, ecology is contemporarily divided into diverse branches, segments and approaches, some of them focusing in rather different elements [focus on flows, or focus on processes, for instance]. This nuances in ecology transform it into a far more complex field, which constitute some of the barriers when trying to incorporate ecological thinking into architectural design, as referred by Kibert (2007), and update its applicability towards contrasted *"old"* and *"new"* ecological thinking, as indicated by Du Plessis (2008).

Ecosystem.

Ecosystem is defined as a complex adaptive system, composed by biotic [living organisms] and abiotic [physical and chemical] elements, and their relationships intra and inter se. (Vitorino, 2012b, with reference to Odum and Barret, 2005; Charest, 2009, and De Groot *et al*, 2002).

The term and concept of *ecosystem* was introduced in 1935 by the botanist and forerunner in ecology studies Arthur Tansley [1871–1955], in his article *"The use and abuse of vegetational terms and concepts"* (Tansley, 1935). The notion of ecosystem derives from the early notion of *biocoenosis* (term coined by Karl Möbius in 1877), that expresses the existence of a geography and interdependence of animal species, emerging from naturalist [botanist and zoologist] studies in the 18th and 19th centuries.

Rowe (1961) defines ecosystem as a particular space-time topographic unit, and, along other authors, as Sukachev (1944), has defined the structural composition of an ecosystem within biotic and abiotic layers and components. According to Odum (1972), the fundamental components of ecosystems include: 1) *Inorganic* substances (carbon, water, nitrogen, minerals... which cycle through the ecosystem) and form an abiotic substrate; 2) *Organic* substances (proteins, carbohydrates that combine *biotic* and *abiotic* constituents); and 3) *Climatic* elements (as rainfall, and temperature).

Among ecosystem biotic communities are considered the producers (plants that produce matter through inorganic substances), the consumers (animals and plants that derive their energy from consuming other species), and the decomposers (that decompose organic matter into inorganic substances). The boundaries that define local ecosystems are conceptual limits, based on common characteristics within a territorial unit, in fact coexisting multiple nested ecosystems within earth's global ecosystem (AIJ, 2005), sharing flow inputs and outputs, processes and interactions.

Restoration Ecology.

Restoration ecology is a specialized branch of ecology that deals specifically with the assistance and recovery process of damaged or unbalanced ecosystems, whose concept has emerged during the 1980s, coined by John Aber and William Jordan. The focus of restoration ecology as a discipline is *ecological restoration*, which is defined by the Society for Ecological Restoration as *"process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed"* (SER, 2004, p. 2).

The concept of ecosystem restoration implies the notion of regeneration and rehabilitation of local ecosystem biotic and abiotic elements and processes, including the reestablishment of diverse ecological functions, among which biodiversity, and by consequence the replenishment of available services to human well-being.

It is worth noting that diverse perspectives and approaches exist regarding ecological restoration and ecosystem health. The *International Primer on Ecological Restoration* (SER, 2004) defines that besides ecological restoration, other human processes concur to positively alter "the biota and physical conditions at a site", including reclamation, rehabilitation, mitigation, and sustainable resource management (SER, 2004). In urban areas, ecosystem restoration imply the increase of vegetation ground cover and infiltration of rain water, the reduction of runoff and improved soil conditions, leading to enhanced air and water quality, biodiversity and evapotranspiration, and reduction of urban heat islands (SITES, 2009).

Ecosystem Services and Functions.

Ecosystem services are what link us to the rest of nature. As seen from an anthropocentric view, these constitute the threads that link and support our species to all the other constituents in a macro ecosystem, but don't exclude that *we are nature*. In fact these delimit what can be interpreted as habitat conditions *sine qua no*n for our species.

Ecosystem services are generally described as the tangible and intangible benefits human beings derive from nature, according to definitions in Costanza *et al* (1997), De Groot *et al* (2002), MEA (2003) and TEEB (2011). Regarding its mediated relation to human well-being, ecosystem services are classified into Supporting, Regulating, Provisioning, and Cultural services, according to the formalized framework of the Millennium Ecosystem Assessment (MEA, 2005), promoted by the United Nations. The concept of ecosystem services initially developed by Costanza *et al* (1997) as a way to attribute a market value to natural capital resources, is presently adopted among ecology and policy professionals as a comprehensive tool to analyze ecosystem changes and its impact on human communities.

Ecosystem services result of an ecological economics approach, 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. Because ecosystem services and functions may be prone to one-way functionalist and anthropocentric interpretation, the approach of the present thesis consciously attempts to avoid it, procuring instead a two-way vision where they are interpreted as links, and tools to understand the interdependent bonds of humans within nature, in socio-ecological systems.

The concept and structure of ecosystem services and functions offer a more comprehensive, holistic and inclusive perspective than the conventional concept of natural resources, in use until the last decades. It broadens the notions about human community interdependency with other ecological elements, beyond resource extraction and disturbance pollution, and also provides insights of interaction and dependency between several different ecological agents and processes.

The assessment of ecosystem services and functions is also used as diagnosis of ecosystem health, and it can be established a relation between ecosystem services and functions and ecosystem restoration. Particularly to architectural designers and other stakeholders in architecture projects, without specific formation in ecology, the knowledge of ecosystem services and functions and their mutual interaction can also perform the function of a powerful tool for eco-literacy.

Resilience.

The concept of ecological *resilience* has been proposed by C. S. Holling. The concept and principles of resilience are fundamental both to ecology as discipline, and to regenerative design, extending to ecosystem integration, having permeated environmental design discourse in the recent years, as it is referred by Mehaffy and Salingaros (2013). Resilience is also referred by Du Plessis (2008), as an essential factor for urban sustainability.

Resilience may be defined as the capacity of a given system to endure change and cope with internal and external pressures. Some of the shared principles of resilience in natural systems that govern regenerative design are for instance the need for redundancy of connections. One of the most important inference of this theory into environmental architecture is that it challenges the concept of efficiency that has been driving environmental sustainability assessment benchmarks in the past decades, with a focus on energy and water efficiency.

The four key principles or characteristics that support resilience in ecological systems, are identified by Mehaffy and Salingaros (2013) on the work of Holling, as: 1) Diversity [and redundancy]; 2) Interconnected web-network structure; 3) Distribution across a range of scales; and 4) Self-adaptation and self-organization. Resilience theory has influenced ecological thinking, recognizing the existence of multiple alternative stable states within an ecosystem, instead of one climax state driven by a linearity process. Permaculture, an organic agriculture method with influence on regenerative design methods, also adopts many of key principles for resilient systems.

The concept of *vulnerability*, might be opposed as antonym of resilience, being defined as the susceptibility of a given system or entity to be affected, in its normal functions, by external or internal impacts, the degree of ability to recover from that impact, and its relative stability. Vulnerability is also referred as one of the factors that antithesis sustainability (Ieda, 2010). Urban areas are often referred as vulnerable spaces (Park, 2010), since they often represent strong dependency from environmental exterior resources, and are often constituted by frequently unstable complex socio-economical structures.

Ecotone, biodiversity and socio-ecological systems.

An *ecotone* is a boundary or intersection area where two or more different ecosystems meet, and it is an area particularly rich in biodiversity. Ecotone is picked up as a reference for ecological design in the 20th century, for instance by Sim Van der Ryn (cf. Van Der Ryn and Cowan, 1996; p. 131), as discussed in detail in the following chapter. The concept of ecotone is particularly relevant to our research because it incarnates a set of qualities or characteristics that a regenerative building or that the design integration of ecosystem functions and services in architectural projects should present, namely allow and foment the flow of resources, energy and biotic interactions, and articulate the connection between different areas.

Among ecosystem services and functions, *biodiversity*, or biological diversity, is considered a supporting function or service, and it is a fundamental factor in ecosystem health and resilience, comprising all living organisms and species, their number, genetic variety and habitats (Williams, 2010). As referred by Edwards (2010), biodiversity is defined and assessed in three main levels: the provision of habitats, number of individual species, and genetic diversity.

Socio-ecological systems consist of organizational units where human social structures and activities and local bio-geophysical elements bond to form a complex, adaptive system. Clear examples of socio-ecological systems include agro-forestry production landscapes, as *satoyama* in Japan, and all urbanized environments. The concept of ecotone is essential to socio-ecological landscapes, and it should play an extremely important role in the design of urban environments and built areas.

Indicators.

The word indicator derives from the Medieval Latin "*indicātor*", a term used to express someone or something that points to something else, a pointer or a cursor. It encompasses a mediated relation between observer and subject and also the ability to demonstrate something. It is used contemporarily, with the meaning of an instrument to measure and record the state or level of a subject.

In many contemporary subjects, indicators, as environmental indicators and quality indicators, translate concepts. In some contexts, the term "*indicators"* is also referred in the sense of analysis topics, which are in fact assessed in further detail by more specific index and variables.

In ecology, indicators are defined by variables which transmit information about the status or tendency of attributes (quality, characteristics, and properties) of a system (Gallopin, 1997). Environmental Descriptive Indicators, as in the DPSIR framework model, adopted by the European Environment Agency, are divided into: Driving forces, Pressures, State, Impact, and Response Indicators, according to which aspect of the system they refer. In the framework of sustainable development, indicators should be defined, as much as possible, as measurable, verifiable and reportable, as supported by the Global Reporting Initiative (GRI), the United Nations Environment Programme (UNEP) and Sustainable Buildings and Climate Initiative (SBCI) (Yashiro, 2011).

Quality Indicators (QIs) and Key Performance Indicators (KPIs) constitute operative criteria that permit to evaluate the quality and the performance of a given product or process, regarding specific benchmarks, in a structured methodology. Applied to Architectural Design Project, both QI's, conceptualized as Design Quality Indicators (DQIs) (Gann, White, 2003; and Gann et al, 2003), and KPI's provide guidelines to assess the degree to which the Project's process achieves the desired outputs (Tatsiana, Saad, 2007). In other words, DQIs and KPIs constitute the measurers of the specific concepts associated with Design Quality and Performance ideas, or *ideals*. Sustainability Performance Indicators (SPIs) refer to the Economic, Social and Environmental spheres of assessment criteria that serve to evaluate any given process, product or development towards the concept of sustainability. Among SPIs, Environmental Performance Indicators (EPIs) are often included in Building Sustainability Assessment methods.

Ecological Architecture and Regenerative Design.

Environmental or ecological architecture consists of a broad umbrella term to express, in the present research, the different environmentally driven approaches in architecture [including green building, sustainable architecture, and regenerative design, for instance].

With incidence after the 2000s, several contemporary authors [including Kibert (2006) and Du Plessis (2012)] have been promoting a more radical and demanding reinterpretation of the term *ecological architecture*, less connoted with the minimization of impacts from conventional architecture and more holistic than eco-efficiency.

The concept of *regenerative design* consists of a paradigm shift of built environment sustainability, distancing itself from other environmental architecture approaches based on the mitigation of negative impacts. Regenerative design suggests objectives that lie beyond the parameters set by existing certification systems, and zero impact standard, crossing the goal of sustainability towards a progressively restorative, reconciliatory and co-evolutionary action with nature (Reed, 2007).

In architecture, the term *regenerative design* has been proposed by John Tillman Lyle (1934-1998), author of *Regenerative design for sustainable development* (1994), and later developed by William Reed and the Regenesis group, among others. This concept assumes that human systems are inherent part of nature, and it aims for potential collaborative co-evolution and positive contributions from architecture to nature, being based on ecological thinking, and resilience theory.

Ecological Literacy.

The concept of *ecological literacy* was introduced by Fritjof Capra and David Orr (and particularly developed in *Ecological Literacy* (Orr, 1992)), being sometimes abbreviated as *ecoliteracy*. This term stands for the education and understanding of ecology, within human societies, including the recognition of *"the interdependence between natural processes and human ways of living"* (Boehnert, 2012, p. 47).

As stated by Joanna Boehnert in *The Visual Communication of Ecological Literacy*, the objective of ecological literacy is in itself a conceptual framework that *"recognizes embeddedness within the ecological systems and thereby organizes cultural, political, legal and economic systems accordingly."* (Boehnert, 2012, p. 47). Ecological literacy is different from the mere knowledge of ecological terms, and implies ecological thinking and acting, being simultaneously a pedagogical project and preconizing a societal paradigm shift.

The lack of ecological literacy, and even just simple education in ecology, in architectural designers is pointed out by different authors, in different times, such as Kenneth Yeang (1999), Kibert (2007), and Boehnert (2012). The need to endow architectural designers with ecological literacy is also expressed in the formulation of ecosystem integration.

Design Integration and Architecture Design Quality.

Design integration, or architectural integration, is an expression generally applied about the inclusive incorporation of a given technology or particular knowledge field, into architectural projects, in terms of overall design quality, and is a key aspect of the present research. This concept is widely used when approaching a specific new material, technique, or equipment, for which there is no abundant previous experience, as for instance the integration of AC mechanical systems or photovoltaic panels.

The definition of the word *integration* itself presupposes already the idea of blending in, of merging parts into a coherent whole. Namely, *integrated design*, more applicable in the context of sustainable building, implies, for instance, a multidisciplinary inclusive approach, in all design stages, with the collaboration and participation of all stakeholders. In another context, as for instance the use of decoration in *art nouveau*, the distinction between applied ornament and implicated ornament is perhaps clearer whether form, structure and decorative elements are interdependent or just juxtaposed.

When addressing the design integration of a specific aspect into architecture, it requires an intentional and controlled design of that element in relation and articulation with others, and it is naturally evaluated from the point the view of architecture quality, and how it is defined, namely in relation with structural, aesthetic and functional values.

Local, Micro-local, and Landscape.

Spatial concepts are central to the definition of both architecture and ecosystem. The present research emphasizes the importance of local approaches to ecology and architecture, and it recognizes the connection between *localness* and the increased perception of resource use limits, and of nature stewardship.

In the present research, the spatial boundaries used to examine ecosystem integration focus at micro-local scale. The term *micro-local* scale corresponds to the frequent property units and project scales in urban environments [building, building envelope and immediate site], and it implies a differentiated response of the project towards ecosystem services and functions. The word *landscape* is used instead in two different ways in the present research: 1) *as context*, either natural or cultural to the project site, or micro-local; and 2) as *on-site non-built areas* within project limits.

The disconnectedness between everyday life, particularly in contemporary urban environments, and the natural resources that support it, has diminished the immediate perception of what is a balanced use of ecosystem services and functions. As referred by Grant (2000), a great part of urban population is environmentally illiterate, and unconscious how their life depend on natural processes and of the life-cycle impacts of the goods and services they consume, and even of nature itself. In smaller scale, local-based communities, and socio-ecological production landscapes, the proximity and visibility of this interdependence with nature, has facilitated and promoted nature knowledge and stewardship. The importance or recognition of the need to a local approach in ecosystem integration is also supported by the celebrated expression *"think globally, act locally"* applied to a diversity of contexts in town planning, and environment, and presupposes site specific responsiveness to local variation, as stated by Kibert and Grosskopf (2006).

02. ECOLOGICAL COLLABORATIVE APPROACHES IN ARCHITECTURE

2.1 Introduction

In the previous chapter, the constellation of terms and knowledge fields that concur to form the concept of ecosystem integration are clarified. In the present chapter, it is observed how this concept has been addressed in the course of art, architecture and broader social contexts. The objective of this chapter is to highlight the approaches that focus primarily on ecosystem regeneration or cooperation, at local scale, and on the development of regenerative design paradigm and current directions, rather than provide an overall history of ecological design or building sustainability.

Among the existing timelines and interpretations that trace the evolution of environmental architecture, one of the more appropriate to frame our thesis is the one advanced by Chrisna Du Plessis (2012), expressed in *Towards a regenerative paradigm for the built environment*. In this thematic organization Du Plessis identifies three main paradigms in the sustainability movement and concept that emerged after World War II, with effects on architecture: 1) Public Policy Sustainable Development, 2) Market Based and Private Sector Ecological Modernization; and 3) Regenerative Paradigm, more closely identified with the promotion of local ecology and creation of positive impacts, being rooted on *"what has been described as radical "ecologism""* (Du Plessis, 2012, p.8).

Contemporarily the two dominant paradigms are embodied by public policy and private sector development strategies. The Public Policy initiatives and advances into sustainability concept are expressed through a series of intergovernmental conferences and expert panels concerned with the conservation of natural resources, the urge and needs of societies in development, and the necessity of providing dignified and accessible habitat to all world population, initiating from the 1940s. Meanwhile, the Private Sector movement towards sustainability derived from the need to reconcile business with the protection of environment, developing into 2 branches according to Du Plessis, "sustainable capitalism" and "eco-efficiency", and being strongly related with quantifiable "limits": focus on energy efficiency, high-performance, LCA analysis, factor 4 and factor 10, and finally on built environment assessment tools; and it develops in parallel to the 1980s and 1990s economic recession, neo-liberalism, privatization of state companies, and globalization (Du Plessis, 2012).

In the following sections, and among these paradigms, are described converging and diverging approaches to the integration of local ecosystem services within architectural practice, with emphasis on the strategies and principles concurring to regenerative design. Among the convergent thinking approaches, are included a section about landscape architecture, and a selection of reference authors, with ecological knowledge and focus on local ecology positive promotion. The thematic organization of these authors, not entirely overlapping a chronological sequence, follow a rise, consolidation and finally the transition signs of a shift of environmental architecture towards regenerative design.

2.2 Divergences and Convergences

Architecture and urban settlements have been benefiting over the centuries from ecosystem services. The provision of raw materials for buildings and infrastructures is one of the most evident, but also hazard protection, environmental modulation, and climate regulation. Cultural services have been playing an important part in the way cities, urban excerpts and architecture are designed: cultural and scientific resources are incorporated in ornaments and structures, landscape and views are intertwined with human made structures. Some of these services and functions relate mostly at macro-local scale (cf. Zari, 2012), but others are inherently micro-local, as many diverse forms of passive design utilize climate and environmental modulation, water cycling, and other services provided by local ecosystem. In a less obvious way, architecture and urban settlements may also support determinate ecosystem services and functions. Cities constitute socio-ecological systems (Du Plessis, 2008), and its simple more basic unit (building architecture) is far from being a sterile ground isolated from nature and ecosystem relationships.

Although one of the primary objectives of building is to protect humans from harsh environmental conditions, to create a human habitat, the surfaces, the boundaries, the envelope, the surroundings and even the interior of architectonic structures also demonstrate diverse ecological associations, providing support for many ecosystem services and functions, as biodiversity habitats for several animals, as swifts and house martins, in urban environments (Williams, 2010), plant development, biological control with selected species, and provision of ornamental resources, among others.

The notion of a positive co-existence and evolution with natural systems is present in several indigenous knowledge systems (Du Plessis, 2012; Grant, 2012), and many pre-industrial socio-ecological productive landscapes, as *satoyama*, in Japan, were based on an intertwined human-nature connection. In addition, “Art and architecture have in the course of their long histories repeatedly had recourse to nature as paradigm for their activity.” (Mateo, 2007, p.1). However, the resource of nature as context, and particularly the intentions to recover, restore and regenerate that natural context, and collaborate with it are increasingly frequent, in the last half of the 20th century, particularly from the 1960’s.

Divergences

However, the main dynamics, themes and arguments that characterize art and architecture in the last decades are not mainly environmentally directed. Mateo (2007) characterizes the recurrent topics in architecture, in the post war period as: 60’s, “social phenomenon”; 80’s “history”, and from the 2000, it’s “nature” that gets to be ubiquitous in the architecture discourse. This “increasing” focus on nature, that can be traced since the 1990’s and even earlier in the architectural discourse, might even be seen more as a reflection of the collective zeitgeist rather than an inherent peculiarity - since the whole society is traversed by nature “media”, green, eco, bio, sustainable got to be common words in all sectors, as pointed out by Ursprung (2007).

In the relation of nature and architecture Ursprung also notes that sometimes the concept of “nature is understood as fiction”, as a “product of human projection” (Ursprung, 2007, p. 11). According to this author the relationship of nature and architecture, from the 19th century, presents two different approaches: one that frames and transforms nature and another that imitates or emulates nature. The perspective of Ursprung over these two approaches is that the later “is based on the assumption that nature and architecture are complementary and that architecture may reflect and emulate nature” and the first “upon the proposition that the concepts of nature and architecture are not separate but interlaced inextricably.” (Ursprung, 2007)

However, as pointed out by Hosey (2012), an important part of contemporary architects still adopts an attitude of distance regarding the green movement or ecological architecture. Peter Eisenman and Eduardo Souto Moura constitute relevant figures of contemporary architecture that publicly disregard an environmental agenda towards architecture practice. In 2009, Eisenman affirmed in an interview that sustainability had nothing to do with architecture (Hosey, 2012, p.2). Also Eduardo Souto de Moura, 2011 winner of the Pritzker Architecture Award, has referred in diverse interviews his disregard towards the need to distinguish ecological or sustainable architecture from general good quality architecture. Asked about if sustainability is a problem of wealthy people [Anatxu Zabalbeascoa, in El Pais, 30 June 2007], Souto de Moura answered categorically that sustainability is a secondary issue in architecture, raised by mediocre agents. Although he considers that it is implicit of good architecture to be sustainable, *per se*, the exclusive consideration of environmental aspects in architecture doesn’t raise architecture quality.

Hosey also points out the present divorce between ethics and aesthetics in contemporary architecture, observing that, comparing a list of the "greatest buildings of the past 30 years" published in 2010 in Vanity Fair magazine, with his own conducted poll for Architect magazine about the "most important examples of sustainable design from the same period" (Hosey, 2012, p.3), few of the selected projects matched, concluding that contemporarily, environmental performance and intrinsic architecture quality are rarely associated.

Yet, the responsibility of the aesthetics-ecological ethics divorce lies not only on the part of designers personal attitudes but also on the intrinsic "distortions" of quantitative environmental performance assessment: "Originally, the concept of sustainability promised to broaden the purpose of contemporary design, specifically by adding ethics to aesthetics, but instead it has virtually *replaced* aesthetics with ethics by providing clear and compelling standards for one and not the other. The most widely accepted measures for environmental performance exclude basic considerations about image, shape, and form. Even the most ambitious sustainable design can be unattractive because attractiveness isn't considered essential to sustainability."(Hosey, 2012, p.5)

In parallel to this, the ecology and sustainability discourses have become into a kind of an unquestionable "morale". A morale that is superficially accepted by almost everyone but which still very few fully understand, and even less, really practices. In the field of architecture, where unconventional thinking and visual fashion tend to be much more appealing, ecology and sustainability have been permeating the field to an almost point of saturation, where its meaning have been lost towards a kind of decoration, and progressively lost its true appeal.

It is in any case applicable to architecture the *value-action gap* theory, complicating the process for architects, clients, constructors. It is, at the same time, true that environmental assessment methods have permitted that "knowledge and application of ecological design are not absolutely necessary to produce a high-performance green building." (Kibert, 2007, p. 99). Although, as pointed out by the same author, their prescriptive or checklist character would not promote "deeper thinking and innovation" and would, without these, result in "building stereotypes" that are unable to add much to architectural design research.

While quantitative environmental design and qualitative environmental design can be opposed in certain circumstances, some other architecture designers, without necessarily affiliating themselves with ecological architecture, find *another way to green*, through regionalism, materials, and vegetation (as Kengo Kuma, Studio Mumbai, or Vo Trong Nghia), delicate, poetic approaches (as Junya Ishigami), or speculative future visions (as Hunderwasser, Vincent Calenbaut, and others).

In the relation between architecture aesthetics and green ethics, another not exclusively visual factor emerges. As pointed out by Hosey (2012), environmental architecture is made of "Invisible green" and "Visible green" techniques. The invisible techniques [as embodied energy, material choices, and others, as other technical infrastructures or insulation] imply design decisions and effort, but little influence on overall design conception, while visible techniques imply with "form, shape, and image". (Hosey, 2012, p. 6]. These later visible techniques can be determined during early design stages and have an enormous impact on building's performance, as referred by Hosey, but may be less preferred or adopted by designers, as imply aesthetical, formal, and perceptive choices. Hosey concludes that *""the look and feel" of a design – are essential to sustainability"* (2012, p.12), which support the thesis that the surface and envelope contours might play also a primary role on the projects relation with local ecosystem.

It is interesting to note that the questions of making "nature visible", or "ecological design visible" permeate many of the leading theoretical authors in ecological architecture, from Van der Ryn to Kenneth Yeang, and, although this will and statement would become physically visible in dissimilar ways according to their practice authors [as biomimicry, as metaphor, as visible vegetation], it is certainly one utterly important characteristic that escapes the scope of common environmental assessment methods, but it is rather essential to architecture. This point, is exactly for us, an ambiguous reference to what we interpret as the collaborative interactions with local ecosystem, the links between design integration. The ability of architecture to extract and collaborate with ecosystem elements in a way that elevate it, and not only in terms of efficiency, also in terms of art.

The importance and need of linking ecological performance with aesthetical and other intrinsic design quality parameters is also reinforced by Hosey's argument that beautiful, appealing design is favored by the users, over a longer period of time, and therefore, more durable and self-sustainable: "Experiments in interaction design also reveal that people generally consider attractive products more functional than they do unsightly ones and therefore are more apt to use them."; and "*If it's not beautiful, it's not sustainable*. Aesthetic attraction is not a superficial concern – it's an environmental imperative. Beauty could save the planet." (Hosey, 2012, p. 7).

Aesthetic design, or conceptual-perceptive appealing design also has more chances of being reproduced and continued, as indicated in *The Shape of Time*, by George Kubler (1962), and produce a long-term influence on other series of objects. In *The Shape of Green*, Hosey intended to create a base, philosophical and methodological, to connect the aesthetic approach to sustainable design, and thus overcome some of the divergences found for the design integration of ecosystem services and functions. From his main arguments, we highlight the following: 1. Aesthetics or beauty are an inherent part of sustainability principles, in its triple social, economic and environmental facets. 2. A clear set of design principles for "the aesthetics of ecology" constitute the methodology for sustainable beautiful designs. 3. The development of this rational approach to design can be applied at every single scale of design, from "products to buildings to cities" (Hosey, 2012, p.9).

The design principles enunciated by Hosey are: *conservation*, shape for efficiency; *attraction*, shape for pleasure; and *connection*, shape for place. The rationale exposed by Hosey evidences in part the lack of design integration of environmental strategies and issues, including local ecology aspects, both in environmental architecture and in non-environmental driven architecture.

In contemporary project design, Hosey defines 6 kinds of architectural style, in 3 categories not mutually exclusive: Market-based form; History-based form; and Place-based form. In the category of Market-based form, Hosey identifies the Corporate Style and the Populist Style. The first one consisting by the franchised and abundantly repeated identity of brands materialized through buildings, while in the second, it is comprised the anonymous mass production of similar/quasi identical buildings found in large suburban or development areas. Hosey refers Market-based forms to be independent [and irresponsive] of place, and even of history, appropriating, particularly in the US, "images away from their origins, distorts them, and plops them down wherever people might buy them". (Hosey, 2012, p. 123)

In History-based form, Hosey includes Personal Style and Epochal Style, as manifestations of particular individualities and zeitgeists. Personal Style it's defined as a kind of signature architecture or individual branding that is also reproduced regardless of its context; while the Epochal Style brands a particular "taste", form or image to a specific time period, as the International Style did.

Only in Place-based form, that includes Regional Style and Circumstantial Style, does Hosey recognizes it "embodies the unique conditions of its locale". "Its purpose is ecological in that it supports and signifies the relationships between culture and nature in a given context."(2012, p. 124) Regional style applies a suitable language and form to a broad regional context, as in vernacular architecture, reflecting a "character that grows out of many people living in and shaping a place over long periods of time."(2012, p.125)
Regionalism, as exposed by Lewis Mumford "[…] is not a matter of using the most available local material, or copying some simple form of construction that our ancestors used…Regional forms are those which most closely meet the actual conditions of life and which most fully succeed in making people feel at home in their environment; they do not merely utilize the soil but they reflect the current conditions of culture in the region." (Mumford, 1941)
Circumstantial Style reflects more specific site and project specific characteristics. "Where Regional Style is a generalization of context, Circumstantial Style is highly specific and localized and may bear little resemblance to other buildings in the area – or anywhere else." (Hosey, 2012, p.125)

Only to the last two styles Hosey recognizes sustainable ability. “The first four architectural styles all are vulnerable to self-interests and fleeting trends […]. the only types fully consistent with the aims of sustainability are the two remaining styles, the Regional and the Circumstantial. Green architecture should embody a beauty born of its place – the sense of its terrain, the sensibilities of its people.”; and “In nature, imagery and ecology are interwoven, and the aesthetics of a living thing emerges from and often echoes its surrounds.” (Hosey, 2012, p. 126)

Convergences

The need to dwell within the natural limits [as resources, benchmarks, carrying and regenerating capacity] is as referred by Du Plessis (2012, p. 8) noted “as far back as the Upanishads” and “German forestry practices”. As noted by Hosey (2012), an overlapping identity between human communities and their territory was identified among the aboriginal peoples of Australia [and others], having as a consequence the protection of local natural elements [rivers, mountains, rocks, trees, etc.] as genealogical relatives or even the extensions or manifestations of the self.

In the industrial and post-industrial society, aggravated by global economy procedures, this immediate, local connection with nature, and the perception of resource consumption and impacts, is lost and distorted, and in fact perhaps one of the main impending factors to contemporary sustainability challenges.

The notion of the existence of a possible limit to human population growth and its respective urban, industrial, agricultural and economic systems, had an important impact during the second half of the 20th century, with the publication of the books, *Silent Spring,* in 1962, by Rachel Carson, and later *The Limits to Growth*, by Donella and Dennis Meadows with Jorgen Randers and William W. Behrens in 1972. Following up, the decades between 1960 and 1990 might be characterized as the rise of *environmental awareness* in design professional fields in modernity and post-modernity [as depicted in the Timeline in Figure 8], building up on conceptual bases proposed by earlier authors, and deriving some of its knowledge from landscape disciplines.

2.3 Land*scape* and Land Art

The land art movement, which also included site specific restoration ecology projects, formed in the 1960s decade, simultaneously to the development of an environmental awareness within society and the necessity to limit and correct human impact on earth. Within the land art movement a more specific trend emerged, connecting diverse art projects under the term of *reclamation art*, and directly related with ecosystem regeneration.

Landscape architecture has, as well, been an intermediate discipline, combining art and design perspectives with natural systems. It has, as referred by Girot (2007) “come to be one of the only design professions capable of dealing with a natural remedy of sorts.” although “[…]what it lacks painfully in terms of design history and theory, it compensates in assertive scientific methodologies.” (Girot, 2007, p.29), meaning that an intrinsic aesthetical/philosophical/critical theory [as found for art or architecture] is relatively missing as compared with the technical body of knowledge related with ecology, botanic, and geography, although it has more easily and steadily absorbed the necessary changes towards ecosystem services and functions integration.

Reuben Rainey (1988) defines three modes of relationships between architecture and landscape: contrast, merger and reciprocity. Reuben Rainey defends that along history of architecture and landscape architecture, these 3 modes have been present, although rarely in “pure form”. Through Rainey’s perspective, the association of these modes, within a specific landscape-built form/architecture relation, is enhancer of the work appearance and also of its complexity of meaning and readings, bringing “contrasts, tensions and ambiguities” that accentuate/increase the quality of the design. Unfortunately, Rainey focus mainly on formal/visual relations between architecture and landscape, and doesn’t reflect further into relations between built forms and ecological systems.

Contrast, as Rainey defines it, expresses the distinction between a “building’s scale, profile, color and materials”, creating a “counterpoint to its immediate setting. There are no transitional gardens or terraces to act as a bridge.” (Rainey: 1988, p. 4) An example of contrast proposed by Rainey is New York’s Central Park “whose sequences of pastoral and picturesque scenery constituted a totally different environment from the surrounding urban grid.” *Merger*, in Rainey’s thought, is the expression adopted by a built form “to appear an integral part of its natural or cultural landscape”: “the form of the building may reflect the surrounding topography or, in extreme cases, be placed underground so as not to be visible.” The works of Frank Lloyd Wright, as Falling Water and Taliesin West are given by Rainey as expressions of both contrast *and* merger, for instance.

Reciprocity, which Rainey considers the most frequent mode of relationship between architecture and landscape, is defined by their mutual influence in terms of design: “buildings and landscape modify one another – each one to some degree is reflected in the other.” Raineys refers to the projection of plans, the inclusion of zones of transition, indoor and outdoor spaces with “same organizing principles”, mimesis, and the formal manipulation of natural elements. One of the examples of reciprocity as Rainey sees it, is the Villa d’Este, by Pirro Ligorio, with its multiple array of axial planes into the garden landscape.

Reciprocity is clearly defined by Rainey in the sense of formal influence or interpenetration, but doesn’t reflect any hint about possible collaboration between built and contextual ecological elements, beyond visual and organizational aspects.

Interestingly, Rainey's modes of relationship between architecture and landscape, being centered on visual/formal aspects, are not necessarily a direct expression of the human-nature, culture-nature understanding by their authors. Also landscape is interpreted not only as natural setting but also including cultural landscapes, being maybe better expressed as *context*. However, this gives us the base/inspiration for another formulation of the existent modes of relationship between architecture and nature [local ecological systems].

The need for a clarification of the term *landscape*, and the formulation of a consistent theoretical and methodological base for landscape architecture, as discipline, has been raised however by Jusuck Koh (2008). Koh points out that Landscape Architecture as an academic discipline is still searching for a comprehensive [and defining] theoretical and methodological basis. Koh refers 3 major works towards this direction [although with their own short comings or unfulfilled practical realization]: Swaffield "Theory in Landscape Architecture"; McHarg "Design with Nature"; and Steinitz "A Framework for Theory Applicable to Education of Landscape Architects".

However, even within the field of landscape architecture, it is noticeable the lack of ecological literacy among professionals. As Koh has observed a "pervasive misunderstanding or very narrow perception of ecological science and ecological design among landscape architects in both Europe and North America". (2008).

In response, Koh has developed its own "*landscape approach*", applicable to the design of buildings, landscape and urban planning, (and also designated by Koh, as an 'eco-poetic approach' to landscape design). The term "landscape approach" is also used by Bernard Lassus, during the 1990's, although with an emphasis on "the poetics of landscape rather than the ecology of landscape" (Koh, 2008). "Landscapes, in this eco-poetic sense, require both a scientific and an aesthetic approach. It is an integrative, dynamic, evolutionary approach that seeks field immersion for its understanding, experience and design of landscape. A landscape/ecological approach to design is then not just ecological but 'eco-revelatory' design." (Koh, 2008)

Koh also refers that the problem with the definition of landscape design theory is "partly due to the ambivalence of landscape architecture itself.", and of the ambiguity/contradictory nature of the word landscape used in different contexts.

The term *landscape* was first conceived as a scientific unit of study by Alexander von Humboldt (1769 – 1859), geographer, considering it as "the totality of all aspects of a region, as perceived by man", almost contemporarily as the notion of ecology by Haeckel in 1869 (Koh, 2008), thus, indicating as referred by Koh, a "cultural and phenomenological orientation in understanding the land and regions in addition to an ecological understanding of people-place (organism-habitat) systems in evolution" (Koh, 2008).

"During the last 20 years, the word landscape has emerged as a borderless and integrative concept of multi-layered meanings […]", at the same time that the discipline has been trying to define itself: "We now know that a city is not big architecture, just as landscape is not a big garden. Likewise, landscape cannot just be an extension of city, just as a garden cannot be a simple extension of building." (Koh, 2008).

Koh argues that "Landscape, a bio-geographical as well as cultural concept, has emerged […] prominently since the 1980s as an integrative concept among architectural, urban, and geographical discourses", agglutinating, deriving or including the successive focus of spatial design disciplines: Form, Space, Environment, Place.

The "landscape approach" proposed by Koh has not only many interesting implications for contemporary environmental design, but also converges with the ecosystem integration aims, and ultimately confronts the perception of architecture as design of static objects. "A Landscape approach to construction recognizes that it takes time. A Landscape approach is then design for and with time." (Koh: 2008)
As opposed to an "architectural approach" to design, that considers "architecture as object, with landscape as background, or simplified ground", Koh's "landscape approach" perceives "architecture as part of landscape", with the blurring of typical envelope boundaries ("roof becomes ground/land/topography") and "indoor/outdoor integration (wall, interface as place)". Similarly, in an "architectural approach", landscape design is perceived as an "extension of building", based on form, structure, function, and compositional order, while in a "landscape approach", landscape design is perceived as a process, a flux "far from equilibrium", and landscape comprehending both natural and cultural, as a "land-people system", inclusive both of the erudite and of the ordinary.

Koh lists 6 of the possible implications for contemporary environmental design, as follows: 1. That landscape is not only a physical system/process but also "experiential phenomenon"; 2. That "Landscape is not just 'what' – space, home, system, or scenery, but also 'how' – process, time, change, unpredictability and ephemerality."; 3. That *form* results from an adaptation process, emerging from it, rather than being imposed by a compositional methods; 4. That a "landscape approach", becomes "more responsive to change, context, and culture than an architectural/compositional approach"; 5. That "it focuses on ground line and condition rather than skyline, on the interfacing of architecture with site and city with nature.", particularly considering "street level experience" and "interrelation of inside and outside"; and that "it means not only seeing architecture and city in the context of landscape but also conceiving architecture and city themselves as landscapes, and as such, cultural and localized processes.” (Koh: 2008)

The cooperation with natural systems, the mimicking of biological processes, as well as a design process based on the ecology framework, are shared by the thinking systems and concepts present in *Design with Nature*, by Ian McHarg [1920-2001], published in 1969 [McHarg: 1992], and Permaculture, acronym for *permanent agriculture*, suggested by Bill Mollison and David Holmgren, around 1974, Although these systems of though and their respective principles/methods only partially overlap the concept of regenerative design, the perception of these authors is also based on a profound paradigm shift, using systems thinking as conceptual base.

In particular, McHarg “called for environmental planning on a local level and advocated taking everything in the environment […] in account when planning.”, while also pointing the fundamental role of cities to handle human growth. He also identified the need for a multidisciplinary approach to achieve built environments that are *“responsive to nature”*, and that the specialization and compartmentalization of knowledge fields was adverse for ecological design. He also advocated that every citizen should have ecological education (Kibert, 2007, p. 105-106). McHarg had a tremendous impact not only in landscape design, but also in the shape of subsequent environmental architecture, and has influenced directly the theoretical work and practice method of Kenneth Yeang, as discussed in the following sections.

Its influence has extended to James Corner and the “landscape urbanism” concept, whose approach to nature and cities has also root on Ebenezer Howard’s concept of Garden City, perpetuated in the Town and Country Planning Association. As stated by Hosey (2012, p. 159), “Its practice rejects the split between town and country by recognizing that cities are ecosystems where cultural and natural forms mix.”

The role of landscape design and the consequences to the professional roles and team working in architecture are described by Kibert (2007, p. 133) in these terms “In the context of green buildings, the role of the landscape architect should perhaps be redefined from that of simply providing exterior amenities for the project to serving as the integrator of ecology and nature within the built environment.”

Kibert considers that with the evolution of green building, it might be more appropriate to review the term “landscape architect” to something like “ecological architect”. “At present, there is no professional on the conventional project team with the knowledge of buildings, ecology, and the flow of matter and energy across the human-nature interface. New, emerging topics for landscape design include storm water uptake, wastewater treatment, food production and assisting in heating and cooling buildings. New approaches that include a robust role for natural systems in buildings are at the cutting edge of high-performance building and point to areas where their design must eventually evolve.” (Kibert, 2007, p.133-134)

2.4 Cardinal Signs: The initiators

A timeline perspective on environmental architecture authors is offered by Charles Kibert (2007), in a brief historical outlook on ecological design. Kibert (2007) makes a distinction between foundational thinkers (the ones that set the bases for ecological design since the beginning of the 20th century), the contemporary thinkers (with major publications or projects between the 1990’s and 2000), and the emerging trend-setting views (that offer avant-garde particular methods and objectives from the main current).

Among the foundational thinkers Kibert refers, for instance, Frank Lloyd Wright (1867-1958) for his understanding of nature and his very site-specific building projects, Richard Neutra (1892-1970) as “one of the first to recognize the concept of *biophilia*, the need or craving of humans to be connected to nature” (Kibert, 2007, p. 105), R. Buckminster Fuller (1895-1983), Lewis Mumford (1895-1990), and Malcolm Wells (1926-2009).

In addition to these authors, Kibert also mentions Ian McHarg (1920-2001) and John Lyle (1934-1998), whose work is highlighted in previous and further sections in this thesis. Ian McHarg, as discussed before, has set the grounds for ecological landscape design and site analysis (including the notion of collaboration with natural systems), with influence on other subsequent authors, as Kenneth Yeang; while John Lyle, author of *Design for Human Ecosystems (1985) and Regenerative Design for Sustainable Development (1994)* focused on the pursue of *regenerative* landscape design, intending to create or modify human landscapes that are able to provide ecosystem services and functions, such as food production, manage storm water, and provide wildlife habitat and biodiversity. John Lyle was also responsible for early attempts of to adapt regenerative (closed-loop) cycles to building design and retrofit.

Although the mentioned authorial presentation is logic and chronologically coherent, other articulations of authors are possible, particularly when focusing on particular aspects, themes or currents within ecological design, such as the one proposed by regenerative design. Drawing up on Kibert’s organization, the ecological collaborative approaches in 20th century architecture can also be interpreted in terms of initiation, consolidation and transition, although with a slightly different selection and arrangement of authors, that are referred in the present text, and in the following sections, as cardinal , fixed and mutable signs [or in alternative words, thinking, building and re-thinking].

Buckminster Fuller is credited to be one of the first 20th century environmentalists, and his early awareness of earth finite resources has led him to produce a theoretical body of work that has been influential to later environmental architecture. His design projects reflect concerns with material and energy efficiency [mitigation of impacts], and he pioneered high performance green design. Although Fuller doesn't yet enounce a collaboration with nature, in the sense of ecological restoration, he is credited to popularize the term *Spaceship Earth "to describe how dependent humans are on the planet and its ecosystems for their survival and how the waste we create ends up in the biosphere"* (Kibert, 2007, p. 103). In his book *Operating Manual for Spaceship Earth*, and the project Dymaxion Map and World Game, one of the base concepts he proposed to the "safe operation of Spaceship Earth" was particularly, synergy.

Likewise, Lewis Mumford, co-founder of the Regional Planning Association of America, also advocated for limited-scale development and the region as a significant base for urban planning. (cf. Kibert, 2007, p. 105) Being an architectural critic and also a writer, he also reflected on post-industrial cities disconnection with nature, and "advocated the implementation of *ecotechnics,* technologies that rely on local sources of energy and indigenous materials, in which variety and craftsmanship add ecological consciousness, as well as beauty and aesthetics." (Kibert, 2007, p. 105)

Later, the ideas associated to the need to dwell within natural resource limits captured by Fuller and Mumford, were also expressed in the concept of *bioregionalism*, coined by Allen Van Newkirk, and supported by Peter Berg and Ray Dasmannn. The perspective proposed by bioregionalism is funded not only on the necessity to adapt and mitigate human consumption of natural resources but to link this need locally to specific bioregions (areas defined by bio-geographical conditions as climate, biotic communities, topography and watersheds), through the use of local materials, native species, food consumption, and in general, a whole locally adapted life-style, as form to encourage nature stewardship.

The idea of a light human footprint on planet earth is also shared by *Gentle Architecture* (1981), where Malcolm Wells launched his concepts of gentle architecture and earth-sheltered architecture. Wells advocated to *"leave the surface of the planet alone and submerge the built environment underground so that the Earth's surface can continue to provide unimpeded services"* (Kibert, 2007, p. 106), and predominantly focused on earth-sheltered buildings, but also proposed to minimize the use of asphalt and concrete, reinforce the use of local resources and solar energy, and through the development of one of the first environmental design checklists provided an insight of the possibility of architecture to create positive impacts as consume waste, create habitat, and regulate climate, collaborating with ecological functions and services.

Other, more recent influential theoretical authors include Edward Wilson and David Orr. In *Biophilia* (1984), Edward O. Wilson, has highlighted *"the instinctive bond between people and other living things"* (Hosey, 2012, p.45), a bond that connects the contact with natural biotic and abiotic elements to human health and wellbeing, and that surpasses the mere provision of services, as air regulation, and is also much dependent on sensorial experience (cf. Hosey, 2012).

David Orr, proponent of the term *ecological literacy*, has also underlined a broader perspective on human interactions with nature, author of *Ecological Literacy: Education and the Transition to a Postmodern World* (1992) and *The Nature of Design: Ecology, Culture, and Human Intention* (2002). Not being a professional in the built environment, but in environmental studies and environmental education, Orr's role in the shaping of the meaning of ecological approach in architecture and design is highlighted for instance by Kibert: *"Orr has made a significant impact on today's green building movement by virtue of his ability to clearly elucidate a vision of ecological design. Orr broadens our thinking about ecological design by comparing it to the Enlightenment of the eighteenth century, with its connections to politics and ethics."* (Kibert, 2007, p. 112)

2.5 Fixed Signs: Consolidation

In *Theories and Manifestoes of Contemporary Architecture,* edited by Charles Jencks and Karl Kropf (Jencks, Kropf, 1997), a selection of diverse authors with active writing between late 1960s to mid-1990s were published under the term of *Post-Modern Ecology*. The included authors, in chronological order but with somewhat disparate approaches, comprised: Ian McHarg (1969), Sim Van der Ryn and Sterling Bunnel (1979), Anne Whiston Spirn (1984), Nancy Jack Todd and John Todd (1984), Hassan Fathy (1986), Kenneth Yeang (1987), Christopher Day (1990), James Wines (1990), Team Zoo (1991), Brenda and Robert Vale (1991), William McDonnough (1992), Peter Calthorpe (1993), Kenneth Yeang (1994), Sin Van der Ryn and Stuart Cowan (1996).

In this perspective, within architecture critics' discourse, ecological architecture is presented as it would be a style or a cohesive current [which it never was, even if some intersectional affinities can be found in author's methods or manifestoes], as post-modern ecological building rhetoric has been used and it was one of the forms of critique to the modern movement and the international style, reinforcing the importance of site specific design approaches.

Although the authors in Jencks and Kropf selection might share the same environmental pursuit and share occasionally formal references as regionalism, the use of vegetation, bioclimatic approach and sustainable materials, nevertheless what characterizes the authors to whom we refer here as fixed signs is not only the experimental character or manifesto style of their proposals but a conscious effort to produce a more methodological and scientific based approach to ecological building design. The fixed signs of ecosystem design integration develop their own practice and methodologies within the decades of 1970, 1980 and 1990, as an attempt to translate the environmental awareness *zeitgeist* into building solutions.

Some of these afore mentioned authors, like John and Nancy Todd, co-founders of the New Alchemy Institute, were greatly influenced by both Buckminster Fuller and by Malcolm Wells, and focused on the concept of self-sustainable detached housing units [often named as *ark*, as the Prince Edward Island Ark] and the development of built systems that beneficiate from ecological services [as the living or eco-machines to recycle onsite wastewater].

In this section we focus on the contributions of a few of the post-modern ecological architects and authors, that were simultaneously particularly committed to both practice and scientifically informed methods (Sim Van der Ryn, Kenneth Yeang, and Michael Braungart and William Mcdonough), and that have eventually influenced the concept of environmental architecture after 1990.

Sim Van der Ryn (1935-…), being influenced by Buckminster Fuller in architecture school, was led by the constant questioning and pushing of design boundaries into ecological design as stated by himself (cf. Van Der Ryn, 2005). The design of Van der Ryn is therefore rooted on the question *"How can we reconnect buildings and cities to the cycles and flows of the natural world that are the basis for all life on earth?"* (Van Der Ryn, 2005, p. 7). In his projects, it is reflected his research for the "architecture of life" natural geometric structures, patterns and processes, as way to reconnect nature with human well-being.

Van der Ryn also perceived or compared the design process to the scientific method, with a research on post-occupancy evaluation of dormitories at Berkeley, in the 1960s, associating it with diverse stages of building life-cycle: 1) hypothesis [design], 2) protocol [design process + construction], 3) laboratory and testing [the building in its real physical world]. In this comparison, Van der Ryn noted that in architecture the stage of hypothesis testing was frequently missing: there were just structural and materials applied science, but no multivariable environmental, human ecology or sociology evaluation put into academic or design practice. The identification of this blank lead him to focus on post-occupancy evaluation issues, which constitute the rudiments of performance design quality indicators.

Van der Ryn also introduced the term and concept of *Building's Ecology* (Van Der Ryn, 2005, p. 26), designating architecture not as an object but a living system that included its users. Within the Farallones Institute, Van der Ryn was involved in early experiments of *Integral urban house*, testing self-sustainable solutions for food, waste and energy, sharing some approaches with John Lyle and the New Alchemy group, particularly on the emulation of integral natural systems (instead of linear degenerative systems).

With Stuart Cowan, he published *Ecological Design*, in 1996, where 5 design principles are suggested: 1) solutions grow from place; 2) ecological accounting informs design; 3) design with nature; 4) everyone is a designer; and 5) make nature visible. (Van Der Ryn, Cowan, 1996)

Van der Ryn and Cowan's *ecological design* is aware of the importance of edge areas, or ecotones: *"An ecotone is a soft overlapping of very different regions. Like patches of watercolors on wet paper, different regions intermingle in an ecotone to create a new spectrum of colors. Ecotones are highly permeable. They are the opposite of a hard edge or boundary that presents a barrier to the flow of resources, energy, or communication. Not surprisingly, they also tend to be places of maximum biological diversity and productivity."* (Van Der Ryn, Cowan, 1996; p. 131) These authors observe that conventional design doesn't incorporate ecotones and that, in fact, "[….] most design is hostile to ecotones." (*ibid*. p. 132)

As noted by Van der Ryn and Cowan, modern urban planning and territorial management in the 20th century avoided, for a long time, intersections and mixed use in human activities, giving priority to single use zoning and single use buildings. This resulted in the sterile separation of housing, industry, commerce, services, leisure, and inevitably, also green or natural areas. As clearly formulated by Van der Ryn and Cowan, the problem is also that "Architects are still designing the *it*, and seldom the *edge*, […]" (or, in other words, the *object*, and not the *relations or flows.* "The result is that modern cities and buildings have hard edges, and they tend to discourage ecotones." (*ibid*. p. 132-133)

On the contrary, "Van der Ryn and Cowan suggest that "By designing ecotones rather than hard edges, we intensify interactions. We bring together a greater diversity of life in an ecological ecotone, and we encourage greater cultural and economic diversity in an urban ecotone. In doing this, we facilitate the flows of materials, energy, and information that can catalyze self-designing processes." (*ibid*. p. 133) The importance of the promotion of local ecological restoration in the concept of ecological design by Van der Ryn and Cowan plays such an important role that leads to their ultimate statement that *"Ecological design, at the deepest level, is design for biodiversity."* (*ibid*. p. 135)

Ken Yeang (1948-…), having studied land use planning with Ian McHarg, was nonetheless one of the first architects to have formation in ecology, pursuing research in the field of ecological architecture since the early 1970s, and completing a PhD degree in 1981 in ecological design and planning with supervision of John Frazer. Yeang's dissertation, *A Theoretical Framework for Incorporating Ecological Considerations in the Design and Planning of the Built Environment* was first submitted in 1974 to the University of Cambridge, and later published in 1995 as *"Designing with Nature"*. In the context of his thesis, there was relatively a lack of research, theoretical models, frameworks, or even scientific support, so his theoretical work focused on producing a foundation for ecological design process.

Yeang recognizes the need for ecological literacy in designers, defining as essential basic knowledge of ecology the understanding of ecosystems structure and functions (Yeang, 1999, p.3). Yeang identifies structural problems within the so called *green architecture* practice, recognizing that many of the projects and approaches lack a global understanding of landscape ecology. One of the critics of Yeang towards previous ecological design attempts is the relative lack of rigor in which the term *ecological* was used.
Regarding conventional design practice, one of the first premises of Yeang's framework is that the concept of *environment* between ecologist and architects is radically different, and that, in order to pursue an authentic ecological approach in architecture it is necessary to face a concept of building setting that includes not only the physical, inorganic milieu, but also the organic and biotic. If, architects are ought to play a role in reversing and averting environmental damage, affirms Yeang (1999, p.8), it is thus necessary to them a complete understanding and ecological perspective of the environment and environmental milieu.

Yeang (likewise Cronon), identifies that no such distinction between *natural* and *humanized* [elements or areas] really exists in the environment. However the waning of this distinction is less rooted in a comprehension that humans are part of nature, but by the observation that, directly or indirectly, all areas in Earth have been altered by human action. No part of Earth can be considered entirely natural, affirms Yeang (1999, p.10). Natural and artificial are therefore defined in Yeang's perspective, both being part of the biosphere, as what is *spontaneous* and what is *designed or manipulated*. Another essential ecological notion, incorporated in Yeang's ecological project approach is that the interactions between ecosystems traverse any artificial boundaries imposed by man, therefore the conception of architectural project should be conceived within its wider geographical context, holistically, as part of the ecosystem unit where it is situated (Yeang, 1999, p.11).

Yeang also adverts for the dangers of considering a project unit, or a certain environmental aspect, in exclusivity, without the referred holistic perspective. For instance, Yeang refers that air, soil, and water are not and should not be treated in a project as independent elements or independent environmental zones, and that the whole ecosystem should be seen in its continuum dynamic state. Since the characteristics of each ecosystem are diverse and species occupy a particular geographic sphere, with particular circumstances and conditions, another Yeang's illation is that each ecological project should be site specific. Building up on Ian McHarg's notions in *Design with nature*, Yeang affirms that each project site should be individually evaluated, attending to its own natural values, processes, limitations, and opportunity range within the ecosystem it belongs, which differ from site to site (Yeang, 1999, p.16).

Regarding the impacts of construction in local ecology, Yeang is particularly aware of project impacts on site and biodiversity, and alterations in surrounding areas; as well of the limitations of artificial substitution systems to provide local ecosystem functions, affirming not to accept in principle technologic means to substitute nature or provide a "controlled environment" [as he writes, this technologic substitutions tend to be a simplification of natural processes, and are vulnerable to failures and breakdown. (Yeang, 1999, p.25).

Yeang considers as one of the essential premises for the ecological architecture project an ecological understanding of the environment. From this, Yeang defends a holistic perception and approach to the project site, including the identification and comprehension of all its biotic and abiotic elements, and internal and external interactions, before initializing the design. The project site should be understood in the perspective used by ecologists, in the context of the specific ecosystem unit where it belongs, and in the framework of the other Earth's ecosystems.

The intrinsic knowledge of ecology and other related disciplines, as physics, and particularly thermodynamics, with its flows of matter and energy, has influenced Ken Yeang in the perception of architecture as a transitory and subordinated system. Yeang suggests to change the traditional concept of the built environment as a static immutable object, to as some entity part of the flows and exchanges of energy and matter within the biosphere. In Yeang's concept, buildings consist of transitory arrangements of energy and material resources, put together by humans. The built environment is therefore seen by Yeang as part of the flows of energy and matter, implying upstreams and downstreams of residues and waste and energy dissipation, a system with inputs and outputs. Yeang's concept of ecological architecture therefore focus more on flows of matter and energy, but less on the relations established with biotic elements or [local] cycles.

The input-output model of the built environment suggested by Yeang can be however very elaborated, comprehending the local biotic and abiotic elements, the outer system with which the local built system exchanges resources and products, the sources of energy and matter that cross the local system, and the information flows. Yeang defines six aspects of the built environment with ecological implications, influencing the premises of ecological project (Yeang, 1999, p.55-57): 1. The built environment has abiotic and biotic components; 2. The ecological project includes the definition of lifestyles and the minimization of requirements from its users; 3. The built environment is part of the flows of energy and materials during its lifecycle; 4. Integration of the built environment within Earth ecosystems; 5. Identification of the lifecycle impacts of the built system; and 6. The external context of a built system is the totality of the Earth ecosystems.

Between 1960 and 1990, notions of life-cycle and environmental impact assessment became also incorporated into the consolidation of ecological collaborative approach, as it is visible in Yeang's theoretical work. The ecological impacts of a built system as conceptualized by Yeang, can be understood as the interactions that take place between: a. exchanges of inputs (incomes) and outputs (products); b. the operation activities in its interior; and c. its external environment, constituted by whole Earth's ecosystems

(Yeang, 1999, p.58). Yeang's ecological understanding is characterized by a strong component of industrial ecology (with focus on inputs and outputs of matter and energy), which has also supported later building environmental assessment systems, tending to emphasize as objectives the mitigation of negative impacts, as minimal emissions or minimal resource use, peaking into Zero Carbon or Carbon Neutral benchmarks.

In *"Designing with Nature"*, Yeang suggest a structural tool, based on this conceptualization, that doesn't indicate ways for project design or design principles but instead, ways of analyzing. Although Yeang affirms that in the development of design solutions and project options it is priority to integrate systematic and spatially the built system components with the local ecosystems of the project's site, and to search for symbiotic and compatible relations with its local environment (Yeang, 1999, p.71), this is not expressed clearly in the proposed tool. Local ecology preservation is overall addressed in the context of rural or semi-natural environments, by Yeang, as the danger of destruction of fragile habitats or species would occur. In urban settlements or project sites, however, Yeang considers that since they are urbanized or surrounded by urbanization, the consideration of biotic elements might not be relevant (cf. Yeang, 1999).

As result of the analysis of local ecosystem, the designer can determine which impacts would be "admissible" or "inadmissible". However, Yeang avoids any possible project objective of ecological restoration, based on the fact that the reintroduction of eradicated species, for instance, is a difficult process. Therefore Yeang affirms that is easier to protect an existing ecosystem than restore it after damage (Yeang, 1999, p.88). Yeang seems to admit that project decisions should be taken according to the ecological limits and opportunities found within the site, but once it is damaged, paved or urbanized, the project is not intended to recover it. However, Yeang still considers some possible positive effects of the architectural project towards the local ecosystem, and talks of *"compatibility links"* (Yeang, 1999, p.91). These positive relations are expressed towards ecosystem promotion, in the following ways: 1. Ecology preservation, through natural reserve management; 2. Added values, in the case of rehabilitation of greyfields; 3. Prevention or mitigation of ecological deterioration factors, in the case of erosion prevention through drainage; 4. Ecosystem restoration, through the reforestation of abandoned fields.

Alike Van der Ryn, Yeang also defends that *ecological architecture* should be visible, and the integration of ecosystem features at building scale has been experimented and developed in Yeang's practice, particularly under the form of vertical landscaping. Yeang also defines post-occupancy evaluation as part of ecological design process which he compares to the scientific method: the first being is analysis, the second, the project or synthesis, and the third, appraisal of the design solution in terms of inputs and outputs through life cycle. In terms of project design, considered by Yeang as *synthesis*, after the precedent analysis stages, Yeang admits that [his] environmental interaction support tool doesn't substitute the creativity of the designer (Yeang, 1999, p.166)

William Mcdonough, architect, and Michael Braungart, chemist, have equally launched a design practice, paralleled by scientifically informed thought and approach, reshaping the meaning of ecological architecture. In *The Hannover Principles*, enunciated by William McDonough, in 1992, among diverse nature harmonization conceptions shared by other precursors, the principle of elimination of waste (i. e. the derived and pollutant sub-products in the production cycle of materials and buildings) has become one of their most celebrated contributions to ecological design, placing an emphasis on recycle, reuse and reduce philosophy.

Together they have published *Cradle to Cradle: Remaking the Way We Make Things,* where the principle of closed loops and materials cycles is reinforced. Mcdonough and Michael Braungart also associate ecological architecture to local-specific solutions, rejecting buildings as *"[…] a bland, uniform structure isolated from the particulars of the place – from local culture, nature, energy and material flows."* (Mcdonough, Braungart, 2002b, p.29) and discouraging every product design that disregards the *localness* of environmental conditions, needs of use, and completion of lifecycle.

Finally, Mcdonough and Michael Braungart come to conclude, in accordance to the transition to a positive paradigm shift discussed in the following sections, that *"less bad",* in terms of environmental impacts, sought since early in the context of industrialization, is *"no good",* (2002b, p. 45), and in *Buildings Like Trees, Cities Like Forests* speak about a "delightful *participation* in landscape" (McDonough, Braungart, 2002a).

2.6 Mutable Signs: Transition

The work of some of the before mentioned precursors and consolidators established the basis where market green building and present assessment methods partially take root, besides launching unique experimental practices. Nevertheless, much of the research lines and radicalness of their propositions was left behind in the mainstreaming development of environmental architecture.

As Chrisna Du Plessis (2012, p. 19) accounts, early ecological architecture proposals of the 1960s and 1970s were based on *"[…] a strong self-sufficiency movement based on locally available, renewable resources and appropriate small-scale technology […]"*, as that of the Brenda and Robert Vale, and John and Nancy Todd for instance, but also the Arcosanti project by Paolo Solari, and the Center for Regenerative Studies, by John Lyle. They were also fundamentally low-tech, using passive design and bioclimatic approaches, on-site energy and water recycle systems, the resource to natural raw materials, organic agriculture and permaculture, and eventually had site and local biodiversity in account or as co-auxiliary factors, in some cases.

These first ecological architectures and thoughts [beginning from the 1960s and extending until the last decades of the 20th century] were often supported by a strong authorial research and manifesto component, and were more likely holistic, radical, local and philosophical in nature. However those propositions had difficulty to thrive in mainstream architecture, due to the facts, also pointed out by Du Plessis (2012), of an inherent inadaptation of those solutions at urban scale, and also because of their predominant counter-culture connotation tended to became marginalized.

In addition, these early experiments and authorial research varied greatly in terms of architecture quality, scientific support, and even environmental scope. Moreover, accompanying the progressive focus shift of the green architecture movement towards *sustainable development*, environmental assessment, and the need to address pressing global impacts [atmospheric emissions and climate change, associated with energy consumptions and materials life cycle] rather than local restoration or radical self-subsistence, the horizon of environmental architecture also shifted from local to global, becoming increasingly technical and high-tech dependent, and even progressively *abstract* to architects [relying on "*invisible green*" technologies and solutions, as referred by Lance Hosey in the *Shape of Green* (2012)].

Hosey (2012) also compares the difference between technological and ecological sustainability, proposed by Orr, with the concepts of High Tech and Hich Touch, proposed by John Nasbitt. As technological sustainability relies predominantly on "fast fixing" technological artificial solutions, a lot of sensory aspects are also removed from those solutions, as compared with the richness of senses and textures, cultural and local identity that a balanced long term ecological sustainability would provide.

The connections with *local* environment, in their cultural, regulating, supporting and provisioning ecology aspects, became relativized in terms of significance and priority, and thus with the divorce of ethics with aesthetics, lead to a fundamental loss of ontological meaning in environmental architecture. This connections might be reestablished with the emerging regenerative approaches, and the call for reintroduction of biodiversity and ecosystem services in architecture and urban built environments, which characterize in our perspective, a moment of *transition*.

One of the central contemporary authors in this direction is William Reed, and the Regenesis Group, including also Pamela Mang and Nicholas Mang. Being a founding member of the USGBC and the LEED methodology, Bill Reed clearly enunciate the need for a positive co-evolution, building up on some concepts earlier enunciated by initiators as John Lyle and Malcolm Wells.

In his writings, Reed (2006), interprets the evolution of environmental architecture into regenerative design, tracing a line between what he calls *issue-based approaches* and *living system approaches.* The *issue based approaches* comprise the conventional mitigation and neutralization benchmarks accepted or driven by the majority of the current environmental assessment methodologies including:

a) “*high performance design*”, a technological approach to mitigate impacts; and b) the “neutral approaches” preconized both by generic *“green design”* (“A general term implying a direction of improvement in design, i. e., continual improvement towards a generalized ideal of doing no harm.”) and “sustainable design” (“Green design with an emphasis on reaching a point of being able to sustain the health of the planet’s organisms and systems over time.”) (Kibert, 2007, p. 124)

Within the *living system approaches*, Reed distinguishes between the interconnected concepts of *restorative, reconciliatory* and *regenerative* approaches. In the *restoration* approaches, *“[…] designers think in terms of using the activities of design and building to restore the capability of relatively independent local natural systems to a healthy state of organization.”,* while *reconciliatory* design approaches recognize humans as integral part of nature, devising design processes based on the principle that *“human and natural systems are one.”* (Kibert, 2007, p. 124). The *regeneration* approach instead focuses on the integral co-evolution of whole local systems, including human communities, biotic and abiotic systems, unraveling a sense of stewardship towards the place through a continuous learning and adaptation process.

Another transition sign is a re-focus on local biodiversity issues raised by for instance the Royal Institute of British Architects, and its Biodiversity Task Group launched in 2008. As referred by Williams (2010) and Grant (2012), one of the results of the focus on energy sustainability and low or zero carbon buildings [such as in the Passive House and the Zero-Energy Building (ZEB) standards] devised in the building industry – particularly during the 1980s and 1990s – changes in materials and envelope system and structures, that altered the “traditional” wildlife habitats provided by buildings in urban and rural areas. Technical guidebook(s) to reintroduce these habitats into contemporary construction has become therefore necessary, as it is the case of *Biodiversity for Low and Zero Carbon Buildings: A Technical Guide for New Build*, published by the Royal Institute of British Architects in 2010 (Williams, 2010). This book covers materials and technical details essential to accommodate birds and bats shelters “for which no guidance previously exists” and “considers some of the ready-made products for roosting and nesting that are on the market” (Williams, 2010, introduction XV) and how can these be integrated in terms of environmental sustainability, proposing technical solutions and façade sections, specific for the UK context and species.

These efforts may be considered part of a restorative approach at maximum, and are still away from regenerative (perhaps risking to become prescriptive and do not guaranteeing an overall design integration). However, they highlight the need of biodiversity habitats integration with several other architectural parameters - such as energy cycle, details and materials, and visual quality-, and within broader contexts such as community involvement and green infrastructures network.

In line with these efforts, a progressive call for design with ecosystem services has been raised by other authors, in relation to urbanism, urban centers, and green infrastructure, including Janis Birkeland, author of *Positive Development: From Vicious Circles to Virtuous Cycles through Built Environment Design* (2008) and Gary Grant, *Ecosystem Services Come To Town: Greening Cities by Working with Nature* (2012).

The resource to ecosystem functions and services assessment framework has also been recently analyzed as a possible design criteria either to ecosystem based design in Suzanne Charest's *Ecosystem-based Design: Addressing the loss of biodiversity and nature experience through architecture and ecology* (Charest, 2009), green building assessment (*The application of ecosystems services criteria for green building assessment*, by Victor Olgyay and Julee Herdt, 2004), and finally, into regenerative built environments, by Maibritt Pedersen Zari in *Ecosystem services analysis for the design of regenerative built environments* (Zari, 2012).

A shift to a deeper transformation is concurrently being addressed by some environmental assessment methodologies, like the Living Building Challenge and SITES, as further discussed on Chapter 3, and even LEED is considering to include positive impacts and ecosystem services benchmarks in future developments of the rating system, as presented in 2013 in one of the SB Conference series in Vancouver.

In addition to the already mentioned authors, other contemporary voices in the turn of the millennium, include possible new orders of ecology and architecture outside the environmental assessment niches, as Joanna Boehnert, in the line of influence by F. Kapra and D. Orr, dealing with the *Visual Communication of Ecological Literacy*; Lydia Kalipolitti, working on Retrospective of Past and Future Ecologies-Architectures; and the reconciliation of ethics and aesthetics in ecological building design by Sang Lee in *Aesthetics of Sustainable Architecture*, and Lance Hosey, with *The Shape of Green – Aesthetics, Ecology, and Design*.

Charles Kibert himself has contributed to shape environmental architecture, reflecting and reinterpreting its past and present authors and envisioning its demanding quests: *"The most exciting and underutilized resources for creating high-performance green buildings are natural systems, and they should be employed as more than superficial components of the project."* (Kibert, 2007, p. 157) *"The high level integration of ecosystems and the built environment is, at present, only a concept."* (Kibert, 2007, p. 158) *"Site and landscape also provide the opportunity to move beyond mere greening to the potential restoration of the land as an integral part of the building project."* (Kibert, 2007, p. 133)

2.7 A Shift to a Positive Paradigm

A shift to another paradigm progresses, as regenerative design principles disseminate through diverse sources and entities: *"Our built environment has the potential to have major negative impacts on biodiversity.*

However, if done sensitively, the development and refurbishment of buildings, can, in fact, increase the ecological value of the site." (Williams, 2010, introduction)

The concept and term "*regenerative"* was promoted during the 70s decade of the 20th century, by Robert Rodale (1930-1990), applied in relation to organic farming systems. The use of the term "regenerative" in the context of building systems or architectural project design is nevertheless attributed to John Tillman Lyle (1934-1998), author of *Regenerative design for sustainable development*.
However, these proposed regenerative practices and systems were not actually introduced or invented, in the 20th century, but more (re)discovered or taken aware of. According to Lyle (1994), several examples of traditional regenerative practices associated with agricultural systems were still persisting in the 20th century, in different parts of the world.

Some principles and underlying ideas of regenerative design are present in such different approaches in space and time as *land art* reclamation projects, performing ecological restoration of mining pits or brownfields, to the *Urban Acupuncture* concept, by Jaime Lerner (2003) in Curitiba (Mang, 2006). Transversal and common to these different approaches, can be found the idea of a local [subtle and non-invasive] medicinal intervention on site, looking to revert the effects of ecological imbalance through regenerative cooperation with the ecosystem.

The characteristics of a regenerative system are listed by Lyle, in the following way: a) Integration with natural and social processes; b) Minimal use of fossil fuels and human production chemicals; c) Minimal use of non-renewable resources, except when reuse and recycling are possible; d) Use of renewable resources, within their regenerative capacity; e) Waste production control, within ecosystem re-assimilation limits, regarding volume and composition.

Lyle also makes a distinction between the concept of *paleotechnic* (associated with conventional industrial technology, whose theoretical reference model is physical and physics) and the *neotechnic* (where the regenerative systems are included, whose theoretical reference model is biology), adding a new facet to the envision of future ecological architecture as "Building projects that regenerate local ecosystem", versus or or in complement with "Buildings that produce more resources that they consume" (cf. ARUP, 2013).

Similarly, according to David Orr, there are two types of sustainability, technological sustainability and ecological sustainability. As referred by Hosey *"Technological sustainability is quantitative and relies on doing the same things more efficiently, whereas ecological sustainability is qualitative and requires a fundamentally new way of doing things."*(Hosey, 2012, p.18) In part this distinction can also be translated in terms of the difference between symptom treatment and partial emergency aid with a preventive, holistic and more resilient approach to medicine (or ecology conservation).

The fundamental support of this evolutionary change is supported by systems thinking as a tool for integrated design. Several systems are contained within the whole: ecology and the social system, integrated by other sub-systems such as physics and the (ethical and cultural) value system. In this theoretical model, design should embrace not only the physical elements but beyond them, the invisible connections that exist among these cycles and flows. In the regenerative design philosophy, it is believed that better results can be achieved when considering not only the potential negative impacts, but also the potential beneficial relationships between all systems.

Some of the theoretical foundations, rooted in a transformation paradigm, and supported by ecological thinking, to achieve the objectives of regenerative design, were synthetized by Nadav Malin, Bill Reed, and Joel Ann Todd in *Expanding our approach to sustainable design – an invitation* (2005, p.19), as follows:

1. "We *are* nature". – It is essential to recognize and comprehend that humans are an integral part of nature, understanding the past history of the relations between natural and social systems, and the evolutionary future potential of this relationship. This concept allows to see ourselves as partners, and envision a future of co-evolutionary and symbiotic relationships with other living beings.
2. "Change *is*" permanent. – The perception that change is a permanent process in nature, and that the universe and all its systems are constantly in mutation and motion, at micro and macro scale, is also fundamental to envision regenerative design systems.
3. "Life wants to unfold into greater resilience". – This concept is also observable at different scales in nature. The diversity and flexibility are factors of paramount importance to the resilience of species and systems. The higher the resilience, the greater the disturbance these can withstand.
4. "Diversity needs relationships". – Resilient systems are based on multiple connections between elements that are redundant, diverse, and cooperative. The variation and diversity of these inter-relationships is the fundamental key to the resilience of systems.
5. "Resilience makes disturbances into opportunities". – Disturbance is a potential factor for learning and innovation, within resilient systems. Developing resilience and creative emergent responses within a system, in face of disturbance, allows its evolution towards more complex and regenerative states, going beyond sustainability.

Regenerative designed systems are then characterized by being designed as: an integral part of nature, adaptable to and carrier of change, and made of diverse elements and functions in interrelation. Regenerative design is influenced and supported by diverse fields of knowledge and methodologies, including resilience theory and system thinking. Some of these approaches, are ecosystem theory and applied ecology, environmental impact analysis, information systems and theory, and public participation methods.

Resulting from these influences, the regenerative design process, as defined by Lyle (1994), reflects the following strategies:

1. *"Let nature do the work"*. – Resort primarily to natural processes, or processes present in nature, to perform the necessary functions, in order to achieve greater resource conservation, reduce environmental impacts and minimize costs. [This principle implies the use of passive design and bioclimatic strategies, as building setting and orientation to control heating gains, shading and wind patterns, as any other landscape integration schemes, in detriment of "active technologies".] Consequently, an essential preliminary step to regenerative design is to conduct the inventory of local resources, processes and needs, present or available onsite, and as a result, deliver site specific systems.
2. *"Considering nature as both model and context"*. – As context, maintain or restore the continuity and the existing macro-scale interrelationships. As model, learn from biological and ecosystem processes [through direct use, adaptation, functional analogy, or biomimicry as proposed by Benyus].
3. *"Aggregating not isolating"*. – Integrated design [and a holistic approach], is an essential foundation of regenerative design, comprising the integrated planning of parts, cycles, functions and their intricate connections. Contrary to a Descartian logic, Lyle notes that the design for segregation of parts inevitably produces disaggregated worlds.
4. *"Seeking optimum levels for multiple functions, not the maximum or minimum level for any one"*. – Given the complexity of objectives and targets, sometimes in conflict between them, optimal level quantification can be problematic. The combination of an acceptable range of optimized values in different functions is preferable, as project option, than focusing on one single objective.
5. *"Matching technology to need"*. – Avoid overdesign. Avert complex technical and technological solutions with high environmental impacts, whose functions could be performed by simpler solutions with less overall impacts.
6. *"Using information to replace power"*. – Functional adequacy of the system can be met through data and information gathering about actual consumption requirements and needs, and its use in the design process. It can be achieved through increased information and research models, and also through constant feedback with the public about possible positive and negative impacts.
7. *"Providing multiple pathways"*. – The combination of different solutions for the same function provides greater resilience of the system. An example of this strategy is the use of renewable energy sources combined, attending to the available conditions. This strategy reproduces the redundancy principle in ecosystems, also advocated by other authors: if a path may be truncated due to weather, human conditions, or other, there is always other possibilities for the system to continue operational.

8. *"Seeking common solutions to disparate problems"*. – Regenerative systems consider flow patterns in an overall design, allowing greater integration of solutions, but also increased interaction between systems. Considering the water cycle as a whole, the solution adopted for collecting rainwater, for example, can provide wastewater treatment and simultaneously reduce the consumption of drinking water. Moreover, the wastewater treatment may act both as irrigation water provider and biodiversity catalyst, resulting in integration of the water cycle with the nutrient cycle and others.

9. *"Managing storage as a key to sustainability"*. – In circular flow patterns, storage is an important factor to balance the fluctuations of the provision ability and usage needs. An example of this strategy is the concept of thermal mass in the building envelope.

10. *"Shaping form to guide flow"*. – To devise passive systems that are able to (re)orient flows through their formal characteristics is a strategy that reduces resource consumption and the application of unnecessary technology. An example of this strategy is the orientation of hot air and cold air streams for natural ventilation of spaces, or wind orientation through urban form.

11. *"Shaping form to manifest process"*. – Since form follows function and flow, to conceal this logic implies an increase in resource consumption, [not ethical or productive, in light of regenerative design]. This principle is assigned as an opportunity to express new aesthetic manifestations, to resolve conflicts between present culture and technology, and to evolve from a state of "applied" to "implied art".

12. *"Prioritizing for sustainability"*. – As the change of degenerative patterns and systems into to regenerative ones is gradual [in a transitional moment existing a simultaneity of both], design options should give priority to more sustainable solutions, foreseeing a potential evolution in the systems and social behavior.

Following the research developed by Lyle and Reed, among others, the concept of regenerative design extends to building industry research, and in 2012 a whole special number of Building Research & Information is dedicated to the topic. In one article in that issue, with focus on evaluation benchmarks, according to Raymond Cole (2012b), Regenerative Design evolves from limited *green* and *sustainability* perspectives into a holistic and regenerative view. While, to Du Plessis (2012), focusing on broader societal paradigms, the field of sustainability is characterized by a three way, where Regenerative Design constitutes a radical ecologic direction, contrasting to the flawed public policy driven "sustainable development", and the capitalist market driven "ecological modernization".

In parallel, and sometimes embraced with regenerative design approaches, the concept of design for ecosystem services also takes part on the current shift to a positive paradigm in the built environment, as previously discussed. Grant (2012, p. 58) explains that from the 1992 UN Earth Summit held at the city of Rio de Janeiro emerged the notion of *ecosystem approach* and the need of scientific assessment and further information drove to the launch of the Millennium Ecosystem Approach. With this study program, the concept of ecosystem services was *"introduced […] into policy discussions and project planning. […] as a new way of explaining how humans are supported by and reliant on the natural environment."* Grant (2012, p. 58)

The positive focus on biodiversity and ecosystem services based project design is particularly noticeable in Anglo-Saxon countries, as the U.K and the U.S.A., being visible on the IHDC competition, and SITES initiatives. The UK Green Building Council has a Biodiversity Task Group since June 2008, among other sustainability and environmental research driver and support topics, and it has launched its UK-GBC first Biodiversity Task Group report in 2009. These initiatives are rooted both in cultural terms, and in an acute awareness of urban biodiversity decline [the decline of the population of local species such as bats, swifts, swallows, house martins, house sparrows, starlings, barn owls, peregrine falcons in the U.K. are reported for instance by Williams (2010)] and derive also from biodiversity comprehensive species protection and building regulations, in Europe, linked with other supra-national measures such as the Habitats Directive, shared by the E. U.

An example of biodiversity protection enshrined in building and urban planning documents is the "Eco-towns biodiversity worksheet, published by the Town and Country Planning Association (TCPA) in December 2009" that offers guidance towards the number of recommended habitat support provision for building-reliant species per species, and units of buildings and urban development projects.

Concurrently to this shift, several architecture and project compilations regarding the provision of ecosystem services have started or are underway, with incidence after the start of the 21st century; including databases mostly centered about food production (as for instance, the AtlasFoodUrbanism, or the Carrot City project, carried at the Ryerson University in Toronto), and simultaneously, diverse series of design competitions (including the Integrated Homes & Design Competitions, the e-volo skyscraper and algae competitions] that are contributing to the re-imagination of a future built environment, and its potential symbiotic properties with several ecosystem services and functions.

2.8 Ecological Approaches in the context of Japan and its Architecture

The context of Japan is characterized by local key environmental issues that are both geographic, social and culturally specific. Facing the number of its inhabitants and territorial extension, Japan has a limited area of arable land, and one of the highest food supply mileages of the world. As stated in the World Wide Fund (WWF) biannual report on the territory: *"Japan is highly dependent on biocapacity from other countries to support its population's needs. If its trading partners are also in ecological debt, Japan is vulnerable to a* *disruption in its resource supply. This highlights the crucial need for governments to manage their use of ecological assets."* (WWF, 2012, p.16)

The resource to raw materials for construction is one of these, namely the use of wood in construction, of which Japan is one of the world's largest importers – although around 68.5% of the land area in Japan is occupied by forest, while 31% is the average of world countries. The provision of local wood is a key point, demanding the revitalization of forest resources in Japan, and considering the importance of sustainable forestry management [and its role in assuring relevant ecosystem services and functions during its cycles of planting, tending and harvesting].

Japan is also characterized by a very intense urbanization, either in number of urban inhabitants and urban centers' density and extension. Although Tokyo, for instance, is sometimes mentioned as one of the greenest cities and has undoubtedly large parks and street greenery, the general characteristics of urban space indicate a high percentage of soil occupation, impervious surfaces, and a pressing need for remediation of riverfronts and canals, among others .

In addition to a still increasing population movement towards urban centers, the problem of shrinking and ageing population has aggravated the disequilibrium between cities and countryside. Sustainable wood harvest and forest maintenance has been provided in Japan within traditional socio-ecological landscapes, called *satoyama*. The human abandonment of forests, coppices and farmland, associated with these areas, is leading to biodiversity and ecosystem changes, and an underuse of local natural resources. In Japan, abandoned agriculture forests and coppices areas are estimated to be 5.000.000 ha, and abandoned or non-cultivated farmland about 160.000 ha (the equivalent of 4% of total farmland) (Takeuchi, 2000, p.80).

Other environmental issues particularly related to sustainable construction, were identified at the end of the 20th century in a report prepared for CIB (International Council for Building/Conseil International du Bâtiment). In this report organized by Tomonari Yashiro (1998), were also mentioned the high populational density and the shortage of habitable land area, as critical issues affecting Japan.

In association with the "*heat island*" effect, in urban areas, [to which the Green Tokyo Plan launched in 2000, among other later initiatives, tries to give response], the primary local issues for building sustainability were identified in line with the global environmental agenda, from which we highlight the following:
a) Global warming and the production of atmospheric emissions [Energy], within buildings life cycle, is pointed out as one of the key environmental issues to be addressed by construction. The construction sector, summing total materials production and transport, and building's operation energy consumptions,

accounted to 34% of national emissions in the early 1990s (Yashiro, 1998). One of the most striking aspects of this being associated with summer cooling energy use.

b) The depletion of material resources and its effects on ecosystems [Materials], is also acknowledged as an important factor, particularly the depletion of tropical forests, associated with the consumption of imported tropical timbers in construction and of plywood derived from tropical wood as cast-in site concrete forms.

c) The production and deposition of construction debris [Waste], is referred as one of the major concerns and considered a critical issue, as the construction industry holds the largest share of national waste production - accounting for 21%, in 1990, from which only 42% were recycled (Yashiro, 1998). Correspondingly, the space shortage for waste disposal, reinforces the increased need for waste reuse and recycle in sustainable construction, in Japan. The short life of buildings is also pointed out as another environmental concern in building industry, in the country: Structural steel structures with an average life span of about 30 years, and the short cycle of "*new build and demolition*" are great factors for resource and energy consumption by the building sector.

In the 20th century, environmental awareness and the formation of an environmental movement in Japan, have emerged in the sequence of a *"period of rapid industrial growth* […] *between the mid-1950s and early 1970s"*, as *"serious pollution problems began to surface all over the country"* (Edahiro, 2009), and as a reaction to local focal points of industrial pollution and its severe impact on human health [heavy metal industry and mining, and petrochemicals, for instance]. Junko Edahiro, from the NPO Japan for Sustainability identifies this as the initial stage of the 3 development stages of environmental citizen movements in Japan (Edahiro, 2009).

The second stage of environmental activism was characterized by the awareness of the ecological impacts caused by everyday life-style and consumption habits, namely the impact of detergents on water cycle and water pollution, among others. In parallel with the international scenario, the beginning of the 1990s also marks the shift of environmental awareness focus from local to global issues. *"Until this point, people generally regarded environmental problems as local issues, such as the local rivers being polluted, or nearby mountains being damaged, or the condition of local seas being threatened."*, as referred by Edahiro (2009). From 1992 [year of the UN Convention on Biological Diversity (Rio de Janeiro Earth Summit)] and 1997 [UN Framework Convention on Climate Change and Kyoto Protocol], climate change along with ozone depletion, atmospheric emissions and energy become the lead driver sustainability topics, as seen on the previously mentioned report. The development of ecological architecture approaches in Japan, and the reach to sustainable construction does not always follow or is always linked with environmental activism, however.

The first approaches to sustainable and ecological architecture in Japan have developed in line with the international post-modern experiments towards local expression and passive design. The practice and, perhaps more important, the theory of Team Zoo, a group of independent ateliers founded in 1971, inscribes itself in the post-modern ecological architecture, of the 1960's and 1970's, having proposed a charter of principles paralleled to that of Van der Rym, for instance, and with focus on regionalism and community. Team Zoo, founded by Keiko Arimura, Hiroyasu Higuchi, Koichi Otake, Tsutomu Shigemura and Reiko Tomida, among others, has based their design philosophy interpreting and linking architecture *as sensorial experience,* and sense of peace. Their approach to ecology or environmental design comes from their concern towards climatic control, leading to and centrally focused on a bioclimatic conception - therefore, incorporating green roofs, air ducts systems, and integration of vegetation, along with vernacular and formal elements.

Simultaneously, the passive design approach was also adopted by Ken-ichi Kimura, in the 1970's, backed up by scientific research and less vernacular/manifesto rhetoric, having developed in Japan a series of experimental passive houses, in line with international research on energy conservation, starting with the building of its own family house, Kimura Solar House, in 1972. While eventually the practice of Team Zoo got dispersed, Kimura later played an active role in diverse institutions in Japan and abroad, as AIJ (Architects Institute of Japan), and PLEA (Passive and Low Energy Architecture), contributing to the debate and development of sustainable construction in Japan.

Immediately after the second Oil Crisis, the Institute for Building Environment and Energy Conservation (IBEC) was founded in 1980, spurring research on building and environmental engineering, but sustainable building issues start to go mainstream only in late 1990's, as referred by Yashiro (1998).

The definition of "sustainable building", adopted by the Architectural Institute of Japan (AIJ), and the Institute for Building Environment and Energy Conservation (IBEC) comprehends the minimization of environmental impacts and the maintenance/harmonization with the local environment: *"A sustainable building is one which is designed: [1] to save energy and resources, recycle materials and minimize the emission of toxic substances throughout its life cycle, [2] to harmonize with the local climate, traditions, culture and the surrounding environment, and [3] to be able to sustain and improve the quality of human life while maintaining the capacity of the ecosystem at the local and global levels."* (AIJ, 2005)

This threefold concept is also translated in the approach of the Environmentally Symbiotic Housing Promotion Council (ESHPC), based on the minimization of global environmental impacts, the compatibility with local contextual environment, and the optimization of human well-being. The ESHPC is an association formed of diverse private and public entities, including municipalities, business and other organizations related with housing and planning development, whose declaration of principles in 1997, precedes the launch of the first environmental assessment methodology for buildings in Japan, CASBEE.

With the change of research focus from local to global issues, and passive to active and hybrid energy systems, developments in green architecture in Japan tended to become assured by large scale construction and design companies, instead of architects-authors. Corporate green architecture, with a predominant high-tech approach, as that of Nikken Sekkei, Nihon Sekkei, Sekisui, Takenaka and Obayashi Corporations, among others, started to unveil at that time, persisting until today.

Although during the 1990s it is observable the practice of Ushida Findlay (formed by Kathryn Findlay and Eisaku Ushida) in and out of Japan, particularly the Soft and Hairy House, sometimes nicknamed as "organic", or connected with ecological architecture in a similar way that of Team Zoo, and the practice of Shigeru Ban with the recycled material content and community involvement; undoubtedly, in Japan, the industry took lead of *green architecture* market, and several corporations and construction companies developed on their own design, materials and building systems, under a policy of research & development, encouraged by governmental recommendations (cf. Yashiro, 1998).

Resulting from the governmental initiatives towards sustainable development, CASBEE - Comprehensive Assessment System for Building Environmental Efficiency – environmental assessment method was launched in 2004, following a project supported by the Ministry of Land, Infrastructure, Transport and Tourism, in 2001 gathering academic institutional and industry stakeholders – including IBEC-, that gave origin to the Japan GreenBuild Council (JaGBC) and the Japan Sustainable Building Consortium (JSBC).

The CASBEE methodology reflects the vision for sustainable building enshrined by the directive definitions provided by local institutions, as the AIJ, and provides an environmental sustainability assessment with unique particularities, namely the notion of building quality and environmental impact, as a balanced ratio between outer and inner boundaries. One of the noticeable features of this methodology is the prominent position of the category "Outdoor Environment on site" which more directly relates with local ecology and the access to ecosystem services.

However, in general, the overall context of Japanese building is still characterized by contrasts as the disparity between the high quality of contemporary erudite architecture (in terms of concept and innovation) and the advanced research in materials and systems for environmental sustainability, with the poor environmental performance and the platitude of its urban and suburban built fabric of non-erudite and disposable architecture. Although along the time several city and regional initiatives towards sustainable development have developed, and specific regulations apply to governmental public building projects, presently there is no compulsory regulation for environmental efficiency of regular buildings in Japan, as there is in other developed countries, for instance in Europe.

In addition, in the overall context of Japanese architecture, green building design doesn't strike as post-modern critic, or self-statement, since both its modern and post-modern movements become fused with the Metabolist Group. Few exceptions might be linked with earlier radical ecologism, regionalism or playful organicism [as Team Zoo and Ushida Finlay]. The tendency to associate Japanese architecture in harmony with nature is however a frequent mantra, an over-reproduced interpretation that relatively escapes the real scope of ecological architecture. In fact, even among architecture practices not at all related with environmental efficiency, there is difficultly a single Japanese architect that is not associated with nature, natural metaphors or organic biological concepts as symbiosis.

Nevertheless, self-subsistence bioclimatic experimental attempts keep being carried by the Permaculture Center of Japan, and others – particularly worth mentioning the eco-villages and co-housing experiences, conducted by TeamNet company, and also the eco-villages and ecological centers developed by Koji Itonaga, influenced by permaculture and community participation principles (cf. Itonaga, 2011) - remaining relatively marginalized from architectural design main discourse, while other architects, as Hiroshi Iguchi, seem to follow the ark concept of the New Alchemy Institute, with a contemporary language twist.

The concept of symbiosis has regained however, for a moment, a functional, rather than formal, significance with the environmental approach of Kazuo Iwamura, in the 1990s, for whom nature is treated as a working context to establish bioclimatic and other collaborative interactions, while adopting archetypical architecture forms, rooted somewhat in regionalism. Some of the projects by Iwamura Atelier might be inscribed in the practice of international post-modern environmental architecture, with environmental certification, but are now more focused to urban planning and community participation.

The architecture of Teronobu Fujimori explicitly derives from the experiences initiated with Team Zoo, recapturing some of their central themes: environmental concern, vernacular-regionalism, and non-industrial craftsmanship. As cited by Dana Buntrock (2010, p.123), Fujimori said in an interview, talking about Reiko Tomita and other Team Zoo members: *"If she and the others had fully carried out* [what began at] *Nago City Hall, well, there would have been no necessity for me to do any architectural design."*

Fujimori is particularly interested in the integration of greenery and green enveloping within architecture (Fujmori, 2007), reflecting on examples of green roofs across history. About the hanging gardens of Babylon, Guinigi Tower [Lucca, 14th century], Akita Shokai Building [1915, Shimonoseki], Ville Savoye [Paris, 1931, Le Corbusier], and ACROS Fukuoka, Fujimori recognize that *"[...] though the intentions are good, the architecture and plants remain visually unrelated to one another."* (Fujimori, 2007, p. 132-133). The necessity of true design integration is reflected on his expression: *"An ordinary roof garden is unrelated to what lies below; it is simply placed like a flower pot on top of a box-like building."* (ibidem, p.133-134)

According to this author, an excellent visual relationship between greenery and architecture is only to be found in the thatch roof houses of Japan or Normandy, where a set of different annual and perennial plants sprout periodically, recognizing that their short number/coverage has also little impact. Fujimori refers to the mere symbolic function of plants grown on the roof's ridge, implying that *"The ideal would be to combine architecture and nature in such a way that each shows the other to advantage."* (ibidem, p. 134) The concern with maintenance demand effort, throughout life cycle, related with greenery is also referred by the same author.

In other recent authors, collaborative concepts reappear as rather poetic ones, as in Junya Ishigami and Hiroshi Nakamura thoughts, for instance. Coexistence between architecture, its human tenants, and local natural context elements is attempted in Dancing Birds, Singing Birds project, by Hiroshi Nakamura. While in Plants *and Architecture*, Junya Ishigami clearly states: *"I am seeking ways to design so that nature comes close enough to be indistinguishable from architecture – the idea being to give equal care and attention to creating architectural and natural spaces."* (in Ishigami, 2008, p.101). In *Anti-Object* (2001), Kengo Kuma also advocates for an architecture that connects with the environment, and it is eminently, local site-specific. Kuma advocates the *desobjectification* of architecture and a blend with the surroundings [natural or not], that is expressed particularly by a dissolution of boundaries, a reinterpretation of visual landscape and the use of local materials.

Finally, it is worth to mention the launch of two environmental design competitions, after the turn of the millennium, that purportedly intend to bridge the existing gaps between industry, academic research, and design practice, and envision a future of ecological architecture. These are the Nikken Sekkei [internal] Environmental Design Competition, and the LIXIL International University Architectural Competition, both taking place annually, since 2007 and 2011, respectively [close to CASBEE methodology launch and some international environmental landmark initiatives as the JSSA launch and publications, and the international conference SB 05, in Tokyo].

The Environmental Design Competition, taking place internally among Nikken Sekkei employees, seeks to stimulate the research in environmental design among its well established corporation practice. It not only looks for potential ideas with future practical application, as referred by Katsuya Iwasaki (in Hashimoto, Iida, Wada, 2010), but also serves the purport to promote the company's image, having a jury formed by both Nikken Sekkei Group members and external professionals. Together with LIXIL International University Architectural Competition, these ideas competitions has been shown to recurrently have a future theme, and mark at the beginning of the 21th century possibly the beginning of a new collaboration and approach that connects architects, industry and academia into ecological architecture.

Likewise other examples of socio-ecological landscapes, or production ecosystems, such as the *montado* in Europe, in S*atoyama* landscapes, the role of human behaviour and activities [including the ones related with architecture] is deeply intrenched in the preservation of the ecosystem. Although the word *satoyama* has only been recently invented (Takeuchi, 2000, p. 74), it refers to secular landscapes and ways of living taking place in rural communities across Japan, forming an interface between natural (spontaneous) settings [forests, etc.] and more humanized landscapes.

Satoyama landscapes encarnate a mutual collaborative interaction between human populations and other local ecosystem elements, being in themselves resilient socio-ecological systems. The current knowledge about *satoyama*, illustrates not only a balanced and clever resource to locally available ecosystem services and functions by these populations, but also the impact and relevance of human presence to maintain and promote some of these ecosystem services and functions, even of supporting and regulating ones.

The terraced rice paddy subsistence farming landscapes in Asia, were as well referred by Odum (Odum, 1971) as *"one of the most energy-efficient forms of agriculture and the most sustainable form of settlement, integrated with productive and multifunctioning agricultural and natural landscapes, requiring the least ecological footprint"*, with *"its closed loop of material cycles and recycles"* (cited in Koh, 2008, p. 8)

A list of keyword illustrating these symbiotic relations is provided by Kazuhiko Takeuchi (2000). Some examples of the collaborative approaches established between human built and living systems and the local ecosystem services in this socio-ecological landscape are indicated below (adapted from Takeuchi, 2000):
1) Agriculture and the maintenance of diverse ecosystem biotopes. – The role of human activities is acknowledged as assisting in the process of secondary forest restoration, by trimmimg materials on the ground, lower and upper levels, necessary for its maintenance. Fallen leaves and undergrowth organic materials, picked from nearby forests were used to fertilize the soils for agriculture use. Also, the formation of special ecosystem habitats, ecotones, and mosaics, in this landscape are specifically due to agricultural use [for instance, the landscape formation of rice paddies, provided waterlife species habitats, using rice paddies and irrigation channels as "green corridors", being the imersion in water of rice fields fundamental for the maintenance of *satoyama* biodiversity and ecosystem, feeding and lodging a variety of water creatures and the predators that depend on them, also resulting in landscape aesthetic fruition and creation of sense of place].
2) Household and construction activities. – The construction and operation of buildings in satoyama landscape, has diverse said positive impacts on local ecosystem services: the collection of bamboo shots in the nearby forests helped the management of the existing groves and maintaned the balance of biodiversity, preventing the development of invasive species; as it did the toppling of trees and shrubs in the nearby forests for firewood and charcoal, used to heating and cooking, in households. The plantation of homestead

woods, in the vicinity of houses, was also a common practice to protect them from winds and snow. These homestead wood trees would also provide wood for production of diverse objects, tools and substances, as resin or mortars. The ash derived from fuelwood and charcoal used for heating and cooking in *minka* traditional farmhouses, was also reverted as soil fertilizer in agriculture fields, while natural charcoal could also be used for health purposes, as purifying drinking water, and balance indoor humidity (as referred by Takeuchi, 2000, p. 77).
3) Community shared areas. - The maintenance of commons, as common grassland fields and forests, allowed the population to collect firewood and provide grass to feed livestock. The resources in these nearby areas were maintaned through cooperative management, and also provided habitat niches. The maintenance of the deciduous forests associated with satoyama is also essential to keep its biosystem, as the abandonment and consequent lack of trimming of agriculture forests and coppices lead to the development of forest evergreens, though natural sucession, and sometimes the thrive of invasive species.

Some other collaborative approaches are entrenched in urban daily life until today. The tradition of "*uchimizu*" was passed down from the Edo Period (1603-1867), and involves sprinkling water to cool the surrounding area, and avoid dust particles in the air, as referred in the Japan Ecological Footprint Report (WWF, 2012). Other themes found in Japanese urbanity related with the provision of ecosystem services are the *potscapes* and private use of public space, in Tokyo, and other cities. Informal mini-scape gardens, referred as *potscapes*, by Marie-Louise Jonas (Jonas, 2008), or urban micro greenery, by Darko Radovìc (Radovìc, 2008). These hybrid landscapes, ocurring as a spontaneous form of private use of public space, can be found abundantly in the streets of Tokyo (Jonas, 2008). These arrangements include often vegetal ornamental and edible species, in pots and trellises, and some times water elements, as fish tanks, and other decorative garden elements - on streetwalkways facing house and shop entrances, and around them. The origins of these *potscapes* may originate from the *bonsai* tradition, the *nagaya* row houses semi-private back alleys, and the influence of western garden culture, and may perform functions as reduce traffic speed, embelish and showcase commercial entrances, attract costumers, hobby, and control microclimate, as referred by Jonas (2008).

These informal pot gardens can be found abundantly also in other Asian and European regions. For instance, it is also reported in the the city of Ho Chi Min (Saigon), the existence of *"flower-pots cramped and displayed here and there all around the streets. This interesting custom has formed the amused character of Saigon over a long period of time and Saigonese love their life with a large variety of tropical plants and flowers in their balconies, courtyards and streets."* (as Vo Trong Nghia architecture practice observes in Archdaily, 2012), and it is also ubiquitous in the city of Sevilla.

Other approaches indicating collaborative interaction concepts in Japanese culture imply old verbal traditions.

Ancient tales, present in Japan and China, such as the *"animal wives"*, incorporate notions of symbiotic relations and profitable co-evolution between humans and other living beings. In these stories, the associations between man and nature (often an animal taking the shape of a woman) are set off by a mutual help, that create wealth and balance, being preserved by behavioural rules that protect common resources balance. Japanese culture was also permeated by Confucionism and Taoism philosophy systems and concepts, both preconizing harmony between man and nature. While, nature, in Japanese language is written 自然, meaning what is spontaneous, the concept of 風土(fudo), as referred by Tetsuro Watsuji is also essential to understand the Japanese context, implying climate, and local natural and spiritual features. As Augustin Berque recalls "*It takes 10 years to create scenery, 100 years to create landscape, and 1000 years to create fudo"*.

The assessment of ecosystem services and functions has been lead in Japan by the Japan Satoyama Satoumi Assessment (JSSA), launched in 2006, sharing and deriving from the framework of the Millennium Ecosystem Assessment Program initiated worldwide in 2005. This organization, in connection with diverse research institutions and universities, among of which the United Nations University, has been monitoring and studying trends in ecosystem services supply and demand, within the country, particularly in mountain forest areas (*satoyama*) and coastal (*satoumi*) settlements.

Regarding biodiversity issues in Japan, the National Biodiversity Strategy Outline, in 2010, defines Biodiversity as essential support for life and livelihood, identifying 4 main national challenges that are: 1) species and habitat degradation, caused by human action and pressure; 2) degradation of ecosystem services associated with traditional socio-ecological production landscapes, as *satoyama*, caused by diminished local human management; 3) ecological disturbance factors, including the introduction of exotic or invasive species and chemical contaminants; 4) global warming crisis effects.

In addition, in the Biodiversity Strategy Outline are established short, medium and long term targets. As long term objective, by 2050, it is expected the improvement of the current state of biodiversity. Other short term objectives (by 2020) imply research, analysis, biodiversity conservation activities, reducing adverse effects by human activities, and mainstream and increase the number of individuals and entities (stakeholders) involved in biodiversity conservation measures.

The Biodiversity Action Plan, that constitutes the second part of the same document specifies and determine "720 specific measures with 35 numerical indicators". We can see that the local sphere of action is more practical, and has a very important weight, while global actions tend to developed in terms of research and policy making. Among the 4 Basic Strategies for Biodiversity Conservation some indicate a possible collaboration with architecture, and may imply the support of ecosystem services in urban areas (identified in the text in italic), as follows: 1) "Mainstreaming biodiversity in daily life" (including the integration of biodiversity in the quotidian, and the promotion and support of actions at *"local level")*; 2) "Rebuilding sound relationship between human beings and nature in local communities" (including wildlife protection measures, and integrated actions for *"natural symbiosis, material recycling, and low carbon society"*); 3) "Securing linkages among forests, countryside, rivers and the sea" (contributing to biodiversity conservation in aquatic ecosystems; 4) "Taking actions with global perspective" (among which the promotion of *satoyama* initiative is one of them).

2.9 Contextualization

Contemporaneously, from the 1990s to nowadays, within and outside architecture, in a broader societal context, it is perceptible the dilution of the meaning of the words *"ecological"* and *"sustainable",* as these words increasingly permeate market and mainstream discourses, leading to a progressive loss of influence. In fact, it might be possible to identify a suppression of environmentally driven architecture discourse, within erudite trends, from the 1990s - the moment where environmental assessment methodologies begin to establish market benchmarks, and a scientific academic niche of its own.
Outside specific conferences and university departments and international councils, as CIB [International Council for Building], ecological architecture loses partially its novelty in the last decade of the 20th century. If not indicating a total suppression, at least, the 1990s mark the beginning of a split, in the way ecological topics are addressed in architecture discourse: one, scientific, objective, quantifiable, highly supported by engineering specialties and environmental science; and another, subjective, poetic, creative and recreational, appealing, but also less documented and precise.

In both cases, outside and inside academia, mainstream *green architecture* seems to be both deprived of a holistic ecological literacy [as criticized by regenerative design heralds], and also of the authorial impulse that has marked its beginning as post-modern critique in the 1970s. It is however worth notice from the beginning of the 21th century the progressive involvement of architectural firms and councils in the development of design assistance methodologies, as further developed in Chapter 3, which can be interpreted as a market adjustment, only afforded by organizations of a certain size and expertise and sufficiently engaged with environmental aspects, but still distanced by common architecture practice, or the possible hint of a global change underway.

The period from 1990 to 2014, covered by the present research, it is characterized by the launch and generalization of building projects environmental assessment methodologies, and an ongoing theoretical transition from environmental mitigation benchmarks to neutralization, and finally to the aspirations of a positive paradigm. On the following Figures, are summed up the themes and timeline frameworks of relevant ecological architecture approaches and respective contextual landmarks, both internationally and in the context of Japan, where specific case study targets are examined.

The Japanese context for design integration of local ecosystem services and functions within architecture projects differs from the general context by at least 2 factors: 1) the local specificity of environmental and construction issues related with sustainability; 2) the history of modern architecture in Japan and its driving theories (namely, a modern movement that is collated and not in divergence with otherwise post-modern metabolism). However, it is possible to identify the same three paradigms of building sustainability as expressed by Du Plessis, namely the non-aligned and somewhat marginalized post-modern experiments linked to local, vernacular or expressionist approaches, community participation and self-subsistence, the force of the institutional and governmental agenda to implement built environment policies and foster regulations, among others, and a thriving market assured by construction consortiums and corporations with action at research & development level, bridged by the Japan GreenBuild Council (JaGBC)/Japan Sustainable Building Consortium (JSBC) and the Institute for Building Environment (IBEC).

It is still difficult to identify within Japan the traces of regenerative design, and architecture and sustainable construction are not yet directly or formally implied into biodiversity and ecosystem services conservation [as it is most noticeable in Anglo-Saxon countries], although a very organized study of ecosystem services assessment and rehabilitation of sociological landscapes is underway by JSSA, linked both with UN and academic initiatives.

Timeline — International
Contextual Influences [Social, Economical, Cultural, Technical, Environmental]

	Timeline		Books and Articles	Macro-Social Events	Institutional [Governmental, Organizational]	Methods	Emerging Concepts and Terms	Architecture Landmarks
vernacular and pre-industrial ➨		...						
		1760		1st Industrial Revolution [start]				
	1800's	1800					*nature conservation* early steps	
		1840		2nd Industrial Revolution [start]		1st nature conservation parks and reserves in Europe and US (~1821; 1822, Germany; 1832, US)		
Pre-Modern: - 1900.		1844	*The Condition of the Working Class in England*. F. Engels					
		1851			population rise in Europe and urbanization			Crystal Palace. Joseph Paxton
		1869					*ecology* [Ernst Haeckel]	
		1870		Industrialized Society [consolidation]				
		1898	*To-morrow: a Peaceful Path to Real Reform*. E. Howard					
		1900						
		1902					*garden city* [Ebenezer Howard]	
		1909						Robie House. Frank Lloyd Wright
		1914		World War II [1914-1918]				
		1928						International Congresses of Modern Architecture (CIAM) [launch]
		1929		Great Depression				
		1931						Villa Savoye. Le Corbusier
		1935					*ecosystem* [Arthur Tansley]	
		1937						Falling Water. Frank Lloyd Wright
		1939		World War II [starts]				
Modern: 1900-1960.		1943	*Athens Charter*. Le Corbusier + CIAM					
		1945		World War II [ends]				
		1948			International Union for Conservation of Nature (IUCN) [founded]		*Nature Conservation National Parks* are founded all over the world	
		1947						
		1949			UN Scientific Conference on the Conservation and Utilization of Resources			
		1950		population growth and economic globalization				
		1952						Unité d'Habitation (Marseille). Le Corbusier
		1953	*Fundamentals of Ecology*. H. and E. Odum					
		1956						
		1959						International Congresses of Modern Architecture (CIAM) [end]
	1960's	1960		Brown Agenda				
		1961			World Wide Fund for Nature (WWF) [founded]	World Game [based on Dymaxion Map (1943)]. B. Fuller		
		1962	*Silent Spring*. R. Carson	pesticides [DDT] environmental impact				
		1963						
		1964			IUCN Red List of Threatened Species [founded]			
		1965						
		1966						
		1967						
		1968	*Operating Manual For Spaceship Earth*. B. Fuller		UNESCO Intergov. Conf. on Rational Use and Conservation of Resources of the Biosphere		*land art* ["Earth Works" group exhibition, New York]	Whole Earth Catalogue [until 1972]
self-sustainable houses ➨		1969	*Design with Nature*. I. McHarg			Life Cycle Analysis (LCA)	*arcology* [Paolo Soleri]	New Alchemy Institute [founded] by N. and J. Todd
	1970's	1970						
		1971			Greepeace [founded]			
		1972	*The limits to Growth*. D. Meadows *et al*	Acid Rain	United Nations Environment Programme (UNEP) [founded]		*natural heritage* [UNESCO] / *sustainable* [Donella Meadows et al, aka Club of Rome]	
		1973		1st Oil Crisis				
		1974			UNEP/UNCTAD Symposium on Patterns of Resource Use, Environment and Development Strategies			Prince Edward Island ARK. John Todd
Post-Modern: 1960-1990.		1975	*The Autonomous House*. B. and R. Vale					
"Environmental Awareness"		1976			UN Habitat 1 [1st UN forum on human settlements]			
		1977		Ozone Layer depletion				
		1978					*permaculture* [Bill Mollison and David Holmgren]	
		1979	GAIA: A new look at life on earth. J. Lovelock /	2nd Oil Crisis				
solar active systems ➨	1980's	1980	*The Integral Urban House*. S. Van der Ryn and the Farallones Institute				*restoration ecology* [John Aber and William Jordan]	
		1981	*Gentle Architecture*. Malcolm Wells.			wilderness-based checklist [Malcolm Wells]		
		1982			UN World Charter for Nature [5 principles of Nature conservation]			
		1983						PLEA (Passive and Low Energy Architecture) [founded]
		1984	*Bioshelters, Ocean Arks, City Farming: Ecology as the Basis of Design*. N. and J. Todd / *Biophilia*. E. Wilson					
		1985	*Design for Human Ecosystems*. J. Lyle					
		1986						
		1987	*Our Common Future*. (aka Bruntland Report)		Montreal Protocol on Substances that Deplete the Ozone Layer		*sustainable development* [Bruntland Report]	
		1988	[World Commission on Environment and Development]					
		1989				GaBi Software [1st commercial LCA software tool]		
building env. assessment methods ➨	1990's	1990		shift of environmental awareness focus from local to global issues		BREEAM [launch]		
		1991					*eco-efficiency* [World Business Council for Sustainable Development (WBCSD)]	
		1992			U N Convention on Biological Diversity (Rio de Janeiro Earth Summit).		*ecological literacy* [David Orr] / *ecological footprint*	Mesiniaga Tower. Kenneth Yeang
		1993			USGBC [founded]			
		1994	*Regenerative Design for Sustainable Development*. J. Lyle				*landscape urbanism* [P. Connolly, J. Corner, et al (RMIT)]	Center for Regenerative Studies. J. Lyle
high-performance energy buildings ➨		1995	*Cities for a small planet*. R. Rogers / *Designing With Nature*. K. Yeang					
		1996	*Our Ecological Footprint*. W. Rees and M. Wackernagel / *Ecological Design*. S. Van Der Ryn and S. Cowan			Habitat Agenda, UNCHS / CSD Working List of Indicators (United Nations Comission on Sustainable Development)		
		1997	*Biomimicry*. Janine Benyus		UN Framework Convention on Climate Change (Kyoto Protocol)		*ecosystem services* [R. Costanza, R. d'Arge, R.de Groot *et al]*	
		1998	*Living Planet Report*, by WWF [biannually, until today]			LEED v.1 [launch]		
		1999						SB global conference series (supported by iiSBE, CIB and UNEP) [launch] /
zero carbon /carbon neutral ➨	2000's	2000	*Millenium Declaration*. United Nations			SPeAR, by ARUP		Dutch Pavilion at Expo2000. MVRDV
		2001			Millennium Ecosystem Assessment Program [launch]			
Contemporary: 1990-2014		2002	*Cradle to Cradle*. M. Braungart and W. McDonough / *The Nature of Design: Ecology, Culture, and Human Intention*. D. Orr				*integration with local ecosystems* [Charles Kibert]	
"Policies and Methods"		2003	*Urban Acunpucture*. Jaime Lerner					
		2004			UN-Habitat Indicators			
shift to positive impacts ➨		2005	*Expanding our approach to sustainable design*. N. Malin, B. Reed and J. Todd		Kyoto Protocol enters in force			
		2006				Living Building Challenge v.1 [launch]		
		2007	*Shifting our Mental Model – "Sustainability" to Regeneration*. B. Reed			Millennium Ecosystem Assessment Publication		
		2008	*Positive Development*. J. Birkeland			UK Green Building Council Biodiversity Task Group [launch]		
		2009				SITES 2009 Rating System v. 1 [launch]		
	2010's	2010						Integrated Habitats Design Competition [launch]
		2011			United Nations Decade on Biodiversity [until 2020]			
		2012	*Ecosystem Services Come To Town: Greening Cities by Working with Nature*. G. Grant				*regenerative design* Building Research and Information Special issue	
		2013						
		2014						

Figure 7. Timeline of Ecological Regenerative Approaches in Architecture

	Timeline		Japan Context Contextual Influences [Social, Economical, Cultural, Technical] Books and Articles	Macro-Social Events	Institutional [Governmental, Organizational]	Concepts and Landmarks
vernacular and pre-industrial ➨		...				
		1760				
	1800's	1800				
		1840				
Pre-Modern: - 1900.		1844				
		1851				
		1869		Meiji Era (1968) [starts]		
		1870		1st Industrial Revolution [start]	Iwakura Mission (1871) [Europe and USA tour to assimilate western ways]	
		1898				
		1900				
		1902				
		1909				
		1914				
		1928				
		1929				
		1931				
		1935				
		1937				
		1939				
Modern: 1900-1960.		1943				
		1945				
		1948				
		1947	*Mu: The God Revolution* . M. Fukuoka			*natural farming* [Masanobu Fukuoka]
		1949				
		1950		Rapid industrial growth [until the 1970's]		
		1952				
		1953				
		1956		Minamata disease [mercury poisoning from industrial pollution effluents]		
		1959				
	1960's	1960	*Metabolism Manifesto.* K. Kikutake, K. Kurokawa, F. Maki *et al*			*metabolism movement*
		1961				
		1962				
		1963				
		1964				
		1965				
		1966				
		1967				
		1968				
self-sustainable houses ➨		1969			Pollution Control Ordinance of Tokyo	
	1970's	1970			64th Diet - Environmental Pollution Control Bills	
		1971				Team Zoo [founded]
		1972				Kimura Solar House. Ken-ichi Kimura
		1973				
		1974				
Post-Modern: 1960-1990. "Environmental Awareness"		1975	*The One-Straw Revolution* . M. Fukuoka			Nakijin village Comunity Centre. Team Zoo
		1976				
		1977		*Red Tide* [Pollution in Lake Biwa]		
		1978				
		1979			Energy Conservation Law	
solar active systems ➨	1980's	1980				Institute for Building Environment and Energy Conservation (IBEC) [founded]
		1981				Nago City Hall. Team Zoo [adoption of "vernacular" passive design strategies as pergolas, etc.]
		1982				Obayashi Tech Center. Obayashi Co. [active solar systems]
		1983				
		1984				
		1985				Niigata City Government. Nikken Sekkei [natural ventilation]
		1986				
		1987				
		1988				
		1989				
building env. assessment methods ➨	1990's	1990		sustainable building issues start to go mainstream		
		1991			Eco-city Project, by the Building Research Institute (BRI) [launch] with LCA analysi	
		1992				
		1993			Environment Basic Act, by the Ministry of Construction	
		1994			Environmental Policy Plan, by the Ministry of Construction [call for industry voluntary measures]	
high-performance energy buildings ➨		1995		Great Hanshin-Awaji Earthquake in Kobe	1st National Biodiversity Strategy	
		1996		"Vision of Construction Industries' Environmental Action", by the Environmental Action Board [industry consortium]		
		1997	*Declaration for Symbiotic Housing* . ESHPC		AIJ Global Environmental Committee / Action Plan for	
		1998			Guidelines of environment counscious public buildings	
		1999				
zero carbon /carbon neutral ➨	2000's	2000				
		2001			"Tokyo Plan 2000"/"Green Tokyo Plan [launch]	
Contemporary: 1990-2014 "Policies and Methods"		2002			2nd National Biodiversity Strategy	
		2003				
		2004			CASBEE [launch]	
shift to positive impacts ➨		2005	*Architecture for a Sustainable Future* . AIJ [english edition]		SB05 Tokyo [International ?] Conference	
		2006			Japan Satoyama Satoumi Assessment [launch]	
		2007			3rd National Biodiversity Strategy	Nikken Sekkei "Environmental Design Competition" [launch]
		2008	*Anti-Object* . Kengo Kuma		Basic Act on Biodiversity [in force]	
		2009				
	2010's	2010	*Japan Satoyama Satoumi Assessment* [publication]		4th National Biodiversity Strategy	
		2011		Great Tohoku Earthquake		LIXIL International University Architectural Competition [launch] / UIA Conference in Tokyo
		2012				
		2013				
		2014				

Figure 8. Timeline of Environmental Building and Ecological Regenerative Approaches in Japan

03. DESIGN ASSISTANCE AND INFORMATION RESOURCES

3.1 Operational Literature Review

The present chapter presents an overview of existing design assistance methods and resources for the application of ecosystem integration in architectural design and other relative approaches, and what significance it acquires within urban ecological systems. In this section, are detailed and clarified the methodological processes employed by common and relevant ecological design approaches towards site restoration and local ecology integration. Namely, it is examined methodologies associated with ecological restoration, processes and principles for site analysis and ecological design both used in landscape and architecture design, discussing commonly and prospective tools and indicators for assistance and assessment of environmental architecture, design quality, regenerative design and the relation between architecture and ecosystem services and functions.

3.2 From *Scar-city* to *Resource-city:* Ecology in Urban Areas

"As the number of cities grew and as those cities increased in size, forests were cleared and agriculture increased." (Grant, 2012, p. 5) The evolution of cities throughout history has always been accompanied by cultural developments, but also until here, simultaneously by an "imbalance" or disequilibrium in ecosystem functions, either by use and consumption of resources, in and out of city boundaries, and by disruption of onsite natural cycles and processes, (cf. Grant, 2012; Cronon, 1991 and Cronon, 1996) with consequences at local, regional and global scales. City-centered human societies are also referred by Grant (2012) as highly dependent from external resources (as water and food supply, and raw materials) and highly vulnerable to hazards.

The environmental impacts of urban areas on ecosystem services and biodiversity are both external and internal to city limits. A recent report by the Secretariat of the Convention on Biological Diversity (CBD) has defined the five main threats to global biodiversity, as follows: 1) habitat loss and degradation [including habitat fragmentation]; 2) invasive alien species; 3) pollution and nutrient loads; 4) overexploitation of ecosystem resources; and 5) climate change (CBD, 2010, cited by EEA, 2010, p.19) – from which the majority relate directly or indirectly to the pressure exerted by urbanized areas.

Grant (2012), among others, points out the influence of built environments on present scarcity issues as:
1) *Agriculture land take*. - Urban population depend on agriculture and other food supply and exert pressure on external ecosystems, requiring great extents of farmland, water and other resources captation elsewhere. (The average of farmland consumption per inhabitant in urban centers varies from 0.2 ha (2000m2) to 1.4ha, depending on the diet and lifestyle (Grant, 2012)).
2) *Material resources consumption*. - Cement, steel, glass and timber, highly used in the construction sector are known to have great environmental impacts, during its stages of extraction and processing, as being highly energy intensive and responsible for the emission of great amounts of greenhouse emissions [as cement, concrete, steel and glass], impacting on biodiversity and habitat loss [steel mining, and timber when not sustainably managed], and local focus of severe pollution [as land contamination in the case of steel, and release of polluted effluents and noise, in the production of glass]
3) *Indirect resources depletion*. – In addition to the eminent scarcity of non-renewable fossil fuels, as oil, Grant also notes that phosphorous [used in paints, coatings, flame retardants as is in agriculture] is another resource whose natural supplies are predicted to be depleted in a near horizon. (Phosphorous, a nutrient essential to all life, cannot be artificially manufactured [although it can be recycled from effluents and manure] being mined as phosphate rock, in a limited number of locations, that are predicted to become exhausted *"sometime in the 21st century"* (Grant, 2012, p. 53), in what some refer as a possible peak phosphorous.

In addition to natural resources life-cycle stages of extraction, production, manufacturing, transport and assemblage, urban and architectural decisions within city limits also are determinant for the depletion (contribution to scarcity patterns), or instead, support of ecosystem services (formation of resource-cities).

As referred by Hosey (2012, p. 150) *"Every city everywhere is to some degree shaped by its setting, however subtly or substantially. Every place reveals a relationship between natural conditions and human motives, and what matters most is whether that relationship is a contest or a collaboration, whether nature and city are adversary or ally."* -, highlighting that *"the image of the ecological city must be relevant and responsive to its natural setting."* (Hosey, ibid., p. 150)

In addition to the long identified [but not always pacified] need to adequate project settings to underlying patterns of water regulation, soil formation, climate and hazard mitigation, for instance, - articulating urban design to hydrographic and topographic conditions to provide comfortable amenities and avoid local disasters, as floods and landslides -, it has also began to be object of discussion (cf. Birkeland, 2008; and Grant, 2012), the scope of collaborative architectural design to, not only mitigate on-site and off-set negative impacts, but to positively provide locally available ecological resources.

Although deep ecological system are inherently different from city to city, due to the imposed alterations, the generality of urban ecosystem services are nowadays quasi confined to the functions performed by parks and garden areas: air quality, water and local climate regulation, as well as cultural, recreational and educational roles.

Table 1. Common factors of disturbance in Urban Ecosystem Areas
[adapted from Gilbert, 1991 and Mendiondo, 2008).

AREA		Factors of disturbance
1.	BIODIVERSITY	Habitat loss
		Habitat fragmentation [and small scale habitat mosaics]
		Introduced [non-native] and invasive species
		Reduction of specialized habitats
		Increase of adaptive opportunistic species
		Severe reduction of plant biomass
2.	LAND AND SOIL	Agricultural land take
		Alterations in soil composition [soil contamination, structure and loss of fertility]
		Soil impermeability and storm water run-off
		Erosion vectors [soil movements and steep slopes]
		Alterations in topographic structure
3.	WATER CYCLE AND STRUCTURE	Alterations in hydrographic structure [channelization, damming
		Alterations in water cycle and storage
		Water pollution [effluents, and storm water pollutants]
4.	MICROCLIMATE	Micro-climate changes [urban heat island, decreased solar radiation exposure, alteration of wind patterns]
5.	POLLUTION	Air pollution [sulfur, nitrogen, carbon, VOC's, particles
		Noise pollution
		Light pollution
		Human and motor traffic disturbance vectors
		Pesticides, herbicides
		Radioactive and electromagnetic pollution
		Organic, bacterial and pathogen pollution
		Salinity
		Acidification
		Heavy metal pollution
		Eutrophication
6.	ECOSYSTEM EXCHANGE	Relations with external and bordering ecosystems [material resources, transport, waste disposal, other impacts]

In contrast, ecological disturbance vectors tend to accumulate in urban areas, along with a deficit in ecological functions and services. A set of urban ecosystems most common factors of disturbance, and of ecosystem functions loss relative to deep original ecosystems, were for instance identified in Gilbert (1991) and Mendiondo (2008), and are illustrated in Table 1.

In addition to these disturbance factors, Grant (2012) highlights the extreme generation of waste [that despite recycling] is still largely disposed in landfills, and points out the benefits of ecosystem services support solutions, as living walls and roofs, to reduce atmospheric and noise pollution, and urban heat island effect. The selection of pavement surfaces and building cladding materials also take an important role in avoiding impacts on soil, water cycle, and micro climate [impacted by soil and water deficient cycles, the raise of temperature and alteration of wind patterns caused by buildings] in urban environments.

Grant (2012) refers to the chronic drying effect caused by artificial drainage, as one of the most severe impacts on urban soil. Vegetation loss also impacts negatively on soil as a deficit in organic matter deposition, reducing root penetration and water absorption capacity, increasing erosion and water runoff. Runoff in urban areas is not only responsible for flooding downstream, or in flat and valley basin areas of cities, but also for the accumulation of pollution on water courses and rivers, carrying the pollutants deposited on buildings and street surfaces.

Sustainable urban drainage systems (SUDS) for rainwater retention and filtration, associated with green roofs and appropriate landscaping, combining the nutrient cycling action performed by plants, constitute alternative drainage solutions to abate local and pollutant contaminations. While the channelization of rivers and watercourses is another problem, as it increases downstream sedimentation, flooding and sometimes the contamination of sewage into rivers.

Regarding biodiversity and habitat functions, presently, not only direct and indirect influences of urbanized areas on habitat loss and fragmentation [smaller habitat areas and with more edge, increasing disturbance on wildlife] are to be taken in account, but as indicated by Williams (2010), within built environments, it has also become actually necessary the active role of architecture to provide urban wildlife support - as the change of building techniques has impacted on several building-reliant species (birds and small mammals), used to habitats provided by less airtight architecture -, besides controlling the negative effects of light pollution on birds, bats and insects, and on human fatigue and stress.

Ecological factors of disturbance, demonstrating local variation, may be interpreted as regeneration priority areas to orient the focus of micro-scale collaborative design. Therefore, the integration and cooperation with local ecological systems within architectural design, can contribute simultaneously to, and through, the reversion of disturbance patterns and regeneration of ecosystem functions in urban areas.

3.3 Site Analysis, Ecological Restoration and Design Process

In collaborative projects, even of micro scale, the knowledge and respect of the particular local underlying (and broader) characteristics of each urban area and project site - referred as *deep local structure*, by Spirn (2003) -, is fundamental to orient site specific indicators, synergies, and conceptual solutions within architectural design.

The ecological site inventory model, developed by Ian McHarg, and presented in *Design with Nature*, published in 1969 (Mcharg, 1992), it is foundational in this regard, consisting of several overlapping information layers of the local ecosystem starting from abiotic to biotic elements [climate, geology, physiography, hydrology, podology and edaphology (soils), vegetation (flora), wildlife (fauna), human communities and land use], as shown on the following Figure. This local inventory system is also commonly nick-named as *layer-cake*, by for instance Kenneth Yeang (1999, p.75) and Anne Whiston Spirn (2000, p.107).

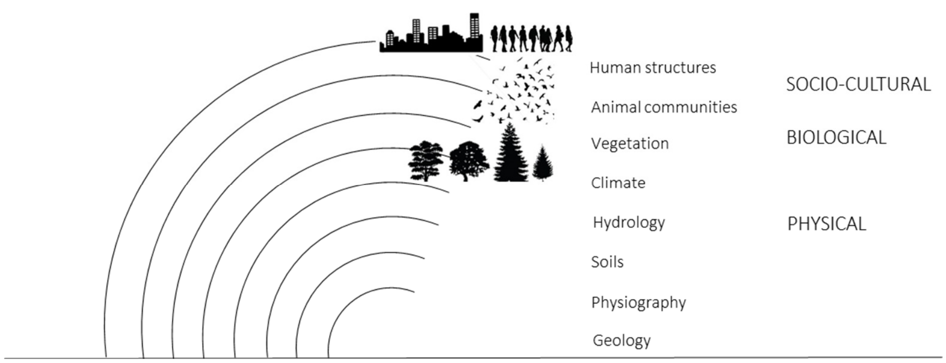


Figure 9. Ecological Site Inventory Method [adapted from McHarg, 1992]

The transposition of Mcharg's site analysis method from landscape design and management into building design process is proposed by Yeang (1999), whose ecological design method also encompasses the knowledge of the place as a fundamental key aspect.

According to Yeang, the ecological description and survey of the project area should precede the design and the evaluation of environmental impacts. As ecosystems entail very complex interactions between biotic and abiotic elements, it is convenient to address it through several information layers (Yeang, 1999, p.74), although the inventory information elements are in reality, subject to interactions and sub-interactions, with mutual influences between them, within the ecosystem, and are changeable over time. In the following Figure is shown a diagrammatic interpretation on how these interactions occur. As also pointed out by Yeang (1999, p. 77), most of these links presuppose reciprocal or two-way interactions.

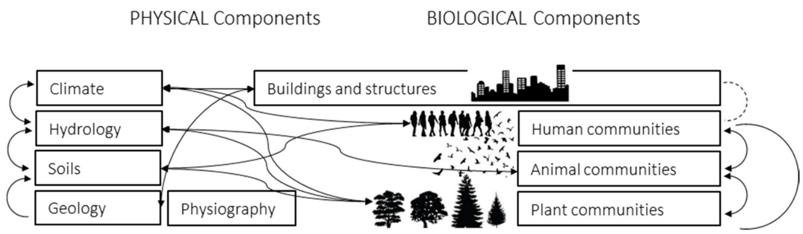


Figure 10. Interactions between ecosystem physical and biological components [adapted from Yeang, 1999]

The application of this ecological inventory method (and the understanding of the interactions and exchanges of ecological elements *inter se*) to architectural design process, presumes a much more complex analysis, and is more demanding from design solutions and program inputs than conventional design methodologies. As discussed by Yeang in *Designing with Nature*, published in 1995, in conventional design [until that time], project site analysis doesn't include much more than topography, drainage, climate (winds and sunlight), and neighboring buildings (Yeang, 1999, p.78).

Yeang's methodology for local and macro-local ecosystem analysis is based on the description of vegetal communities present on site, as they provide the basis to extrapolate climate regime, fauna species, geology, as well as identify the disturbances over time, and the state and stability of the ecosystem in the area. It is referred as sequence of 4 steps: 1) Identify species, distribution, and abundance of flora communities; 2) Relate the species and communities with significant biologic processes; 3) Assign values of relative importance to species and communities, based on their role and on the fundamental ecosystem processes to maintain; and 4) Take the coherent project decisions to minimize biotic changes to the ecosystem, avoid irreversible physical alterations, and mitigate multiple wide range impacts towards other ecosystems (Yeang, 1999, p. 86-88).

Before the launch of any building environmental assessment methodologies, Yeang has also proposed a design assistance tool that resulted from his doctoral research at the University of Cambridge. This method consisted of a base structure that could fit any designer to think and predict environmental impacts in any kind of project (cf. Yeang, 1999). In it, Yeang has organized the interactions between built system and global ecosystem in 4 groups, represented in a matrix, which constitute the model of his methodology, as follows:
a) Group 1. *External interdependencies or relations of the built system*. - All biosphere ecological processes including climatic regimes, interrelations between ecosystems, and slow biosphere processes as fossil fuel formation, that can be influenced by the built environment and influence it.
b) Group 2. *Internal interdependencies or relations of the built system*. - All the activities that take place in the built environment or are related with it and its users, affecting the immediate ecosystem and all other nested ecosystems.

c) Group 3. *Inputs of energy and matter*. - All the resources necessary to the built system, including its construction, operation, and end use.
d) Group 4. *Outputs of energy and matter*. All the products and effluents generated by the built system, including waste, waste water, etc.

As though, Yeang's approach represents a decisive advancement towards the integration of both local and global ecological aspects into architectural design, and constitutes an huge improvement leap from conventional to green design, part of its theoretical support is to some extent based on a linear perspective of ecosystems, instead of dynamic, complex and adaptive human integrated systems over time; and tends to in practice focus on impact mitigation instead of co-evolution, as previously discussed on Chapter 2.

In regenerative design, the design method is as well deeply rooted in site specific knowledge and adequacy, implicating the complete account and understanding of local ecosystem key elements and relationship networks, within a bioregional framework and micro-local specificities. Nevertheless, likewise ecosystems are dynamic and evolve non-linearly over time, regenerative design doesn't aim for a static environmental balance condition. The methodological process that allow a regenerative co-evolution for a given context, comprises a deep knowledge of the site, which includes tracing back the history of the ecosystem, its interaction with human communities and disturbance factors, and a forecast of future directions and driver factors within and around the place. As such, one of the fundamental methodologies of regenerative design consists in tracing back the local ecosystem history, as part of what Reed (2007) identifies as understanding the *master pattern of place*. As for architectural design projects, there is a demand for a constant iteration between micro and macro scales, this is also valid regarding local site diagnosis, between past and future scenarios (as also referred by Koji Itonaga, in AIJ, 2005, p.215-217).

According to Reed (2007), the development process of regenerative design consists of three fundamental catalytic moments, following a continuous cycle or "evolutionary spiral":
1) Understanding the fundamental *pattern of the place*. - Clarifying and aligning human aspirations for the project and the site; identification of past and present patterns in local natural systems, including human and social structures, and their inter-relationships, developing a History/Story of the place.
2) Translation of place patterns for guidance of the project concept and its driving lines. - Establishing a framework for decision making by defining the Pattern of Place. From the understanding of the patterns of interaction of systems and species, the benchmarks and parameters of action can be established – supporting and guiding the design, selection of materials and technologies, and strategies for construction, operation and maintenance.
3) Establishment of continuous feedback loops: learning and participation. - With the active involvement of the community through participatory action, reflection and dialogue charrettes, it is possible to strengthen

the community bonds to the site, enhancing their ability for cooperation and self-regeneration. Throughout this process, the monitoring of the work is essential as a strategy for integrated design, in order to overcome conflicts, and ensure optimization of systems in relation to the whole.

The need to assure *multifunctional design*, that is the integration of multiple design aspects with diverse local ecological cycles and processes, has also been a recommendation stated by Grant (2012), and also Birkeland (2008), that is essential to the regenerative design guidelines, proposed by Lyle (1994).

Other complimentary design procedures that preconize site analysis and ecological restoration, implying the transposition of information from contextual landscape to micro-local include the concept of green networks (including wildlife corridors) and green infra-structures, the inclusion of biodiversity reporting and accounting in architectural projects [through Biodiversity Action Plans or equivalent], and the directives suggested by the Sustainable Sites Initiative.

The preservation and restoration of sites and species, - which is local and macro-local -, is linked contemporarily with the concept of green networks, as *"nature reserves cannot survive in isolation and need to form core sites within future networks of expanded habitats and restores landscapes."* , as referred by Grant (ibidem, p. 60). The concept of green infrastructure, develops, plans and preserves at macro scale a network of restorative landscape areas and elements, providing the base for urban planning and design *"with full consideration of existing land forms, biodiversity, flood management, water conservation, maintenance of micro-climate"* (Grant, 2012, p.60), and thus guaranteeing the provision of supporting and regulating ecosystem services and functions in urban areas. As stated by Grant (2012), urban areas can include sometimes patches of natural or semi-natural habitats, even sometimes *"encapsulated countryside"*, planned parks and gardens, and neglected brownfields that support self-established vegetation, and are ecologically important and biodiversity rich.

In order to protect and restore priority habitats and species, the figure of the Biodiversity Action Plan (BAP) was introduced, for instance, in the context of the United Kingdom designating measures at national, regional and local levels for each species and habitat, in the sequence of the Convention on Biological Diversity in 1992. The influence of these BAPs onto urban planning and building developments is predicted particularly at local level, where local authorities are required *"to report annually against a series of Core Output Indicators",* within the Local Development Framework, one of which the assessment of biodiversity change. (Williams, 2010, p.18-19)

As result of BAPs, construction developers are made responsible to gather data on habitats and species at design stage [to which a database is made available through the Gateway of National Biodiversity Network, accessible to everyone], and to report to local authorities data on expected biodiversity loss and gains, in planning application submissions. Although this measure is specifically targeted at biodiversity enhancement [not addressing ,for instance, all ecosystem services and functions as a whole], and it partakes the benefits and limitations of planning regulation acts, it demonstrates how broad macro regional issues of ecosystem restoration can be implemented and connected to smaller micro scale and building developments.

As referred by KIbert "A desired outcome of any building project would be a landscape and an ecosystem that are regenerated and improved as a consequence of the project." (Kibert, 2007, p.146). As such, other environmental checklists, as the Environmental Building News checklist, and the Thompson and Sorvig checklist, have been developed "for owners and designers to use in helping restore the vitality of natural ecosystems".

In turn, the Sustainable Sites Initiative, - launched by the American Society of Landscape Architects and other institutions in 2005, and responsible in the U. S. for the development of SITES, a design tool for guidance and assessment of landscape sustainability - proposes at the level of landscape design, several principles and guidelines to promote ecosystem services and functions within urban areas and design projects, that envisage the transformation of degraded to restored landscapes. The guiding principles proposed in *The Sustainable Sites Initiative: Guidelines and Performance Benchmarks* (SITES, 2009, p.7) advocate the adoption of the following rules within design process: a) avoid negative impacts; b) prevent risk and irreversible damage; c) design in accordance to local contextual nature and culture; d) resource to preservation, restoration and regeneration, in that order; e) support intergenerational balance and responsibility; f) plan for social and environmental change; g) use systems thinking and an eco-literate approach to socio-ecological systems; h) sustain collaborative stakeholder integration and ethical community connection; i) promote transparency and technical rigor; and j) develop environmental stewardship in present and future generations.

The SITES Initiative is itself based on the assumption that *"any landscape, whether the site of a large subdivision, a shopping mall, a park, an abandoned rail yard, or a single home, holds the potential both to improve and to regenerate the natural benefits and services provided by ecosystems in their undeveloped state."*(SITES, ibid. p. 5), and through its system of pre-requisites and credits specifies and encourages quantitative and qualitative integration of local ecosystem services and functions.

3.4 Design Assistance and Assessment Tools

At present, in parallel with the growing interest and engaging initiatives towards regenerative design, there is underway a fast change and development of different methods and tools for building environmental assessment and assistance, still far from being stabilized. A recent review of some of these methods can be found in a special issue of *Building Research & Information* (2012, 40), in particular by Cole, (2012b), although the issues of design quality are there only marginally addressed.

In this section, both assessment and non-assessment methods dedicated to environmental and design quality are analysed and compared in order to clarify the range of the indicators, stakeholders, project's stage usage, and its specificity of purpose regarding project design evaluation or decision-making. Sometimes, more than one version of the same assessment method is presented, as several sustainability assessment methods present a range family of different tools, which focus on a specific project's life cycle stage or building typology. These methodologies are based on a specific variable set of indicators, with different aggregation methods.

DQIs, KPIs, and SPIs are used in Architectural Design Process to monitor the Project's results, either by assessment and non-assessment methods. Assessment methodologies are defined as being result-comparable, where the evaluation is objective, and not subject to different outputs according to different users. Other methodologies may present sensitive weighting, and therefore produce non-comparable results, although they may represent for each project a support tool for decision-making and evaluation.

Some problems and criticism associated with the use of indicators, particularly in the context of environmental architecture and building assessment, are for instance stated by Du Plessis (2012). These critics include generically the following: 1) that they are being constructed without an overall structured framework of built environment; 2) that the majority of indicators reflect the interests of their authors, or policy makers targets, or express stakeholder's subjective approaches; 3) that existing building assessment indicator sets tend to "[..] reinforce existing building types and practices. These practices try to improve on flawed 'best practice' through aggregate technical solutions or, even worse, deteriorating into mere 'accounting games' that obscures total resources flows and systemic interactions. Moreover, this approach discourages solutions that build on synergies and symbiosis (Birkeland, 2007, p.4)" p. 13; and 4) that the complex aggregation of indicators into metrical formula output doesn't encourage a "systemic understanding".

In this section, the following project design tools are analyzed, regarding the respective purpose, stage of project's life cycle usage, stakeholders, key performance indicators, methodology and results display, weighting system and graphical output:

- Design Quality Indicator (DQI), developed by David Gann and Jennifer Whyte, and adapted as Design Quality Indicator for Schools, by the Department for Education and Skills and the Construction Industry Council (CIC), in the United Kingdom.

- Sustainable Project Appraisal Routine (SPeAR), developed by the architectural firm ARUP.
- Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) developed by the Japan Sustainable Building Consortium and supported by the Japanese Government's Ministry of Land, Infrastructures and Transport.
- Leadership in Energy and Environmental Design (LEED), developed by the United States Green Building Council (USGBC).
- Sustainable Building Tool (SB-Tool), developed by the International Initiative for a Sustainable Built Environment (iiSBE).
- Building Research Establishment Environmental Assessment Method (BREEAM), developed by Building Research Establishment Ltd. (BRE).
- The DGNB Certification System, developed by the German Sustainable Building Council, with the Germany Federal Ministry of Transport, Building and Urban Affairs.
- The Living Building Challenge, created for the Cascadia Green Building Council and managed by the International Living Building Institute.
- The Sustainable Sites Initiative (SITES), developed by the American Society of Landscape Architects in conjunction with the United States Botanic Garden, and the Lady Bird Johnson Wildflower Center (from The University of Texas at Austin), with the United States Green Building Council (USGBC) as stakeholder.
- Living Environments in Natural, Social and Economic Systems (LENSES), being created by the Institute for the Built Environment of Colorado State University.
- REGEN, being developed by Berkebile Nelson Immenschuh McDowell (BNIM), for the United States Green Building Council (USGBC).
- Regenerative Design Framework, being developed by the architectural firm Perkins+Will and the University of British Columbia.

Building Design assessment methods can vary in a great extent [regarding its stakeholders, indicators, weighting systems and stage of the project's life cycle in which are used], reflecting the main intrinsic purpose of each assessment tool and the priorities considered by the developers. For similar reasons, each assessment methodology has developed several different tools or versions, which belong to the same assessment "family", but serve different purposes and express different indicators, in order to adapt to the specificities of building typology or project life cycle stage.

One important aspect in this analysis is the binomial measurability-operability, expressed in the level of preciseness of the Indicators, and the involvement of stakeholders. Typically, methods that can be used during pre-design and design stage, are more likely to include both clients, users and design team, and incorporate less detailed indicators; while methods that focus on post-design, can incorporate more detailed indicators information, and are less likely to integrate non-specialist stakeholders in the process.

It is also important to differentiate stakeholders integrated in the process, from stakeholders as target audience. Typically, sustainability assessment tools are considered to perform a leadership of the construction market, reaching through an indirect way, consumer’s, industry and public opinion, whereas decision making tools, as DQI, contribute to evaluate the design process while it is still occurring and drive decisions accordingly, acting as a direct communication facilitator tool among project’s direct stakeholders. Nevertheless, it was noted that all of the evaluation methods discussed require a special category of professional, either a certified facilitator or a credited assessor, with expertise in the area and well acquainted with the tool itself, to implement the methodologies.

Another observation about indicators refers to the use of prescriptive criteria as opposed to pure performance evaluation criteria. While performance indicators constitute more rigorous and comparable standards, it is noted by assessment tools developers that “pure performance [doesn´t allow] many hints for the designers” (Larson, 2010). In this perspective, LEED methodology, acting as a checklist, constitutes the most prescriptive of the sustainability assessment methods. [For instance, under Energy indicators, the existence of a drying space is considered as assessment criteria, both in BREEAM and LEED]. At the same time, this factor allows a more easy adaptation of the assessment method to pre-design and design stages.

It is important to note that some of these support methods and tools have different launch dates, or that some are under development, and that some are produced by private offices for their own use, by public institutions, by market initiatives, or by mixed public-private initiatives. Regarding Indicators selection, it was observed that, from methodology to methodology, there is a large diversity, reflecting local conditions [climatic, social, cultural, economic or others] (IOS, 2009) and the specificity of interests and priorities of the developing teams.

Between the methodologies in analysis, there is differentiation between methods that focus on design quality aspects [DQI], sustainability aspects [BREEAM, CASBEE, LEED, LIDER A, and SB-Tool], and both [SPeAR]. While environmental and sustainability performance indicators and key performance indicators may be partially included as design quality evaluation parameters, several of the indicators that might be considered in design quality evaluation are not used in sustainability comparative assessment methodologies. This is due to environmental/sustainability assessment focus, but it is also related to the fact that not all the key indicators identified for design evaluation of architectural projects may be represented through quantitative, objective, indicators and variables. Qualitative evaluation of architectural design is therefore difficultly taken in account in assessment methods partially because of its subjective nature. However, some sustainability methods show an attempt of including quality indicators, such as quality comfort parameters [BREEAM, CASBEE, LEED, LIDERA and SB-Tool] innovation character [BREEAM, LEED, LIDERA], and even cultural and perceptual indicators [SB-Tool].

It is important to notice, as well, that BREEAM, CASBEE, LEED and LiDERA constitute essentially environmental assessment methods, focusing on EPIs, and that SPeAR and SB-Tool present the objective of assessing sustainability as a whole, and therefore including environmental, social and economical SPIs, as well. Regarding sustainability and environmental indicators, it was also observed that in all the discussed methodologies, some EPI's constitute the most frequent and common indicators used [such as Energy, Water and Material Resources consumptions, Waste and impacts, Site's ecology, and Thermal, Atmospheric and Lighting indoor comfort]. However, even in the occurrence of common key topic indicators, these can be arranged in different thematic groups, from methodology to methodology, and express different levels of weighting or detail. As a result, the different assessment methodologies don't present results that are universally comparable *inter se,* as often indicators expressed by the same or similar name are assessed in different methodologies with different variables [Energy consumption indicator, for instance, is assessed with different variables selection in each method, which may include criteria as equipment performance, renewable sources on-site, availability of energy-saving prescriptive factors, or fabric energy loss].

As previously observed, architectural quality appreciation, in its perceptive and conceptual aspects, is often omitted from environmental and sustainability [and even design quality] tools. The characteristics that consubstantiate the *delight* in architecture are hardly translatable into objective indicators and are therefore frequently left out of the agenda.

Regarding the project engagement with the site ecosystem, it was observed that the indicators and analysis topics used to evaluate local biodiversity, soil and water cycles, fall usually under "sustainable site" or equivalent label, but sometimes these are also spread (and assessed) through other categories, and show an overall dispersion through the aggregation method.

It also noted that, due to the fact that environmental assessment is the main objective in most of these methods, there is no indication about design integration in practically any of them. The lack of connection with architectural integration, or design quality, results in quantitative but not qualitative analysis, and doesn't promote or valuate essential features of ecology and regenerative design, as redundancy, and interconnection. Local ecology is a parameter, but not ecology integration [i.e. its passive and not active relationships that are sought for, afterwards].

In post-design stages, assessment should avoid prescriptive indicators, and give preference to absolute values and performance indicators, allowing a universal comparison metric, even if the indicators selection could vary from local context to another, reflecting its local idiosyncrasies. While there is simultaneously a recognized need of Universal Metrics Systems, regarding building's environmental performance, [such as ecological footprint, CO2, water or materials], sustainable design assessment tools, built on national level, should also be able to represent the variety of micro-local level conditions, as it is noted that they don't reflect enough the diversity of micro-local variations [of climatic or resource availability] within the same country [from desert regions to northern continental lakes, in the U.S. (Kibert, Grosskopf, 2006); or from tropical islands to snow landscapes in Japan, or from urban to rural areas, in most of the countries.

The inclusion of whole sustainability factors [environmental, social, economic, cultural] in assessment and decision making eco-design tools, while highlights important factors to be taken in account in architecture projects, in the lack of incentives for interrelation between factors, and with a "blind" overall result display, has the result, in fact, to dissolve the relative importance of ecologic issues in design and construction.

Regarding the use of assessment criteria in pre-design and design stages, performance indicators could be translated into guidelines, [preferably allowing different design alternatives], both understandable to architects and clients, avoiding however detailed prescriptions which might limit project's creativity. And then, design assistance and assessment tools could also become instruments of eco-literacy.

Regarding visualization outputs, it is also observed a strong tendency of contemporary ecological design tools to evolve towards *mandala* forms [a holistic representation of the world, through frequently circular diagrams with radial symmetry, which is used as aid to meditation in Buddhist philosophy]. Instead of prescriptive or cumulative checklists, performance or indicators visualizations in circular shape, induce to a notion of wholeness [distancing itself from the curse of linear systems], and act effectively as a mandala, as tools for thinking [as for instance, SPeAR, REGEN, Regenerative Design Framework, and LENSES].

An interesting contribution to visualization of vulnerability issues that is purportedly based on the concept of *mandala* is for instance proposed by Naesun Park (2010b). Circular shapes help visualize multi-dimension, multivariable assessments, but also *the interconnections* between dimensions and variables.

Figure 11. Diagrammatic representation of visualization outputs from different assessment and assistance methods
[from left to right: SPeAR, DGNB, and REGEN]

Manuel Lima, in *Visual Complexity* (2011), observes the recent evolution of diagrams from Trees to Networks, as forms of understanding and communicating complexity. The circular or sometimes petal shape, evocative of mandala figures is also fostered by permaculture holistic vision, as the flower diagram proposed by Richard Holmgreen, and the petal is also a metaphor used by the Living Building Change method. The recent evolution, towards mandala shapes, in the display of environmental assessment of architectural projects, fundamentally highlights the need and role of *interpretation*.

3.5 Synthesis of Previous Research

The research conducted in the field of the present dissertation, - focusing on the development of design assistance methods to support the integration of local ecosystem services in architecture design -, has known partial yet insufficient development hitherto. As the present topic deals with diverse knowledge systems [namely the collaboration with local ecology within design and planning fields, the integration and assessment of ecosystem services in architectural design, and the development of design assistance support instruments with specific focus on design quality, regenerative design or integration issues] literature review was therefore conducted with focus on different areas.

Integration of Local Ecology in Architecture Design

From the perspectives of site analysis and local ecological context characterization, important contributions were introduced earlier in the 1960s (paralleling the development of environmental impact assessment) by McHarg, namely with *Design with Nature* (1969), in order to provide adequate design response, in the sphere of landscape design, to specific given natural conditions. The influence of ecology and ecological principles and frameworks into landscape design and land use management are, since, object of extended research, including the development of processual methodologies (Lovell, Johnston, 2009), and practical applications (Makhzoumi, 2000), at different scales.

Following, in the fields of urban planning, diverse methodologies and guidelines have been advanced towards the promotion and collaboration with natural systems, comprising macro regional scale approaches. Other approaches that drive from the application of ecological concepts and the integration of natural processes into human structures are found in regenerative design research (Lyle, 1985; Lyle, 1994) and permaculture (Mollison, 1988).

The adaptation of local landscape ecology knowledge applicable to building design has known a considerable impetus during the 1970s, where the research developed by Yeang, *A Theoretical Framework for Incorporating Ecological Considerations in the Design and Planning of the Built Environment,* defines a key moment in the foundation of environmental building assessment methodologies. Yeang's research is based simultaneously on global environmental impacts, with focus on inputs and outputs, and local site analysis.

Subsequently, with the aim to increase the sustainability of the built environment, previous methods and guidelines for the diagnosis of the site environment, have been synthesized and incorporated by diverse architectural councils and associations, as for instance the Architects' Council of Europe (ACE-CAE, 2001) and the Architectural Institute of Japan (AIJ, 2005), being at present readily available for architects. The formed body of knowledge, nevertheless, is predominantly directed to mitigate negative impacts, rather than to identify and develop positive synergies, being more explicit about data compilation but to a great extent less clear about appropriate design principles and response to the given ecosystem context, or about possible associations achieved with building design quality.

From the 2000s, a plea for a deeper integration of local natural systems and landscape into sustainable building has been addressed, particularly under the perspective of construction ecology by Kibert (Kibert *et al*, 2002; Kibert, Grosskopf, 2006; Kibert, 2007), defining ecosystem integration as a yet underexplored resource. In it, the integration of local ecosystem services with the built environment (as climate regulation, water cycle and regulation, perceptive environmental modulation, food supply, nutrient cycling and waste processing, biodiversity habitats and cultural services) is referred as potential source of cost-benefit synergies. However, the practical implementation attempts of this concept in architectural projects are still primarily considered as partial rather than whole integrations of local ecosystem services, at present. The integration of wetlands to manage storm water or "living systems" to address building effluents and waste, are among the most frequently developed design solutions.

Questions considered pertinent to this research are addressed in *Revising Green Infrastructure: Concepts Between Nature and Design* (Czechowski, Hauck, Hausladen, 2014), including multidisciplinary perspectives on the relationship between design and ecology, including aesthetics, applicable to landscape and green infrastructures. However, the research basis on ecological engineering and green infrastructure conceptual design principles and guidelines (Mitsch, Jørgensen, 1989; Mitsch, 2003; Mitsch, Jørgensen, 2004; and Bergen et al, 2001), are more frequently articulated to civil engineering codes of practice and design scales and program valid to its implementation.

Research in waste and water biotechnologies and its integration within built systems (including sometimes food production systems), have been conducted by Todd, in *From Eco–Cities to Living Machines: Principles of Ecological Design* (Todd, Todd, 1994), *The design of living technologies for waste treatment* (Todd, Josephson, 1996) and *Ecological design applied* (Todd, Brown, Wells, 2003), with an emphasis on specialized biological engineering and on the benefits towards building environmental performance, being seldom articulated with other questions of architecture design integration.

Integration and Assessment of Ecosystem Services in the Design Field

Following the publications of Millenium Ecosystem Assessment (MEA, 2005), research conducted on the analysis of ecosystem services to inform sustainable building design has begun to sporadically emerge with incidence from the 2000s.

Research on ecosystem services within urban areas and built landscapes, from a macro-scale perspective, has captured larger attention to date, within the fields of ecology, geography, landscape design, and urban planning, and tendentiously with a focus on management and policy, and as a way to increase urban quality and resilience, and minimize impacts on external ecosystems. These include the researches on *Ecosystem Services in Urban Landscapes: Practical Applications and Governance Implications* (Haase, Frantzeskaki, Elmqvist, 2014), *Urban Landscapes and Ecosystem Services* (Breuste, Haase, Elmqvist, 2013), *Urban form, biodiversity potential and ecosystem services* (Tratalos, et al, 2007), and in relation to methodologies to support innovation *The concept of ecosystem services in adaptive urban planning and design: A framework for supporting innovation* (Ahern, Cilliers, Niemelä, 2014).

While tools and methods for urban ecosystem analysis have been identified by diverse authors, including Piracha and Marcotullio (2003), the TEEB Manual for Cities (TEEB, 2011) has explored particularly how to integrate ecosystem services in urban policies and decision making processes, including several stakeholders [although not prescribing a decision support method or tool].

Ecosystem services in Urban areas (Bolund, Hunhammar, 1999), has identified common typologies of urban ecosystems and the range of multiple ecosystem services generated within urban environments [considering for instance street trees as urban ecosystem, but not ecosystem services provision within private property or interspersed landscape within building sites], reflecting on the importance of six relevant locally generated ecosystem services in urban areas: air purification, climate regulation, noise reduction, water cycling and regulation, waste treatment, and recreational and cultural services.

Despite the generalized adoption of the ecosystem services framework among landscape ecology and policy professional fields (Carpenter *et al*, 2009), less frequent research so far has been developed with a focus on micro-scale design, on the connection between ecosystem services and architectural projects, or its consequences on the design of the built environment.

Existent researches in this direction tend to focus on the perspectives of site analysis and environmental building assessment, as it is the case of *The application of ecosystems services criteria for green building assessment* (Olgyay, Herdt, 2004). In *Ecosystem services analysis for the design of regenerative built environments*, Pedersen Zari (2012), develops a framework of possible applications of ecosystem services integration into building design, identifying benchmarks and barriers and opportunities for its use. A significant contribution from this study is the acknowledgement of the need of site specific local benchmarks derived from the use of ecosystem services into building assessment, however the selected set of key ecosystem services examined is restricted, and based on already developed technologies, with an emphasis placed on mimicking integration processes.

Alternatively, the framework proposed by Perkins + Will (Cole *et al*,2012) is partially based on ecosystem functions [whose framework has a close parallel with ecosystem services], and analyses the relations between the support of ecological functions with resource flows and spheres of human systems (social, cultural, health, and economy) [although not focusing on other design quality aspects and on the specific relations with on-site landscape elements].
Hitherto, the conducted researches addressing the ecological functions and services framework seldom focus on the integration of local ecosystem services in terms of design process or quality, or focus on the existing and potential relations of local natural systems with broad architecture design quality assessment, beyond environmental or sustainability performance.

On the other hand, technical guidelines have been developed regarding the integration of particular aspects of ecosystem services into architecture projects and building envelope surfaces, comprising for instance the provision of habitat niches for urban fauna (Edwards, 2010), and the addition of plant species into living walls, roofs and pavements (Johnston, Newton, 2004). So far, however, the development of research on ecological literacy instruments to effectively inform design teams and support decision making on pre-design and design stages, about local ecosystem services integration is relatively limited.

Alternatively, Vitorino has proposed a multi-criteria analysis framework for local ecosystem services integration assistance in architectural design (Vitorino, 2012b; Vitorino, 2013), that expands the recurrent emphasis on environmental and sustainability aspects towards more comprehensive design quality intrinsic parameters, although further testing of the proposed method, both by application to specific project references, and by different target users is required.

In addition, another knowledge limitation in the field has been stated by Kibert (2007), Pedersen Zari (2012) and Svec *et al* (2012), in what regards the lack of built examples. Further research is needed, both including experimental practical attempts and post-occupancy assessment [which should not be limited by existing previous examples], and also efforts directed to reach additional design synergies with ecosystem services so far considered as less relevant. Therefore, the development of design process guidance and/or incentives research in order to spur practical application and experimentation in the field is mostly determinant.

Research on Design Assistance Methods and Tools

The integration of ecosystem services into building design assistance and assessment methods is presently at its initial stage, paralleling an evolution of the paradigm and value system proposed for these instruments, towards, for instance, regenerative design goals. Accordingly, the Sustainable Sites Initiative (SITES, 2009) has pioneered the development of environmental assessment benchmarks for landscape design based on ecosystem services analysis.

Presently, the scope and application of building environmental assessment tools is being expanded from initial role and objectives, in order to articulate integrative design demands including the encouragement of creative synergies, closed loops, and the provision of appropriate local response to ecological structures and social backgrounds (Cole, 2012b), as well as addressing social, economic and cultural sustainability issues and design quality valuation. However, some authors agree that the performance rating system model might be not able to incorporate all the necessary qualities to guide the required paradigm shift (Svec *et al*, 2012; Zimmerman, Kibert, 2007) or be the most suitable to introduce changes in design process (Cole, 2012b).

Among the developing researches on design assistance methods to support a co-evolution with natural systems, few different approaches have been proposed, the majority of them with a focus on educational value, including:

1) Data inclusive tools, as the frameworks REGEN (Svec *et al*, 2012) and LENSES - Living Environments in Natural, Social, and Economic Systems, proposed by Plaut, *et al* (2012) -, as integrative design support tools, based on connections between different environmental and sustainability aspects, to guide stakeholder dialogue and decision making.

Particularly unlike other methods, the REGEN comprises links to diverse information databases and case study project resources. However, further developments are referred as needed to improve the existing research, including: the incorporation of metrics and indicators; the simplification of the proposed interface; the improvement of graphics and language; and the reconciliation of the open-source approach with the need of a moderator to keep data unbiased.

2) In-house comprehensive tools developed by design and building offices, that intend to be used as base to stakeholder communication and decision making and project guidance, such as the Perkins + Will framework developed in partnership with the University of British Columbia (Cole *et al*, 2012) and SPeAR, the Sustainable Project Appraisal Routine, developed by Arup (2012), that purportedly incorporate wider concepts as sustainability and qualitative design aspects.

3) Methodological analytical processes, as the Eco-Balance (Fisk, 2009), with emphasis on urban planning approach, that is largely supported on the equilibrium between sourcing and re-sourcing of specific natural capital [water, air, food, energy and materials] within a given spatial boundary, adaptable to ecosystem services framework. [Although incorporating some design options at building scale pertaining to local ecosystem services integration, it is situated outside the scope this method the visualization of this integration in relation to architectural design quality parameters].

The articulation of design quality as a necessary aspect of value in construction has been expressed, in parallel to ecosystem services, around the 2000s (cf. Construction 21 Steering Committee, 1999; Gibson, Gebken, 2003), but the articulation of both has not yet been addressed through an assistance method targeted to designers and multidisciplinary design teams.

In comparison, the development of assessment tools and methods based on intrinsic design quality indicators, namely related with qualitative valuation of projects, is less established than quantitative performance systems, due in part to the subjective analysis it entails and the need to involve multiple agents and stakeholders, both in pre-design, design or post-design stages. The framework of assessment in the development of the DQI (Design Quality Indicator) (Gann *et al*, 2003) is based on impact, build quality and functionality, in direct relation to the Vitruvian triad, and is intended to be used in complement to the use of sustainability tools and other environmental performance benchmarks. However the scope of this methodology doesn’t focus on local ecology or ecosystem services integration and therefore is of limited assistance to spur the design planning around its issues.

Another stated research question is related to the degree of acceptance and dissemination that design assistance methods and decision support tools find among general architecture practices. As Erbas and van Dijk (2012) recognize, there is a reduced percentage of architecture offices that presently employ decision support tools, even to guide environmental design practices; and mainstream construction and architectural projects are still very dependent on the environmental and social drive of project clients, owners and developer to counterwork present economic and paradigm constraints (Plaut *et al*, 2012).
Present challenges posed to the aspirational researches on design assistance methods, frameworks and tools, are also identified by Cole (2012b) as: a) whether these can concur to reinforce the environmental ethics component of building (Cole, 2012b), extendable to widespread design practices and not limited to exceptional buildings projects); b) whether these have the ability to communicate key ecological literacy aspects to regenerative design as systems thinking and deep ecological thinking; c) whether they concur to fulfill deep mindset shift among design teams and intervening stakeholders (Cole, 2012b); and lastly, if they contribute to encourage innovative design solutions and boost creativity.

Finally, regarding research on integration methods and decision support tools, it is reported an investigation emphasis towards the analysis of both passive and active energy systems, water and materials [to which several support methods are developed, including building information modeling systems], but towards an evaluative integration of local ecosystem services and functions, provided by the building and surrounding landscape, very few researches exist.

In addition, conventional design composition and thinking methods [including spatial composition and component composition] generally employed by designers are of limited relevance to the integration of ecosystem services. Architecture design teams tend to support their decisions in terms of physical or visible systems, and the programming of local ecological services and functions pertain to some extent to a non-visible domain, being consequently underestimated. A method to visualize the expected anticipated functions and guarantee the adjustment between the provision of ecological services and spatial and physical systems it is therefore needed. In this regard, the research conducted by Erbas and van Dijk (2012) demonstrate the preference for decision support tools integrated with information databases, and with display of the relationships among the several criteria.

As such, throughout literature review it was not identified a suitable decision support assistance method combining issues of integral design quality with integration of local ecosystem services, nor that have satisfactorily addressed the possible impacts and connections between ecosystem services integration on design quality parameters.

PART 2.

RESEARCH DESIGN METHODOLOGY
[METHODS]

04. ECOSYSTEM DESIGN INTEGRATION: MODEL AND CRITERIA

4.1 Research Design Methodology

In Part 1, the concept of Ecosystem Integration is formulated within the theoretical and circumstantial frameworks that contextualize the approaches to local ecology in contemporary architectural design. In the precedent chapters, the potentialities and shortcomings of the existing design assistance methodologies to Design Integration of Local Ecosystem services and functions within Architectural Projects were also addressed through the review of literature, and an insight into site analysis and design support methods.

Addressing the subjacent objective to *potentiate a collaborative integration of local ecosystems in architectural design*, the present chapter addresses the general adopted methodological approach of the dissertation and explains the development of the analysis framework designated by Ti[l]es (Tool for Integration of Local Ecosystem Services) that focus on its design integration aspects. The objective of the proposed methodological framework is to clarify, identify, and interpret the reciprocal relations between architectural design and local ecology aspects.

From the viewpoint of its objectives, the present investigation combines descriptive and exploratory purposes, seeking to examine how collaborative interactions between local ecosystem and architectural design quality parameters are contemporarily realized and expressed, and trying to find out in their interpretation patterns, possible potentialities and obstacles to a deeper ecosystem integration. In order to achieve this, the research aims to develop a tool to think and interpret these interactions, which constitutes the *observational lens*, further explained in the following sections. Descriptive research methods are employed, with support of operational literature review, in order to produce a conceptual framework of criteria and parameters, which in subsequent stages, support the analysis and interpretation.
The proposed research methodology follows qualitative and quantitative methods, with diverse interdisciplinary processes of inquiry, and a structured approach. The sequence of the overall research design

methodology followed the successive stages: 1. *Critical Literature Review* (for the definition of the contextual framework, and support in the elaboration of the interpretation structure); 2. *Construction of Observation Tool* (as explained within the present chapter, deriving from the conceptual definition of ecosystem integration and including the selection of criteria and structure of analysis, focusing on qualitative assessment elements); 3. *Data collection* (as further detailed in Chapter 5, a triangulation of data and research methods with several stages for data collection was employed, including document analysis, case studies, interviews and questionnaire surveys); 4. *Data analysis*. (recurring to diverse analysis procedures, the main adopted approach is inductive, extracting tentative assumptions from the observation of result patterns based on interpretation of the framework); 5. *Synthesis of the Results and Communication* (embodied in the present dissertation, it reflects about the found interpretation patterns in data observation, and the possible use of the proposed theoretical-methodological framework).

The proposed observation framework for Ecosystem Integration addresses fundamentally the questions of Design Integration of local ecosystem aspects in architecture, expressing the qualitative reciprocal relations of local ecosystem services with architectural criteria. The method is projected as a potential design assistance tool, providing project guidance, identifying opportunities and evaluating different possible solutions, within a specific project, within a site, and thus supporting and informing decision making. Eventually it is also envisaged as a communication and visualization tool to stakeholders, increasing accountability and transparency of the design process and of project priorities.

In this chapter, the concept, criteria selection and mode[s] of application of the Ecosystem Design Integration Model are presented and explained. In the proposed Ecosystem Design Integration Model, the criteria for ecosystem and architecture quality are referenced in a matrix diagram, or correlation framework, for multi criteria analysis, whose general concept is presented on Figure 12. In the resulting diagram, each of the architectural design quality parameters is related to each of ecosystem functions and services, in order to identify possible collaborative interactions.

The idea encapsulated in this framework is that design integration could be represented visually, and interpreted through the number, diversity and range of collaborative interactions between local ecosystem services and functions and architectural quality parameters [referring by collaborative interactions the positive connections established between ecosystem regeneration and architectural quality promotion]. In the proposed Ecosystem Design Integration concept, the greater collaborative interactions achieved, more resilient is the ecological built system, and better the project, both in terms of architecture and local ecology. In function of this, a Local Ecosystem Integration Index, as a way to interpret the Design Integration of ecosystem services and functions within architectural projects, could be derived.

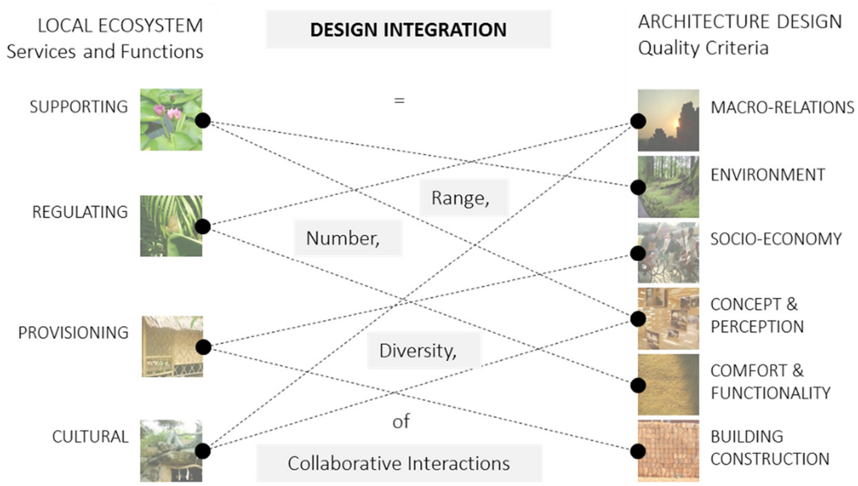


Figure 12. Ecosystem Design Integration Model

The construction of research indicators, variables and observation criteria, considered in the Ecosystem Design Integration Model result from a methodical review and selection of considered parameters found within existing frameworks. The procedure to determine these indicators followed an analysis-synthesis process, being initially inclusive, and subsequently, selective and depurative, defining key classification areas within these indicators. In the first stage, a detailed and extensive inventory of all the possible criteria for ecosystem and architecture was gathered, followed by a subsequent reanalysis and adding of missing criteria, resulting in a preliminary selection of indicators [Tables 3 and 5]. In the second stage, these criteria were subject to a reanalysis, by relevance to the study, available data, elimination of redundant parameters, and finally the regrouping of similar and overlapping indicator topics, in order to increase the easiness of use of the support tool to other users. The following sections disclose the method, sources and final selection of the indicators for Local Ecosystem and Architecture Quality Criteria, contained in the Ecosystem Design Integration Model (or TI[L]ES matrix), which support this research.

4.2 Local Ecosystem Services and Functions

In the proposed framework, the assessment of local ecosystem integration is translated, represented and organized through ecosystem services and functions, - natural ecological processes and products essential to the maintenance of healthy ecosystems and the provision of derived benefits indispensable to human well-being. Although *ecosystem services*, described as the tangible and intangible benefits human beings extract from nature, are an economical oriented representation of ecosystem processes and structure, its essential purpose is to value natural resources and highlight the dependency and coexistence of human beings within nature. A framework for ecosystem services assessment within built environments was for instance identified by Zari (2012), and Brown *et al* (2012) as the need to collaborate with and assess environmental performance through and within local ecosystem services capacity.

Within this framework, the disadvantages of the substitution of natural ecosystem sources by built replacement sources of ecosystem services, are also adverted, as leading to a consequent decrease of its ecological value (cf. Brown et al, 2012). Another particular advertence in the design for ecosystem services includes the dangers of trying to manipulate ecosystem services in separate.

The approach of ecosystem services framework into ecological design has also been discouraged on the basis of its nomenclature, but as Braungart and Mcdonough come to recognize *"it is useful to think of these processes as part of a dynamic interdependence, in which many different organisms and systems support one another in multiple ways."* (Braungart, Mcdonough, 2002, p.80)
In addition, it is necessary to understand that the possible impacts [both negative and positive] of the built system to and from local ecology don't act directly through functions or services but rather on ecosystem processes and structures (as depicted on the following Figure 13).

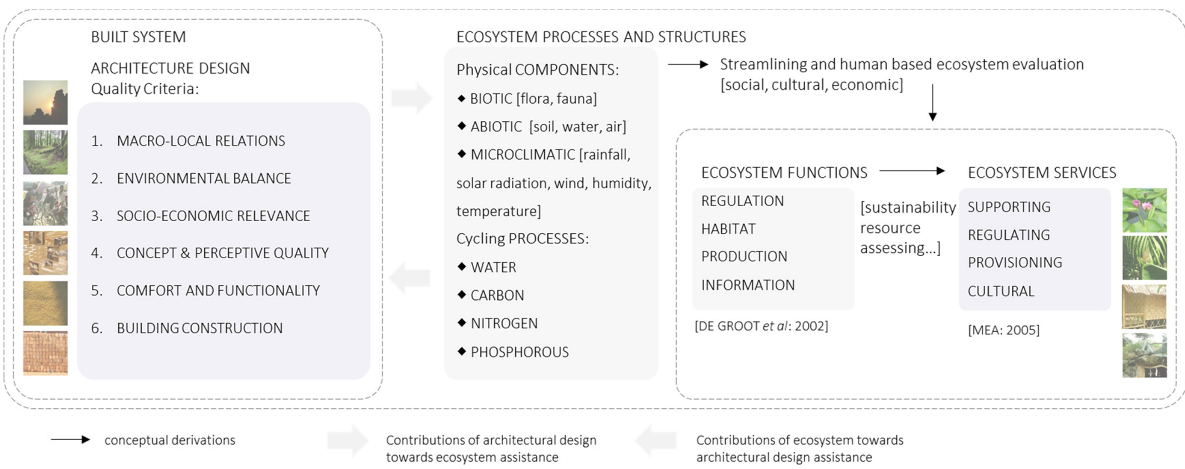


Figure 13. Mediated relations between Architecture Design Quality Criteria and Ecosystem Services and Functions

Nevertheless, the systematized framework of ecosystem functions and services offer a comprehensive communication tool, and an analytical structure of ecosystem complex processes, as also referred by Vitorino (2012b), for which there are already defined a scientific assessment base and well established indicator metrics, as the ones comprised in Millennium Ecosystem Assessment (MEA, 2003).

In addition, in effect, ecosystem services and ecosystem functions, not being exactly the same, present a high degree of equivalency [with the exception of habitat functions and cultural services], so it was opted in this study to combine both systems, even if these are more frequently referred as ecosystem services or local ecosystem criteria within this dissertation. The selection of ecosystem assessment criteria was based, adapted and selected from the structures of ecosystem services and functions expressed in Costanza *et al* (1997), De Groot *et al* (2002), MEA (2003) and TEEB (2011). The resulting indicators, are concomitantly organized, in Table 2, through the four key ecosystem services areas: Provisioning, Regulating, Cultural and Supporting.

Table 2. Primary Selection of ecosystem services and functions [ecosystem assessment criteria].

Functions and services	Indicator detail
PROVISIONING	
1. Food supply	Provision of edible habitats: crops, fisheries, wild food
2. Fresh water supply	Contribution to fresh water filtering and storage
3. Fibers and raw materials	Provision and renewability of materials: wood, hemp
4. Fuel and energy sources	Provision of renewable energy sources: wood, biofuel
5. Medicinal resources	Provision of habitats for medicinal and chemical sources
6. Genetic diversity	Preservation of biodiversity resources for breeding
7. Ornamental resources	Provision and renewability of natural ornamental sources
REGULATING	
8. Air quality regulation	Bio-chemical balance and particle filter by vegetation
9. Climatic regulation	Land cover and vegetation influence on local climate
10. Water regulation	Land cover role to runoff, flooding, and aquifer recharge
11. Water purification	Filter of compounds in inland and marine waters
12. Erosion control	Soil retention and prevention of landslides
13. Hazard protection	Hazard moderation by natural structures and buffer zones
14. Biological control	Biological control of pests, diseases and disease vectors
15. Waste treatment	Biota role to breakdown compounds in air, soil, and water
16. Pollination	Vectors for plants reproduction, seeds and fruits
CULTURAL	
17. Sense of place and identity	Identity features and historical cultural landscapes
18. Cultural and artistic resources	Inspirational sources for literature, visual arts, folklore
19. Landscape aesthetic fruition	Scenery valuation, and nature observation points
20. Recreation and ecotourism	Landscapes with recreational use, sports and leisure
21. Science and knowledge	Sources for education, scientific research and knowledge
22. Spiritual valuation	Valuation of sacred landscape areas and sacred species
23. Mental and physical health	Healthy conditions for physical and psychological balance
24. Environment modulation	Perceptual moderation and modulation: light, noise
SUPPORTING	
25. Soil formation and fertility	Weathering of rock and accumulation of organic matter
26. Photosynthesis	Production of oxygen by plants
27. Primary production	Assimilation of energy and nutrients by organisms
28. Nutrient cycling	Storage and cycling in air, soil, water, and organisms
29. Water cycling	Water cycling and concentration through the ecosystem
30. Biodiversity refugium habitats	Provision of habitats for native and endangered species
31. Nursery habitats	Habitat conditions for reproduction and juvenile breeding

A visualization of the interactions between ecosystem functions and services, based on data adapted from the *SEQ Ecosystem Services Framework* [SEQ, 2013] is shown in the following Figure. In Figure 14, is shown the relative weighting of ecosystem functions and services criteria, deriving from the magnitude and correlation frequencies between them, which influenced the revision of ecosystem criteria. The nodes size and centrality reflect the frequency and magnitude of contribution of each ecosystem service relative to the others ecosystem services and functions, emphasizing the central role of supporting services [as biodiversity, photosynthesis, water and nutrient, and soil formation] to the maintenance of all the others.

From this perception of the interrelation between ecosystem services and functions, emerged also the notion of regulating and supporting functions as core ecosystem health criteria, and provisioning and cultural as more anthropocentric, optional criteria [eventually more important when related to questions of accessibility and transports in the case of food supply; and regional and cultural fruition attributes]. It can be argued that all of these ecosystem services and functions work together, and none is exactly anthropocentric or not, since fresh water and the maintenance of landscape values serve not only humans but a whole bunch of species. In the context of analysis of ecosystem services and functions promotion within architectural scale, however, provisioning and cultural services are particularly envisaged towards its direct use by human communities, while supporting and regulating are more transversal.

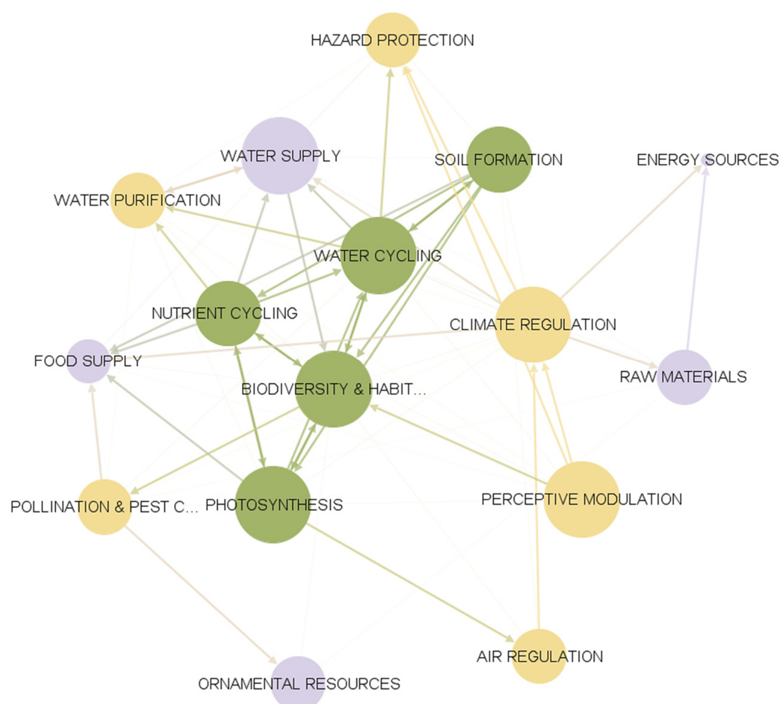


Figure 14. Visualization of most relevant interaction between ecosystem services and functions
[Green nodes: Supporting functions; Yellow nodes: Regulating functions; Purple nodes: Provisioning functions]

It was therefore decided to place and designate this division between *core* [nature based] and *complimentary* or peripheral [human based] ecosystem services. The reasoning for the final selection of local ecosystem services and functions, as shown on the following Table 3, is explained in further detail in Vitorino (2013), and also benefits from the inputs provided by an experimental application of the TI[L]ES framework with other users, detailed on Chapter 8.

Table 3. Final selection of ecosystem services and functions [ecosystem assessment criteria.

Ecosystem Services and Functions	Indicator detail
Core	
SUPPORTING	
E1 SOIL FORMATION AND FERTILITY	Weathering of rock and accumulation of organic matter for productive soils
E2 PHOTOSYNTHESIS AND PRIMARY PRODUCTION	Oxygen production and accumulation of energy by plants
E3 NUTRIENT CYCLING AND POLLUTION TREATMENT	Storage, cycling and balance of chemical elements in air, soil, and water by organisms
E4 WATER CYCLING AND REGULATION	Concentration and cycle of water through the ecosystem, runoff regulation and aquifer recharge
E5 BIODIVERSITY AND HABITATS	Provision of food, water, shelter and reproduction conditions to endangered and native species
REGULATING	
E6 CLIMATIC REGULATION	Land cover and vegetation influence on local temperature, humidity, precipitation and wind
E7 EROSION CONTROL AND HAZARD PROTECTION	Mitigation of extreme wind, flood, landslide and soil dispersion by vegetation and topography
E8 BIOLOGICAL CONTROL & POLLINATION	Biota role to control pests and diseases and assure plants pollination and reproduction
E9 PERCEPTIVE ENVIRONMENT MODULATION	Moderation, filter and modulation of light and sound through natural elements
Complimentary	
PROVISIONING	
E10 FOOD SUPPLY	Production of edible goods (agriculture, livestock, fisheries or wild food sources)
E11 FRESH WATER SUPPLY AND PURIFICATION	Filtering, retention and storage of water for consumption
E12 RAW MATERIALS, ORNAMENTAL & MEDICINAL RESOURCES	Provision of raw materials, medicinal sources and ornamental elements
CULTURAL	
E13 SIGNIFICANT ECOSYSTEM VALUES AND SPECIES	Local significant species, historic-cultural landscapes, sacred areas and elements
E14 LANDSCAPE AESTHETIC FRUITION	Landscape and scenery valuation and nature observation points
E15 LEISURE, RECREATION AND PSYCHOPHYSICAL HEALTH	Sports, recreation and leisure areas, and psychophysical healing environments

4.3 Architecture Design Quality Parameters

In the proposed framework, the assessment of local ecosystem integration is translated, represented and organized through the relation of local ecosystem services with architecture design quality and performance, tentatively expressed through a comprehensive selection of design quality and performance indicators -

determinate criteria to estimate the quality and performance of built systems regarding specific concepts associated with it.

However, unlike the available frameworks to assess ecosystem services, the existent systems to grasp architecture design quality are much more arguable. To start with, there is a shortage of consolidated information, including consensual references regarding what architecture quality *ideal* actually is. Secondly, due to its inherent subjectivity, qualitative criteria is often not addressed in sustainability and environmental assessment methods due to accountability and measurability issues. Relevant architectural qualitative criteria is only secondarily included in design assistance tools and indicators, and is not the main focus of sustainability assessment methods.

For these reasons, environmental sustainability, building performance, and comfort parameters tend to be more consensual [in the observed methods in Chapter 3] – although still prone to diversity in terms of weighting and selection - , while conceptual and perceptive qualities and functionality are less frequent criteria in the available methodologies. Alternatively, they are included marginally, under ambiguous topics, as *Form and Space*, *Innovation*, *Beauty*, *Cultural and Perceptual Aspects*, being frequently dispersed and spread into Comfort and Social issues. The possible links between these and other performance aspects is resultantly weakened.

However the relation of architecture with its place, is often based on both perceptual and environmental qualities, that are inherent both to architecture and nature appreciation [including most of the considered *cultural ecosystem services*]. An example of perceptual modulation both present in nature and architecture are the different degrees of light filter (translated for instance by the Japanese word 木漏れ日 [*komorebi*] meaning sunbeams streaming through leaves).

Also, the interdependent relation between architecture quality and sustainability aspects is possible, although not entirely explored. For instance, Hosey relates the impact of aesthetics and landscaped spaces to promote socialization and wellbeing and lower crime rates of iconic design to enhance community identity [Highline, NY], of iconic design to increase economic value and stimulate local economy [Seattle Public Library], and of beautiful design places to promote maintenance by users and diminish litter disposal and vandalism [Bryant Park, NY] (cf. Hosey, 2012, p. 12).

Nonetheless, few authors have attempted to express and objectively order structured definitions of architecture quality standards. Among these, the triad proposed by Marcus Vitruvius Pollio in the 1st century BC, in *De Architectura,* Utilitas (function) + Firmitas (structure) + Venustas (aesthetics) has been difficultly been replaced – although with a possible contemporary extension to Sustainabilitas (sustainability).

Another structured approach is explored by David Gann and others to the U. K. Construction Industry Council, in the form of DQI (Design Quality Indicator) a method based on occupancy validation of a comprehensive list of tangible and intangible aspects related with architecture design quality, and involving the perception of different stakeholders, presented for instance in *Design Quality Indicator as a tool for thinking* (Gann et al: 2003). Nikos Salingaros, author of *A Theory of Architecture* has also tried to rationalized design as a "scientific problem", and a mathematical equation form, expanding the concept of "*Architectural Life*" of Christopher Alexander in "Nature of Order", as referred by Hosey (cf. Hosey, 2012, p.119). Comparing 25 world known built structures, Salingaros uses a formula to define architectural quality (*L*), as L= T x H, being T= Temperature (including perceptive details as color, density, and contrast) and H=Harmony (including volume, proportion, and organization).

According to Hosey (2012), and Rachel Carlson, in the *Sense of Wonder* (Carson, 2000) the definition of beauty - either in architectural and cultural manifestations or towards natural references and contexts -, is connected above all to perceptive information and sensory delight. Thus in the inexistence of an organized framework for qualitative criteria, it was followed the reasoning that architectural fruition is mainly derived from all sensorial perception (not only visual, but also acoustic, tactile, olfactory and kinesthetic) and intellectual interpretation, being supported by cultural, social, environmental, structural, spatial and functional aspects, addressed in other assessment frameworks.

The selection of architecture design criteria was partially based on existing design assistance tools, attempting to reflect generally accepted concepts associated with design sustainability and performance, including environmental sustainability. The resulting criteria were partially adapted and selected from SPEAR (ARUP, 2012), REGEN (SVEC *et al,* 2012), LENSES (PLAUT *et al,* 2012), CASBEE (JSBC, 2010), BREEAM (BRE, 2011), LEED (USGBC, 2012), DGNB (DGNB, 2012), and LIVING BUILDING CHALLENGE (ILFI, 2012), with the addition of perceptive and sensorial criteria. The resultant framework of architectural design criteria and indicators, in Table 4, is tentatively organized into 7 main areas: Local relations, Environmental sustainability, Building performance, Comfort, Conceptual and perceptive quality, Functionality, and Occupancy and social relevance.

Table 4. Primary selection of Architecture quality parameters

Architectural design area	Indicator detail
LOCAL RELATIONS	
1. Adaption to eco-physical context	site selection, hydrography and topography
2. Cultural relations	socio-cultural and context society references
3. Creation of sense of place	identity attributes and landscape, system of views
4. Community integration	relevance to local communities and social structures
5. Functional articulation	relations with functions, infrastructures, volumes

ENVIRONMENTAL SUSTAINABILITY	
6. Biodiversity and ecosystem	soil, water, biodiversity…
7. Energy	passive performance, renewable energy, consumption
8. Water	consumption, rainwater harvest, on-site management
9. Materials	local source, recycled and renewable, low impact/intensity
10. Solid waste	waste reduction, local treatment and management
11. Atmospheric emissions	CO2, SO2 and NOx emissions, null CFC emission
12. Effluents	waste emission and local treatment, reuse
13. Other sources of local pollution	light pollution, noise, thermic effects, voc's, glare
14. Transport and local relations	low impact transport and proximity to daily life functions
15. Sustainable life support systems	kitchen gardens, compost, laundry natural dry
BUILDING PERFORMANCE	
16. Details and finishes	durability, coherence, aesthetics and rigor of materials
17. Execution quality of construction	rigor, durability of construction, on-site management
18. Structure stability and quality	resistance to regular loads and hazard preparedness
19. Durability of systems & materials	long life cycles, resilience of systems and materials
20. Maintenance preparedness	ease of repair, local materials and technologies
21. Buildability and deconstruction	deconstructability and material end-cycle closed loops
22. Safety and emergency systems	fire, earthquake, flood, intrusion and hazard preparedness
23. Management, process quality	quality control and project management during life cycle
COMFORT	
24. Acoustics	internal and external sound control and propagation
25. Lighting	natural and artificial light comfort balance, avoid glare
26. Indoor air quality	renovation, voc's, humidity condensations
27. Humidity and temperature	hygrothermal comfort daily and annual cycles
28. Exterior areas	amenities, landscape, climate, shadows, safety
29. Qualitative occupancy comfort	human well-being, socio-psychological comfort
CONCEPTUAL AND PERCEPTIVE QUALITY	
30. Relations with the exterior	framing, views, element relations
31. Concept and creativity	artistic and conceptual valuation
32. Visual	light/shadow, texture, contrast of scales, rhythm, form
33. Acoustics	acoustic properties, propagation and materials sounds
34. Materiality and tactility	surfaces apparent temperature, colors, texture
35. Kinesthetic and balance perception	pavement, height levels, steepness, and regularity
36. Olfactory	scents from materials, uses
FUNCTIONALITY	
37. Ergonomics	adequacy to human movements and dimensions
38. Accessibility, universal design	access and use by handicapped and elderly people
39. Circulation functionality	circulation flows fitness,
40. Function and occupancy	space, volume, organization fit to use ocupancy
41. Operation of control systems	passive comfort operation and other controllable systems
OCCUPANCY AND SOCIAL RELEVANCE	
42. User & commission supply	user targeting, occupancy assessment
43. Cultural adaptation	anthropologic, behavioral adequacy, cultural relevance

44. Customization possibilities	interior space, envelope control, extension and change
45. Community and stakeholders	integration with local communities, and stakeholders
46. Social diversity and mix	conditions for multifunctional uses and typologies
47. Economic dynamics and equity	economic impact and distribution
48. Responsible construction	security and employment, responsible material sourcing
49. Lifecycle costs	balance of initial investment, operation and end use costs

From this initial preliminary list of 49 topics indicators, a final selection of 24 architecture design quality criteria was obtained, attempting to eliminate redundant and overlapping parameters, aggregating similar thematic criteria and excluding from the selection criteria with less relevant or lack of available data, which can be used as additional optional indicators in the proposed tool, as indicated in the following section. The final selection of indicators has also been later grouped through *Intrinsic* and *Extrinsic* parameters, as shown on the following Figure, resulting from the analysis of the several methodologies and theoretical architecture quality systems.

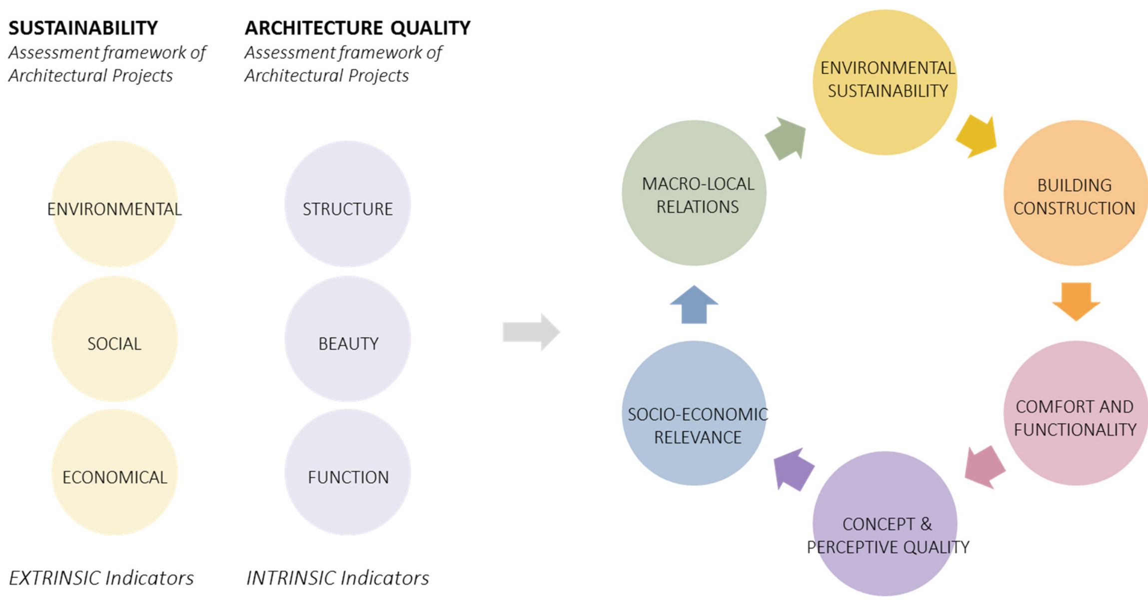


Figure 15. Thematic organization of architectural design parameters

The reasoning for selection and arrangement of architecture quality parameters, as shown on Table 6, is explained in further detail in Vitorino (2013), and benefits from the inputs provided by an experimental application of the TI[L]ES framework with other users, detailed on Chapter 8.

Table 5. Final selection of Architecture Design Quality: Assessment Indicators

Extrinsic	
MACRO-LOCAL RELATIONS	
A1 ADAPTATION TO ECO-PHYSICAL VALUES & RESTRAINTS	Site selection and project adequacy to hydrography and topography
A2 SENSE OF PLACE AND CULTURAL IDENTITY	Local context references, landscape integration, socio-cultural adequacy and relevance

A3 FUNCTIONAL ARTICULATION W/ CONTEXT	Relation with infrastructures & volumes, access to daily functions, & low impact mobility
ENVIRONMENTAL BALANCE	
A4 ENERGY CYCLE [AND ATMOSPHERIC EMISSIONS]	Energy consumption through life cycle, passive performance and renewable energy use
A5 WATER CYCLE [AND EFFLUENTS]	Consumption of water, rain water harvest, waste water management, treatment and reuse
A6 MATERIALS CYCLE [AND WASTE]	Local, renewable and low impact materials, deconstruction, recycling and biodegradability
A7 EXTERIOR AREAS AND LOCAL POLLUTION	Landscape and amenities, control of light pollution, noise, heat island effect and glare
A8 SUSTAINABLE LIFE-STYLE SUPPORT	Provision of kitchen gardens, compost, bicycle parking, laundry dry
SOCIO-ECONOMIC RELEVANCE	
A9 CUSTOMIZATION AND OPERATION	Interior space, comfort and envelope control, possibilities of extension and modification
A10 COMMUNITY PARTICIPATION AND USER SATISFACTION	Participatory processes, engagement with local communities & stakeholders and user targeting
A11 ECONOMIC DYNAMICS AND LIFECYCLE COSTS	Economic impact and distribution, balance of initial investment, operation and end use costs
A12 HUMAN HEALTH AND WELL BEING	Human health and well-being and other psycho-sociological aspects
Intrinsic	
CONCEPT & PERCEPTIVE QUALITY	
A13 CONCEPT ORIGINALITY AND INNOVATION	Artistic and conceptual valuation, contemporaneity, innovation, logic and intention
A14 VISUAL	Scale, rhythm and volume, colours and texture, transparency-opaqueness, light-shadow, and view framing
A15 ACOUSTICS	Sound reflection, insulation and absorption, sounds from uses and materials
A16 OLFACTION, TACTILITY & MOTION PERCEPTION	Surfaces texture, pavement regularity and steepness and height levels, scents from materials & uses
COMFORT AND FUNCTIONALITY	
A17 LIGHTING	Optimization of natural light sources, and luminance adapted to function and comfort levels
A18 INDOOR AIR QUALITY	Air renovation, elimination of VOCs (volatile organic compounds), dust particles and humidity condensations
A19 HUMIDITY AND TEMPERATURE	Hygrothermal comfort through daily and annual cycles
A20 ADEQUACY TO FUNCTION, OCCUPANCY & CIRCULATION	Functional and program organization, and circulation flows
BUILDING CONSTRUCTION	
A21 DETAILS AND FINISHES	Coherence, quality and attributes of details and finishing materials
A22 EXECUTION QUALITY & PROCESS MANAGEMENT	Rigor of construction methods, on-site management during life cycle and quality control

A23 STRUCTURE STABILITY AND DESIGN	Resistance to use and regular loads and structure design quality
A24 DURABILITY & MAINTENANCE	Long life cycles of systems and materials, ease of substitution or repair, and local maintenance

4.4 TI[L]ES Framework of Collaborative Interactions

The selected indicators are shown in the resulting Collaborative Interactions Framework (TI[L]ES table or matrix) in Figure 16, used to reflect the qualitative connections and aspects of Design Integration, between local ecosystem services and functions with architectural quality parameters. In it are displayed the limits between intrinsic and extrinsic architecture criteria, and core and complimentary human based ecosystem criteria.

The application purpose of the TI[L]ES framework is envisaged as a possible design assistance tool, in the following perspectives:
a) As a *tool for thinking,* during design process, to identify opportunities and provide project guidance.
b) As *appraisal analysis* of the positive impact and range of local ecosystem services integration in different design solutions, within a project, within a site, and thus supporting decision making.

The development of the Tool for Integration of Local Ecosystem Services is particularly directed to designers and multidisciplinary design teams, including different areas of expertise, to support decision making process, discussion and communication with other intervening stakeholders.

The purpose of the analysis doesn't intend to be comparative between different projects, but to provide assistance towards a more effective and integrated approach between local ecology and architecture design, within a specific project, and evaluate [graphically, and with a weighting ratio] different possible solutions.
Differently from environmental sustainability tools and assessment methodologies, the results stem from diverse architectural quality areas [some of intrinsic qualitative appreciation of architectural projects], - whose indicators might be used for an overall design quality evaluation, as for architectural competitions.

The system boundary considered to the analysis of integration of local ecosystem services, in this method, is defined by and within the limits of the project site property, concordant with the extension of architecture authorship responsibility and project ownership. The spatial scope of local ecosystem services integration in this study is therefore defined at the scale of building, building envelope and immediate landscape contained within project site.

			Core										*Complimentary*							
LOCAL ECOSYSTEM SERVICES AND FUNCTIONS **ARCHITECTURE QUALITY PARAMETERS**		01. SUPPORTING	1 Soil formation and fertility	2 Photosynthesis and primary production	3 Nutrient cycling and waste treatment	4 Water cycling and regulation	5 Biodiversity and nursery habitats	02. REGULATING	6 Climatic regulation	7 Erosion control and hazard protection	8 Biological control & pollination	9 Perceptive environmental modulation	03. PROVISIONING	10 Food supply	11 Water purification and fresh water supply	12 Raw materials, ornamental and medicinal resources	04. CULTURAL	13 Significant species and ecosytem values	14 Landscape aesthetic fruition	15 Leisure, recreation and psychophysical health
01. MACRO-LOCAL RELATIONS																				
1 Adaption to eco-physical values and restraints	*Extrinsic*																			
2 Sense of place and cultural identity																				
3 Transports and functional articulation w/ context																				
02. ENVIRONMENTAL BALANCE																				
4 Energy cycle [and atmospheric emissions]																				
5 Water cycle [and effluents]																				
6 Materials cycle [and waste]																				
7 Exterior areas and local pollution control																				
8 Sustainable life-style support systems																				
03. SOCIO-ECONOMIC RELEVANCE																				
9 Customization possibilities and operation																				
10 Community participation and user's satisfaction																				
11 Economic dynamics and lifecycle costs																				
12 Human health and well being																				
04. CONCEPT & PERCEPTIVE QUALITY																				
13 Concept originality, innovation and creativity	*Intrinsic*																			
14 Visual																				
15 Acoustics																				
16 Other senses: olfaction, tactility, motion perception																				
05. COMFORT AND FUNCTIONALITY																				
17 Lighting																				
18 Indoor air quality																				
19 Humidity and temperature																				
20 Adequacy to function, occupancy and circulation																				
06. BUILDING CONSTRUCTION																				
21 Details and finishes																				
22 Execution quality and process management																				
23 Structure stability and design																				
24 Durability & maintenance of systems and materials																				

Figure 16. Collaborative Interactions Framework: TILES Table.

Regarding its integration within Design Process, the application of the proposed analysis tool is potentially applicable for pre-design and design stages. It is potentially useful at the states of “Prototype/Test/Choose”, “Refine/and Validate” and “What if?” (as illustrated on Figure 17), and it might be useful to determine also in early stages possible solutions, strengths, weaknesses, and opportunities. In an early stage of the design process, and or pre-design, it may serve to define, communicate or think the priorities and aims of the project, the type of solutions employed, and later evaluate different stages of design, comparing it with initial objectives.

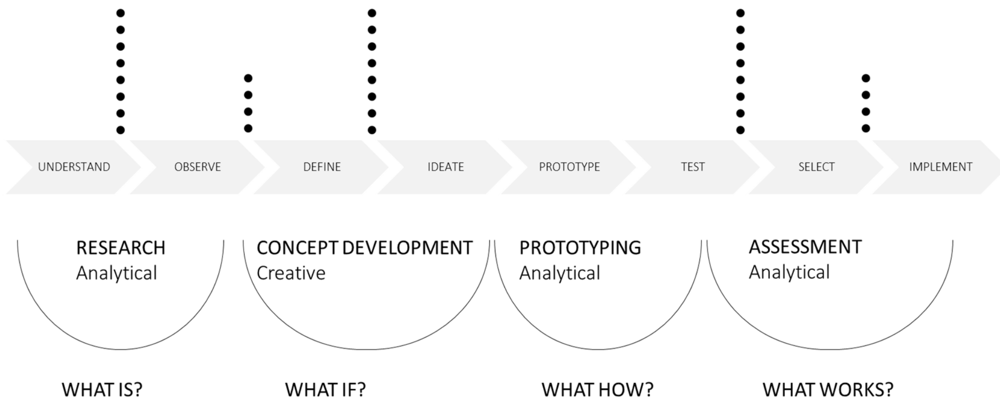


Figure 17. Opportunities for implementation of the method within Design Thinking Process

In the present research, the analysis with the Ti[l]es framework are performed with a *closed* set of indicators, comprehending 15 ecosystem services and functions and 24 architecture quality parameters. The distribution and number of indicators to each category already represent a type of weighting through the areas of assessment [between core and human based, in ecosystem criteria; and through subtle variations in architecture extrinsic and intrinsic parameters]. A possible application of the Ti[l]es framework by customizable modules would permit the user to select and personalize project-specific relevant analysis topics, while still representing broad design integration areas.

The final selection of criteria attempts to represent essential evaluation factors in the diverse areas, while avoiding redundancies between indicators and eliminating less relevant indicator topics or to which data availability was more scarce. As such, it can be pointed out that certain ecosystem services and functions, or architecture quality indicators, may be missing to the selected list of indicators. In future application and development of the framework, it is envisaged that personalized optional indicators might be added to this central set of 15x24 indicators. Some of these possible optional indicators might include: Fuel and energy sources [Ecosystem | Provisioning]; Infrastructures and lifelines [Architecture | Building Construction]; Transportation sources [Ecosystem | Provisioning]; and Inspiration [Ecosystem | Cultural]

05. RESEARCH INSTRUMENTS AND METHODS OF ANALYSIS

5.1 Data Collection Tools and Methodologies

As described in the previous chapter, local ecosystem services and architecture design quality criteria are referenced in a matrix framework designated as Ti[l]es, which constitutes an interpretation instrument to analyze the Design Integration of Local Ecosystem services and functions within Architectural Design. As the purpose of this instrument envisages its application as possible design assistance resource, - as a tool for thinking, supporting project guidance and decision making through multi-criteria analysis, the identification of opportunities and evaluation of different possible solutions, within a specific project, within a site -, evidence of its potentialities and limits are searched within the selected data collection and analysis methods. In order to investigate the application of the Ti[l]es framework, the research design methodology is unfolded as shown on Figure 18, in three methodological steps: 1) the constitution of a reference database, 2) the application of the framework to specific case study targets, and 3) the application of the framework by multiple users with different qualitative perception.

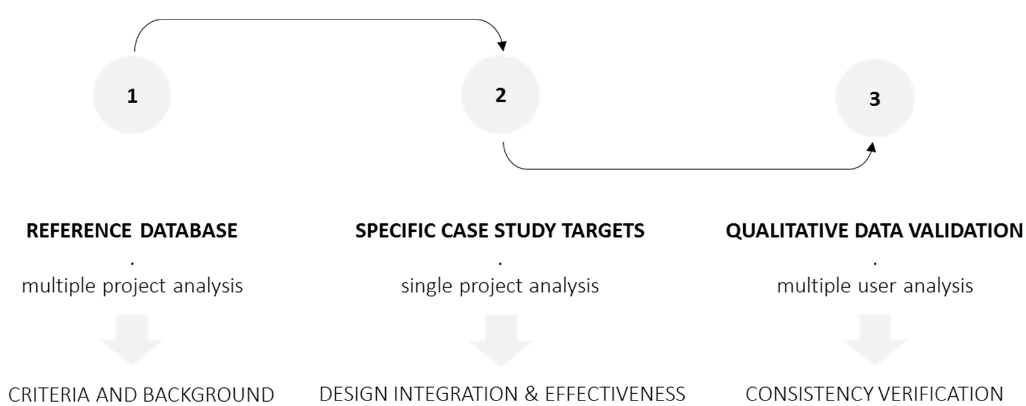


Figure 18. Research Design Instruments and Methodological Steps

The combination of these three methodological steps concur to reply to the questions: *How collaborative interactions between local ecosystem services and architecture quality parameters are contemporarily perceived, interpreted, attempted* and *how does the proposed framework may contribute to its understanding and strengthened implementation?*

The objectives of each of these research approaches are enunciated as follows:

1] *Reference Database* [multiple project analysis]: The identification and classification of collaborative interactions identified in diverse study case projects, aims to provide: a) an overall perspective of current state, approach diversity and forms of design integration; b) a reference background and contextual comparison for the application of the Ti[l]es framework as a design assistance tool.

2] *Ti[l]es Tool Application* [single project analysis]: The application of the proposed method to specific study cases, as ecosystem integration assessment, aims to: a) identify how collaborative interactions are possibly related with the provision of ecosystem services and enhancement of onsite ecology; and b) test the applicability of the framework.

3] *Qualitative Data Validation* [multiple user analysis]: Associated with the previous stages, the application of the Ti[l]es framework is object of analysis through different users, with focus on the same targets as step 2, in order to: a) verify the consistency of the method, and/or possibly identify patterns in qualitative estimations.

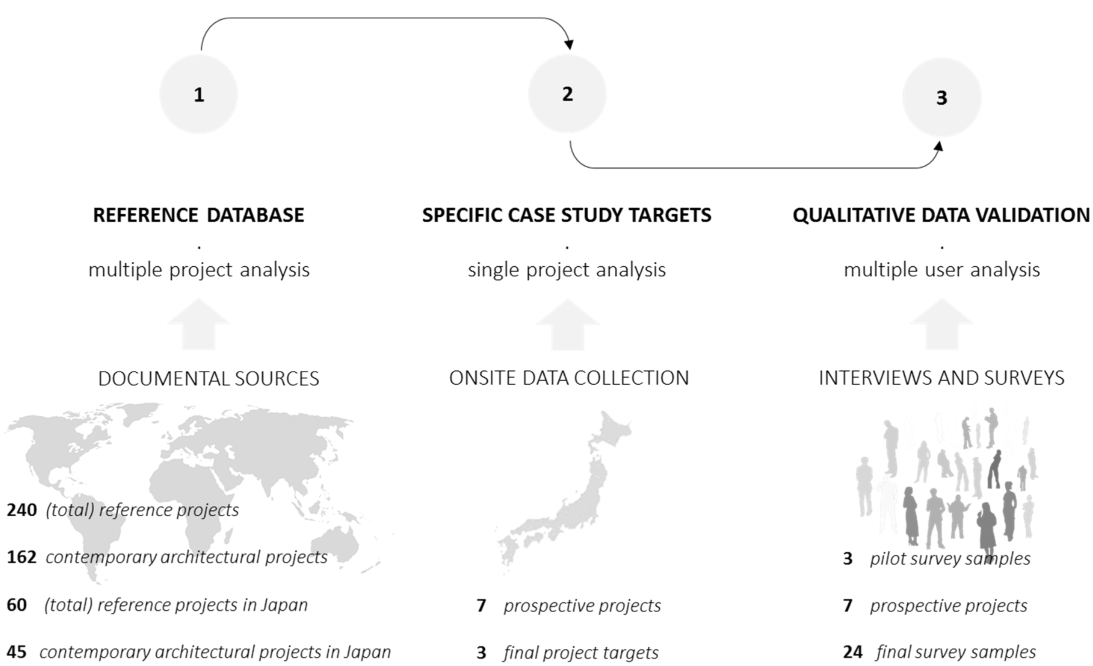


Figure 19. Implementation of the Methodology

In the following sections, are explained in detail the instruments and criteria for primary and secondary data collection and respective methods of analysis in these methodological steps.

5.2 Reference Database

The reference database comprises a systematization of collaborative interactions identified in diverse projects. In this section, several reference study cases were gathered and analysed, regarding the perceived and stated correlations between local ecological services and functions, and architecture design quality parameters. Within the present research, this framework is used as a way to systematize and offer an insight at the relations established within contemporary architecture, between local ecology parameters and architecture design quality parameters, how they are represented, attempted and perceived.

The targets for study case collection and elaboration of the reference database consist of built and non-built projects with referred ecosystem integration synergies, in international background, and the criteria for selection attended to: diversity of geographic location, diversity of program and typology, chronological distribution, architectural interest and aesthetic diversity, local ecosystem impact and diversity of ecosystem collaboration design synergies, and lastly, available documental resources.

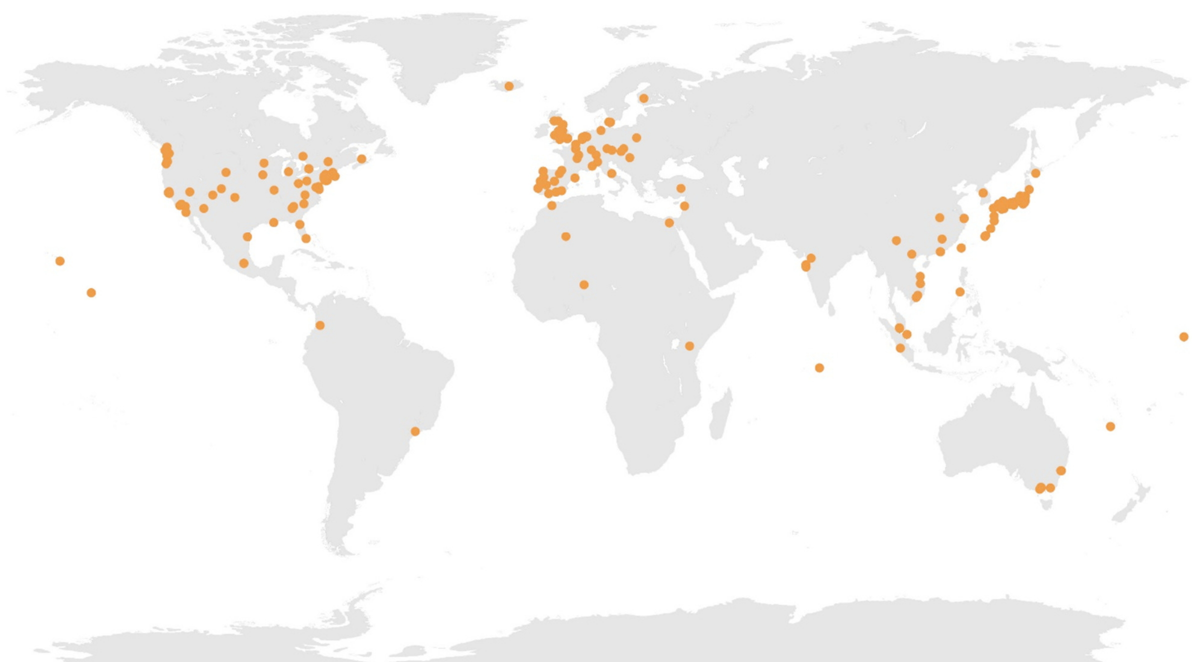


Figure 20. Geographical distribution of reference study cases

The objective of the construction of the database doesn't envisage an exhaustive collection of existing projects but to provide ample coverage and illustration of the different approaches towards local ecosystem services. The selected projects don't comprise exclusively sustainability certified projects, but also include peer appointed design projects with no direct relation to environmental assessment. The selection of projects in the reference database doesn't intend to reproduce or present a historiography of ecosystem functions integration in architecture, but to be as inclusive as possible given the diversity of possible collaborative interactions with design quality parameters. The selection purposely includes projects in and out the frontiers of formal building architecture [art installations, landscape design, detached building elements and systems, and urban and regional planning], as it identifies in them specific relations between local ecology functions and architecture design criteria.

The sources for selection and information on the referenced cases included research on online databases and case studies [including USGBC-LEED, SITES, BREAAM, Living Building Challenge, and JSBD-CASBEE], printed and online magazines [including AD, Domus, Dezeen, Archdaily, Green Source, and Inhabitat], design competitions entries [including Holcim Foundation, e-volo magazine, and IHDC] project compilations as Carrot City and FoodUrbanism, specific literature review and individual research. The study case selection and secondary data collection was performed from April 2012 to the end of March 2014.

In terms of analysis, the selected study cases included in reference [or context] database were analyzed and categorized according to the *suggested* ecosystem integration relations available in secondary sources. The definition of the relevant ecosystem integration aspects in each project are derived from literature review [information provided by authors and project teams, architectural press, case study technical sheets and book references]. These referred qualitative links, however, were not assessed regarding their factual efficiency towards local ecosystem or architecture quality indicators.

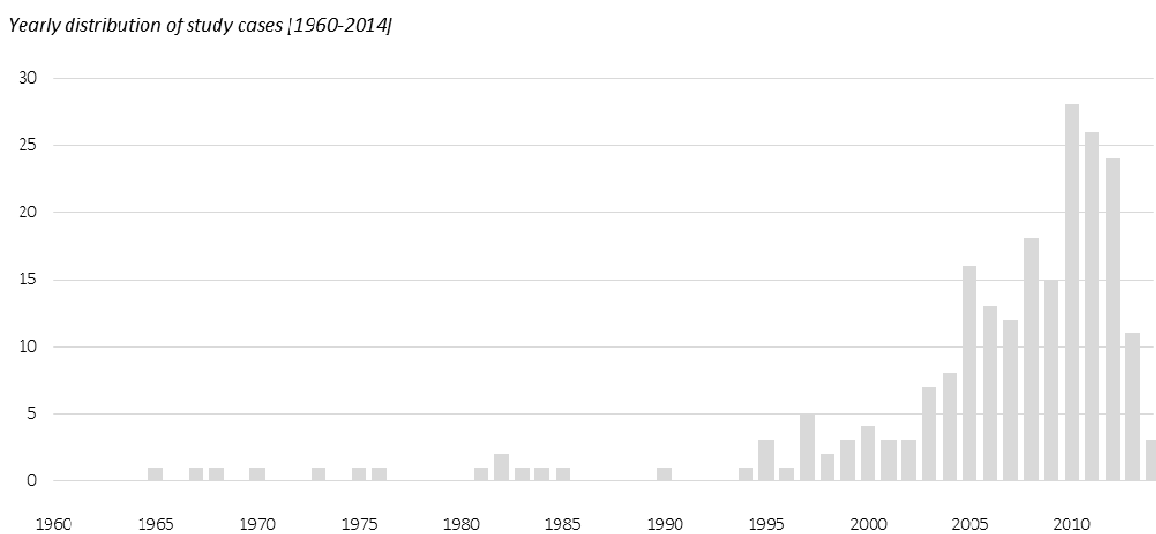


Figure 21. Yearly distribution of reference study cases [1960-2014]

The Design Integration Reference Database [presented in Appendix I, and further discussed on Chapter 6] is organized through architectural design criteria, and overlaps information found in multiple projects, selecting 1 or more positive interaction per study case, as reference sample of the interactions with each specific ecosystem service. Collaborative interactions in the Reference Database are further characterized with descriptions of the possible Design Options, Project Life Cycle introduction stage, and Envelope Design Integration.

The complete Catalogue of Reference Study Cases [available in Appendix II] includes 240 entries, from which 162 are contemporary building projects, 45 of which located in Japan. A general characterization of the referenced case studies is also provided according to the following descriptors:

1. *Year of completion |Periodization*.
- 1. Contemporary: 1990-2014.
  (The focus of this study - marked by the Rio Earth summit and the launch of building environmental assessment methods, among the institution of other inter-governmental and regional sustainability *policies* [within this period, the following sub-divisions are also considered: 1990-1999, 2000-2009, 2010-2014]).
- 2. Post-Modern: 1960-1990.
  (This time period is framed by the publication of Rachel Carson's *Silent Spring*, the raise of *environmental awareness*, and first steps and consolidation of ecological architecture)
- 3. Modern and Pre-Modern: >1900-1960.
  (This periodization covers a few references from before 1960, including vernacular, pre-industrial and modern structures)

2. *Concretization*.
- 1. Built | Realized.
  (Including constructed structures, including temporary and already dissembled buildings, projects in construction)
- 2. Unbuilt | Plan.
  (Encompassing unbuilt projects and plans, with different levels of concretization and feasibility)

3. *Environmental Assessment*.
- 1. Certified.
  (Projects certified by an environmental assessment method)
- 2. Non-certified.
  (Projects non certified by an environmental assessment method)

4. Location, Country and *Geographic Cluster*.
- 1. America-Pacific
- 2. Europe-Africa-Middle East
- 3. South and East Asia-Oceania

5. *Scale*.
- 1. Component.

(Elements and small scale systems, movable or adaptable structures, or parts of buildings as roofs, walls, and compartments)

- 2. Building.

  (Independent standing structures, comprehending diverse scales structures, with or without adjacent landscape area)

- 3. Landscape Unit.

  (Spatial units as parks, plazas and other areas without relevant built or habitable structures)

- 4. Ensemble.

  (Groups of several buildings, or groups of buildings and landscape units, as neighborhood projects, and large campuses)

- 5. Plan.

  (Urban or regional planning large scale projects including several landscape units and or ensembles, as master and regional plans)

6. *Context.*

- 1. Urban.

  (High and medium density urban areas, corresponding to T4 and T5 transects. Level of urbanity [+++])

- 2. Sub-urban.

  (Low density urban and village areas, corresponding to T3 and T4 transects. Level of urbanity [++])

- 3. Non-urban.

  (Rural or predominantly natural settings, corresponding to T1 and T2 transects. Level of urbanity [+])

7. *Use |Function*.

- 1. Residential. (single and multiple family housing)
- 2. Educational. (schools, kindergartens, universities and research institutes)
- 3. Cultural. (museums, visitor centers, libraries and art centers)
- 4. Mixed Use. (combination of residential or business functions with other uses)
- 5. Commercial. (shops, retail and restaurants-eateries)
- 6. Offices. (business and public or private services workplaces)
- 7. Public Open Space. (parks, gardens, urban plazas and streets)
- 8. Pavilion. (free standing structures with no particular associated function)
- 9. Agriculture. (farming and cultivation of animals and plants for food and resource supply)
- 10. Art Project. (temporary or permanent installation with artistic purposes)
- 11. Tourism. (hotels, hostels and other commercial temporary housing)
- 12. Social. (public facilities with social character as day and community centers)
- 13. Infrastructure. (technical structures and facilities)
- 14. Healthcare. (medical facilities, as hospitals)
- 15. Details. (landscape and building elements, added to main structures, as planters or ornaments)

Besides this base characterization, the reference cases are also classified with a brief Ecosystem Integration Description, and its most relevant collaborative interactions, referenced to the TI[L]ES matrix. Further typological classification of the case studies emerged regarding specific modes of ecosystem services integration as described in the analysis of the results, in Chapter 6.

5.3 Application of TI[L]ES framework to Specific Study Case Targets

The application of the proposed method for qualitative assessment of ecosystem integration to selected study cases targets is designed to test its use as design assistance tool, and to verify possible correlations between ecosystem functions promotion and the level of Design Integration. The results provided within this stage are later compared with qualitative data surveys, to assess questions of validity and consistency.

The criteria of selection for these in-depth analysis targets consisted on the following: diversity of location in urban or semi-urban context, availability of data and documental resources, direct observation prospects; exceptional qualities or specificities [architectural interest, aesthetic diversity and/or environmental quality]; coverage and diversity of collaborative interactions; similarity of cultural-regional context, ecological background, and climate conditions; different levels of complexity regarding surface materials and species.

As such, within the compiled Catalogue of Reference Study Cases, the reasons to select a group of study case projects in the context of Japan are fundamentally the following: provide a similar ecological (natural, climatic) and cultural (architectural, urban, philosophical) context for basis of inter-comparison, with comparable context for native species and local resources; strong urbanization, either in number of urban inhabitants and urban centers density and extension, but also the characteristics of urban space [high percentage of soil occupation]; high quality of top contemporary architecture (construction, concept, innovation, etc.); advanced research in materials and systems for environmental sustainability of building sector, and for biomimicry, for instance; existence of an environmental sustainability assessment method with the particularities of CASBEE [notion of building quality and environmental impact, as a balanced ratio]; a cultural, socio-ecological [and architectural] context defined by Shinto philosophy; the developed research on socio-ecological landscapes, satoyama and satoumi, and ecosystem services and human wellbeing; the particularity of the different approaches on ecological architecture; and also a great contrast in the environmental performance of general urban fabric and non-erudite architecture.

From the reference database, were tentatively selected the targets for primary data collection and application of the analysis tool, consisting of the following built projects, in Japanese territory, as shown on Fugure 22: Green Cast, in Odawara; Fukasawa Symbiotic Housing, in Tokyo; Dancing Trees, Singing Birds, in

Tokyo; Pasona Urban Farm, inTokyo, ACROS Fukuoka International Hall, in Fukuoka; Makino Museum of Plants and People, in Kochi; and ZeroCO2 House Prototype, in Koga.

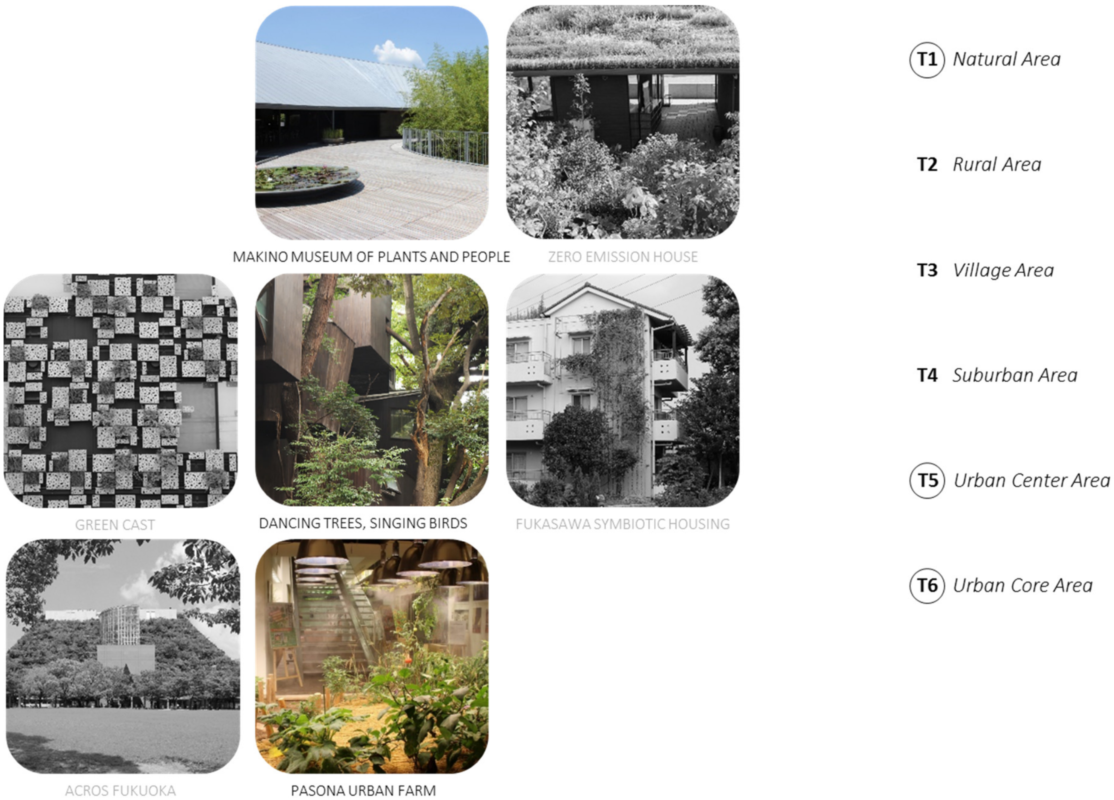


Figure 22. Specific Case Study targets

The respective location in urban transects is based on the definitions and scale provided by the Living Building Change and on the original urban-to-rural transect concept, proposed in the New Urbanism movement, by Andrés Duany, with a few alterations. The notion of transect is itself borrowed from ecology sciences to explain and illustrate a landscape and structural gradient. From these case study targets, are presented on Chapter 7, the results obtained to the 3 of them that are also object of analysis through qualitative data surveys.

During August and September 2013, field survey was conducted *in situ*, to the target projects. On-site data collection, consisted of: systematic data collection [surface materials, vegetal species, etc. and their characterization], and non-systematic [informal] data collection [about other species, built context, etc.], regarding the following aspects:

1] Site [within project boundaries]

- Percentage of surface area of materials and textures, relative to building enclosure [base envelope, lateral envelope, top envelope, on-site landscape]
- Characterization, quantification and location of landscape species

- Identification of strategies and design solutions for ecosystem functions and services promotion, and its relative influence to architecture criteria
- Detailed complementary information on the project

2] Context [immediate surroundings and macro region]

- Identification of possible affinities in materials, species, and strategies for ecosystem integration [Photographical evidence was obtained within a radius from the Project site.]
- Landscape and views, habitat connectivity, urban density transects, and geo-physical elements

The methods for data collection combined architectural and ecological survey, photographic records, written annotations, drawings and mapping [location and extension: in site plan, roof plan, and elevations].

Off-site data collection, consisted of documental analysis and communication established with Iwamura Atelier, Kono Designs, Hiroshi Nakamura & Nap, Naito Architects & Associates, Sekisui House, and Kengo Kuma & Associates, and permission to use the projects as case studies was set with the majority of the designers. In the case of Kono Designs, and Sekisui House, personal tours of the buildings were also arranged with Yoshimi Kono, principal designer of Pasona Urban Farm, and Shigeru Kikuchi, staff from the Zero Emission Center. From this communication resulted the additional compilation and exchange of data referent to the study cases: background and design process information, and technical data. Other off-site data collection included maps and contextual geo-information, species, literature on case studies

The analysis of specific single project analysis, combines quantitative and qualitative data, focusing simultaneously on a double perspective on effectiveness and design integration:

1. *Effectiveness*.

The concept of effectiveness, in the promotion of ecosystem services and functions within architectural projects, aiming for regenerative design standards, can be addressed in comparison with at least 3 site-specific, project specific yardsticks: a] Previous/Existing situation: the promotion/production of ecosystem services and functions can be compared towards specific available data of project site prior to construction, or towards an hypothetical average business as usual estimation for the site, prior to construction [similar constructions in the neighborhood for instance]; b] Project Consumption rates of ecosystem services; c] Maximum climax or site biocapacity in pre-development conditions.

Independently of these variable site-specific and project-specific benchmarks [that should guide individual assessment but are more difficult to compare multiple project assessments], for an immediate cross comparison between the target projects, the production of ecosystem services and functions within site boundaries are related with intercomparable project dimensions, as site area, and construction. There are different existing methods, indicators, and index that can be used to measure, quantitatively, ecosystem services and functions within a certain area. For the purposes of the carried research, and for inter-comparison objectives, specific standard indicators were chosen, for instance, number of species.

2. *Design Integration*.

Since in most of the case studies, post-occupancy quantitative studies were never realized, and in a consistent same-criteria basis, and would imply a long-term in-field research that totally would escape the scope of the present thesis, indicators for design integration [that is, architecture quality criteria] follow a predominantly qualitative-projection analysis. Also, the present selection of architecture quality indicators is composed by not only quantifiable indicators, but also by qualitative specific indicators, for which there are no current consensus on how to measure. Given the predominant role of qualitative perception in this evaluation, the impact and reasons for possible variations in this assessment are studied in third methodological step, Qualitative Data Validation - multiple user analysis, which is detailed in the following section. Similarly to most of available environmental assessment tools, indicators are "assumed" and documented from pre-occupancy stage [which is the main lifecycle stage targets for the utilization of the tool], having in account determined parameters/variables.

5.4 Qualitative Data Surveys

In order to monitor the application of the TI[L]ES framework, and verify the consistency and variation regarding qualitative perception in the use of the method, the collaborative interactions framework was tested through multiple user analysis, exposing it to different individuals, with different background, culture and design approaches.

Likewise the development of the TI[L]ES is particularly directed to designers and multidisciplinary design teams, including different areas of expertise, these qualitative surveys [also referred as multiple user analysis] are targeted to architects, consultants, and professionals in the field of ecological engineering and landscape design, rather than project occupants.

The objective of this segment of the study is of prospective rather than characterization nature, intending to verify the existence of possible dissimilarities in the response and interpretation of qualitative relations between architecture design quality parameters and local ecosystem services, in different projects. As such, its intention doesn't procure to define a particular trend or the general opinion of a specific group, but to identify variations, barriers, and specific problems and opportunities in the application of the TI[L]ES framework.

Survey methods for data collection, as interviews, self-administered questionnaires and surveilled questionnaires were applied to specialized panels, potential stakeholders in the design process [of local ecosystem integration]. The data was gathered in three distinct moments and forms: an initial pilot research survey, interviews conducted with design team members, and a final research questionnaire. Both questionnaires and interviews followed essentially a close ended structure, with some open ended questions. In addition to the formal replies answered within the close ended questionnaires and interviews, informal comments and observations were also collected regarding the application and format of the method.

Pilot Research Survey

An initial questionnaire survey was designed to simultaneously test and refine the applicability of the TI[L]ES framework, and to identify possible variations and interpretations by different users, conducted within a reduced test group. The objectives of this preliminary inquiry were to verify the variations by different users in the use of the method and perception of a specific project; identify difficulties in the interpretation of concepts related with indicators and collaborative interactions; and detect eventual problems, regarding the questionnaire format, the presentation of criteria and project data materials, and in the application procedures of the questionnaire itself.

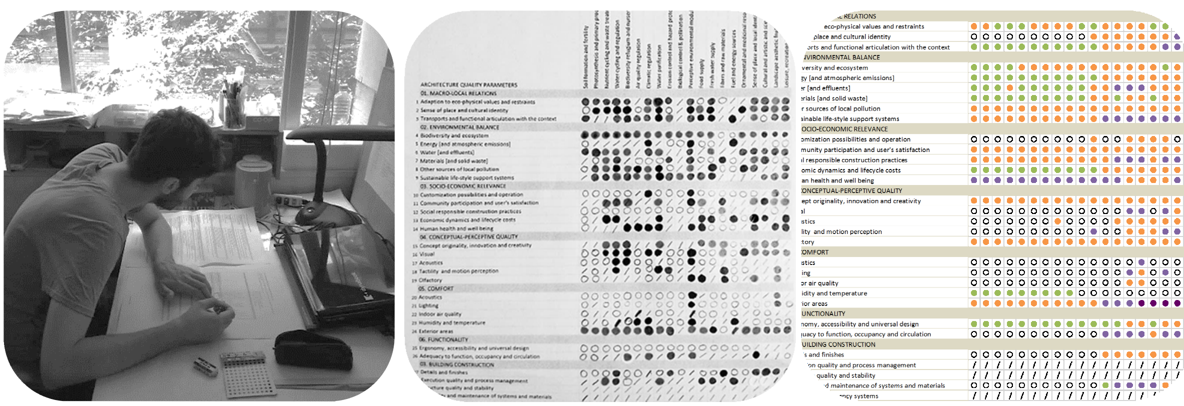


Figure 23. Application and Results of the experimental survey questionnaire

As an experimental application, this pilot questionnaire was conducted with 3 different users with comparable professional and academic backgrounds [one of which the author of the present thesis]. This pilot-test was distributed and applied in July 2013, and the results received in August 2013.

The respondents were given individually a digital or paper version of the questionnaire, being allowed to choose the format of their preference. The questionnaire was applied with the supervision of the author, and communication was allowed in order to clarify and register questions related with questionnaire filling and application format of the collaborative interactions matrix [excluding exchange of information regarding the final answers].

The close ended questionnaire, elaborated in an Excel Workbook, was divided in 3 sections. In the first section, it was inquired the personal, academic and professional background of the respondents, and also the degree of the respondent's knowledge of the specific project. In the second section, a preliminary version of the TILES matrix diagram [with 20 ecosystem criteria indicators x 31 architecture design criteria indicators] was proposed to analyze one of the case studies of the reference database [Sidwell Friends Middle School], as part of a close ended questionnaire. In the third section, it was asked a brief validation and assessment of the support tool.

The Sidwell Friends Middle School project was chosen from the reference database, as target of this experimental survey, due to the complexity and broad integration of local ecosystem services and functions within architecture design, and the readily available information and case study technical data. The research questionnaire also included in attachment datasets of information materials regarding: 1. Terms and Indicators (written descriptions of the criteria included in the tentative Ti[l]es matrix; and 2. Project Information [consisting of text descriptions extracted from technical sheets, photographs, architectural drawings and diagrams]. The full Questionnaire Format, and the provided Information Materials, regarding Terms and Indicators, and Project Information can be consulted on Appendix IV.

Interviews and Surveys with Design Teams

With the input provided from the pilot research survey, an improved version of the questionnaire with included modifications to the selected indicators, was implemented into structured interviews. These interviews were carried in the sequence of communication initiated with design team members, responsible for the projects described on Chapter 7. The objective of these interviews were two-fold: to study the impact of qualitative data variation and identify the perspective within design teams regarding the integration of local ecosystem services within their own projects.

Figure 24. Structured Interviews with Design Team members of selected projects

The structured interviews were conducted with design team members responsible for the architectural projects of *Dancing Trees Singing Birds*, *Pasona Urban Farm* and *Makino Museum of Plants and People*, during November and December of 2013. Due to diverse circumstances including the schedule of the interviewees, the mode of employ of the interviews differed as follows: Yoshimi Kono [personal interview, conducted in English]; Tetsuya Kombayashi [personal interview, conducted in Japanese]; and Hiroshi Nakamura [written interview, conducted in Japanese].

The structure of these interviews consisted of 2 sections. In the first section, it was inquired about the background personal approach to architecture design quality and its connection with local ecosystem integration. In the second section, specific questions about the respective targeted project were asked based on the final version of the TI[L]ES matrix diagram [with 15 ecosystem criteria indicators x 24 architecture design criteria indicators]. The interviews also included in attachment information materials regarding the concepts associated with the referred Terms and Indicators. Additionally, these consultations also provided further material for case study analysis and a first-hand insight into the design process of these projects, as well as the improvement of the survey format.

Final Research Questionnaire

With the inputs of both interviews and pilot research survey, the final version of a questionnaire to identify variations in the perception of qualitative and subjective aspects in the Ti[l]es framework was prepared. This questionnaire survey was applied online, in digital format, with Google Forms, in order to ease the input (answer) by the respondents, and facilitate the collection and analysis of the gathered data. The questionnaire was spread by e-mail and through professional and social network media, being displaced on a public website, and results were received until the end of March 2014.

In attachment to the research questionnaire, datasets of information materials regarding: 1. Instructions, Terms and Indicators, and Purpose of the Tool; and 2. Project Information, were also provided. The targets of this questionnaire, besides general background and methodology feedback, aimed at the perception of ecosystem services design integration in the 3 specific projects: *Dancing Trees Singing Birds*, *Pasona Urban Farm* and *Makino Museum of Plants and People*; also subject to design team interview and application of the Ti[l]es framework, as described in Chapter 7.

Within the questionnaire the respondents were allowed to choose freely from these 3 alternatives, which project they wished to reply about. This close ended questionnaire was similarly divided in 3 sections, as in the pilot survey. In the first section, it was inquired the personal, academic and professional background of the respondents, and the degree of the respondent's knowledge of the specific target project. This first part also focused on the respondents' perspective on architecture design quality and its potential connection with local ecosystem services.

In the second section, the final version of the TI[L]ES criteria [with 15 ecosystem services x 24 architecture design quality parameters] was proposed to analyze one of the afore mentioned case studies. In this part, the respondents were asked to identify relevant indicators implied in the design integration of local ecosystem services within the target project. In order to reduce the required answer time, instead of reproducing the whole collaborative interactions matrix, a sample of indicator pairs was additionally selected from Ecosystem services and Architecture quality parameters to be object of analysis, within this questionnaire. This open ended question also gave the opportunity of respondents to identify other positive relations besides the ones listed in Table 6. Guaranteeing the representativeness of all architecture criteria, these 24 randomized selected pairs of indicators account for 6,7% of the total possible correlations. The representation of the sample pairs of indicators in TI[L]ES Table is shown in the Figure 25.

In the third section, it was asked the respondents a brief validation and assessment of the proposed method of analysis, including the relevance of the development of design assistance resources to ecosystem integration, and the possible uses and qualities of the exposed framework. The full Questionnaire Format, and the provided Information Materials, regarding Terms and Indicators, and Project Information can be consulted on Appendix IV.

Table 6. Ecosystem and Architecture criteria – research questionnaire sample pairs of indicators

ARCHITECTURE QUALITY PARAMETERS			LOCAL ECOSYSTEM SERVICES	
A1	Adaption to eco-physical values and restraints	+	E6	Climatic regulation
A2	Sense of place and cultural identity	+	E15	Leisure, recreation and psychophysical health
A3	Functional articulation w/ context and transports	+	E4	Water cycling and regulation
A4	Energy cycle [and atmospheric emissions]	+	E2	Photosynthesis and primary production
A5	Water cycle [and effluents]	+	E5	Biodiversity and nursery habitats
A6	Materials cycle [and waste]	+	E7	Erosion control and hazard protection
A7	Exterior areas and local pollution	+	E12	Raw materials, ornamental and medicinal resources
A8	Sustainable life-style support systems	+	E10	Food supply
A9	Customization possibilities and operation	+	E14	Landscape aesthetic fruition
A10	Community participation and user's satisfaction	+	E12	Raw materials, ornamental and medicinal resources
A11	Economic dynamics and lifecycle costs	+	E11	Fresh water supply and purification
A12	Human health and well being	+	E5	Biodiversity and nursery habitats
A13	Concept originality, innovation and creativity	+	E9	Perceptive environmental modulation
A14	Visual	+	E11	Fresh water supply and purification
A15	Acoustics	+	E7	Erosion control and hazard protection
A16	Other senses: olfaction, tactility, motion perception	+	E14	Landscape aesthetic fruition
A17	Lighting	+	E9	Perceptive environmental modulation
A18	Indoor air quality	+	E3	Nutrient cycling and waste treatment

A19	Humidity and temperature	+	E2	Photosynthesis and primary production
A20	Adequacy to function, occupancy and circulation	+	E3	Nutrient cycling and waste treatment
A21	Details and finishes	+	E6	Climatic regulation
A22	Execution quality and process management	+	E1	Soil formation and fertility
A23	Structure stability and design	+	E13	Significant ecosystem values and species
A24	Durability & maintenance of systems and materials	+	E8	Biological control & pollination

ARCHITECTURE QUALITY PARAMETERS / LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	01. SUPPORTING	1 Soil formation and fertility	2 Photosynthesis and primary production	3 Nutrient cycling and waste treatment	4 Water cycling and regulation	5 Biodiversity and nursery habitats	02. REGULATING	6 Climatic regulation	7 Erosion control and hazard protection	8 Biological control & pollination	9 Perceptive environmental modulation	03. PROVISIONING	10 Food supply	11 Water purification and fresh water supply	12 Raw materials, ornamental and medicinal resources	04. CULTURAL	13 Significant species and ecosytem values	14 Landscape aesthetic fruition	15 Leisure, recreation and psychophysical health
01. MACRO-LOCAL RELATIONS																			
1 Adaption to eco-physical values and restraints								●											
2 Sense of place and cultural identity																			●
3 Transports and functional articulation w/ context					●														
02. ENVIRONMENTAL BALANCE																			
4 Energy cycle [and atmospheric emissions]			●																
5 Water cycle [and effluents]						●													
6 Materials cycle [and waste]									●										
7 Exterior areas and local pollution control															●				
8 Sustainable life-style support systems													●						
03. SOCIO-ECONOMIC RELEVANCE																			
9 Customization possibilities and operation																		●	
10 Community participation and user's satisfaction															●				
11 Economic dynamics and lifecycle costs														●					
12 Human health and well being						●													
04. CONCEPT & PERCEPTIVE QUALITY																			
13 Concept originality, innovation and creativity											●								
14 Visual														●					
15 Acoustics									●										
16 Other senses: olfaction, tactility, motion perception																		●	
05. COMFORT AND FUNCTIONALITY																			
17 Lighting											●								
18 Indoor air quality				●															
19 Humidity and temperature			●																
20 Adequacy to function, occupancy and circulation				●															
06. BUILDING CONSTRUCTION																			
21 Details and finishes								●											
22 Execution quality and process management		●																	
23 Structure stability and design																	●		
24 Durability & maintenance of systems and materials										●									

Figure 25. Visualization of ecosystem and architecture sample pairs of indicators in TILES Table

PART 3.

COLLABORATIVE INTERACTIONS
[RESULTS]

06. MULTIPLE PROJECT REFERENCE DATABASE

6.1 Collaborative Interactions in Reference Database

The present reference database attempts to trace the multiple interpretations of design integration of ecosystem services and the way it is translated into project decisions. For the assistance of the designer, and as a complement of the analysis tool during design process, it was elaborated a directory of potential usable synergies, with general descriptions and suggestions of diverse design solutions, illustrated by case studies. The aim of the present catalogue is auxiliary and although it attempts to be as exhaustive as possible, it is not impossible that specific correlations or rehearsed design solutions might have escaped the knowledge of the author. The fact that a specific collaborative interaction is omitted or missing in the present compilation doesn't mean that it doesn't exist or may exist.

This reference database serves as a support for thinking assistance during design process, and might be complemented further, by designers. Altered and selected, according to their individual perspective and priorities. The aim of the database is auxiliary, demonstrating whether there are information available about certain types of correlations, or where there is not, serving as a databank reference library for the application of the tool. It might point out areas of development, both in design, and as future research, and it also demonstrates whether there are information available about certain types of correlations, or where there is not.

The reference database illustrates a "map of intentions" suggested by designers, or referred by peers, of possible ecosystem integration strategies, indicating explicit and implicit correlations in project descriptions. This reference database is organized through [architecture criteria x ecosystem criteria] in accordance with the Ti[l]es framework and the collaborative interactions are filed and organized with General descriptions, Design Solution Options, Case Studies Reference sample, Life Cycle introduction stage, and Envelope Design

Integration. The considered intervention scale is predominantly micro-local. The full reference database can be consulted on Appendix I. Design Integration Reference Database.

The collected data results in a preliminary reference database, built upon 240 reference study cases, representing 360 possible correlations of ecosystem services and functions enhancement and architectural criteria. From these 360 potential positive intersections between local ecosystem services and architecture design criteria, 52 (14,4% of total) couldn't be clearly identified among the project sources. The 308 (85,6% of total) identified positive correlations were roughly classified as Mutual positive correlation, Positive impact on local ecosystem services, and Positive impact on architecture quality parameters, regarding whether appropriate design options would predominantly beneficiate one or other indicators, or equally beneficiate both. From the classification of these 308 positive correlations, 175 (48,6% of potential total) were considered as reciprocal correlations (mutual), 79 (21,9% of total) as positive towards local ecosystem services, and 54 (15% of potential total), as positive towards architecture design factors.

6.2 Macro-Local Relations

In the TI[L]ES framework, Macro-Local Relations agglutinates the architecture design [extrinsic] quality parameters that relate mainly with the project context: 1. Adaption to eco-physical values and restraints, 2. Sense of place and cultural identity, and 3. Transports and functional articulation with context. In the following text characterization and Figures, are summarized the reported positive connections between these parameters and local ecosystem services and functions, with the support to the reference case studies.

1. Adaption to eco-physical values and restraints.

This architectural design parameter is defined by project adequacy to local hydrography and topography and site selection. Through the identified reference case studies it is evident its predominant active and mutual role in the collaborative integration with on-site ecosystem services. Collaborative solutions emphasize project decisions at pre-design and design stages, and integration with base envelope [setting] and on-site landscape.

Collaborative design options include: to avoid greenfields, farmland, rich ecological soil areas, 100 year flood zones and wetland features; to regenerate used land [greyfield, brownfield, and blackfiels]; to preserve and restore existing native vegetation and soil coverage; to define building setting and location preferred for minimal earthworks and excavation [adaptation to topography, soils and drainage patterns]; and to avoid steep slope areas, and fragile coastal areas.

1. Adaption to eco-physical values and restraints

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
🟢	1	Soil formation and fertility	34	Rinker Hall
🟢	2	Photosynthesis and primary production	215	Evergreen Brick Works
🟢	3	Nutrient cycling and waste treatment	201	Scenic Hudson's Long Dock Park
🟢	4	Water cycling and regulation	237	El Coso municipal office building and Public Space
🟢	5	Biodiversity and nursery habitats	85	Pola Museum of Art
		02. REGULATING		
🟢	6	Climatic regulation	144	Neepsend
🟠	7	Erosion control and hazard protection	114	Palisade Bay
🟢	8	Biological control & pollination	200	Phipps' Center for Sustainable Landscapes
🟢	9	Perceptive environmental modulation	36	Dancing Trees, Singing Birds
		03. PROVISIONING		
🟢	10	Food supply	32	Center for Regenerative Studies
🟠	11	Water purification and fresh water supply	180	Tyson Living Learning Center
🟠	12	Raw materials, ornamental and medicinal resources	53	Tree Mountain-a living time capsule
		04. CULTURAL		
🟠	13	Significant species and ecosytem values	72	Pocono Environmental Education Center
🟢	14	Landscape aesthetic fruition	1	Okinawa Institute of Science and Technology
🟠	15	Leisure, recreation and psychophysical health	175	Mill Creek Canyon Earthworks

Figure 26. Local Ecosystem Integration and Macro-Local Criteria: 1. Adaption to eco-physical values and restraints

2. Sense of place and cultural identity

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
🟠	1	Soil formation and fertility	112	Iceland turf houses
🟠	2	Photosynthesis and primary production	107	Tokyo micro-greenery
🟠	3	Nutrient cycling and waste treatment	215	Evergreen Brick Works
🟠	4	Water cycling and regulation	147	World Birding Center Headquarters
🟠	5	Biodiversity and nursery habitats	140	Edge Hill Halls of Residence
		02. REGULATING		
🟠	6	Climatic regulation	108	Real Alcázar of Seville
🟠	7	Erosion control and hazard protection	53	Tree Mountain-a living time capsule
🟠	8	Biological control & pollination	194	Mediterranean window pots and gardens
🟠	9	Perceptive environmental modulation	104	Vine pergolas in South Europe
		03. PROVISIONING		
🟠	10	Food supply	222	Edible Terrace + Edible Terrace2
🟠	11	Water purification and fresh water supply	39	River remediation and development in Medina of Fez
🟠	12	Raw materials, ornamental and medicinal resources	110	Cliff dwellings of Anasazi
		04. CULTURAL		
🟠	13	Significant species and ecosytem values	103	Ise Shrine
🟠	14	Landscape aesthetic fruition	113	Jean-Marie Tijbaou Cultural Center
🟠	15	Leisure, recreation and psychophysical health	88	Seto-chi Shinanodai Elementary school

Figure 27. Local Ecosystem Integration and Macro-Local Criteria: 2. Sense of place and cultural identity

2. Sense of place and cultural identity.

This quality parameter presupposes a local socio-cultural identity that emerges from the project or to that the project adapts, dealing with local context references, landscape integration, socio-cultural adequacy and relevance. Its role in collaborative integration is considered primarily as mutual, beneficiating from the provision of on-site ecosystem services and contributing to it through local [regional and cultural] common practices. Collaborative solutions emphasize project decisions at pre-design, design and operation stages, and integration is possible with lateral and top envelope [walls and roof] but predominantly with on-site landscape.

The case study samples organized to this criteria tend to be pre-modern [and mostly vernacular] representing well established local identities in relation with ecosystem services, and part of them are also, in terms of scale, larger territorial units, as ensembles. It blends and partially overlaps with social parameters as 9. Customization possibilities and operation, and 10. Community participation and user's satisfaction.

3. Transports and functional articulation with context

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
	01. SUPPORTING		
1	Soil formation and fertility	1	Okinawa Institute of Science and Technology
2	Photosynthesis and primary production	31	HighLine
3	Nutrient cycling and waste treatment	178	The perfumed jungle
4	Water cycling and regulation	207	Urban Ecotones
5	Biodiversity and nursery habitats	72	Pocono Environmental Education Center
	02. REGULATING		
6	Climatic regulation	47	Masthusen Bo01 District development
7	Erosion control and hazard protection	109	Philipines mangrove coastal settlements
8	Biological control & pollination		
9	Perceptive environmental modulation	143	Shrubhill Works
	03. PROVISIONING		
10	Food supply	132	Dakakker Shieblock
11	Water purification and fresh water supply	219	Pixel
12	Raw materials, ornamental and medicinal resources	155	Low Cost House
	04. CULTURAL		
13	Significant species and ecosytem values	202	National Renewable Energy Lab
14	Landscape aesthetic fruition	173	Charles David Keeling Apartments
15	Leisure, recreation and psychophysical health	141	Matripolis

Figure 28. Local Ecosystem Integration and Macro-Local Criteria: 3. Transports and functional articulation with context

3. Transports and functional articulation with context.

The project relation with surrounding infrastructures and volumes, access to daily functions, and low impact mobility is addressed by this parameter. The reference case studies evidence its predominant active role within on-site ecosystem services integration. Collaborative solutions generally emphasize project decisions at pre-design and design stages, and integration with base envelope [setting] and on-site landscape. However this pattern changes when addressing provisioning services (as food, water and other resources supply), where it may be defined as active but also receptive in terms of positive correlations, including design options also on operation life-cycle stages, and allowing integration in lateral and top envelope and project enclosure.

6.3 Environmental Balance

Environmental Balance groups the extrinsic architecture design parameters that qualify the project regarding its environmental performance: 4. Energy cycle [and atmospheric emissions], 5. Water cycle [and effluents], 6. Materials cycle [and waste], 7. Exterior areas and local pollution control, and 8. Sustainable life-style support systems. The modes of ecosystem integration observed in the reference case studies, highlight the following connections with ecosystem functions and services, as following.

4. Energy cycle [and atmospheric emissions]

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
●	1	Soil formation and fertility	164	California Academy of Sciences
●	2	Photosynthesis and primary production	16	Photo Stack
●	3	Nutrient cycling and waste treatment	185	LOTT Regional Services Center
●	4	Water cycling and regulation	154	Museum Brandhorst
●	5	Biodiversity and nursery habitats	70	Solaris
		02. REGULATING		
●	6	Climatic regulation	239	Putrajaya 2C5 Commercial Development
○	7	Erosion control and hazard protection		
○	8	Biological control & pollination		
●	9	Perceptive environmental modulation	48	Centre for Interactive Research on Sustainability
		03. PROVISIONING		
●	10	Food supply	223	Agro Housing
●	11	Water purification and fresh water supply	129	Bloom [Aquatic Farm]
●	12	Raw materials, ornamental and medicinal resources	42	Suginami-ku assembly hall
		04. CULTURAL		
●	13	Significant species and ecosystem values	24	Reading room
●	14	Landscape aesthetic fruition	106	Wind mills landscapes
●	15	Leisure, recreation and psychophysical health	167	Green Float

Figure 29. Local Ecosystem Integration and Environmental Balance: 4. Energy cycle [and atmospheric emissions]

4. Energy cycle [and atmospheric emissions].

This design quality parameter is defined by the project's energy consumption through life cycle, passive performance and renewable energy use. Reported positive interactions between this indicator and on-site ecosystem services in the reference case studies consist primarily of mutual and passive strategies.

Collaborative solutions include project decisions predominantly at design stage, and also at pre-design and operation stages. Integration with on-site landscape is predominantly referred, although lateral and top envelope, and marginally enclosure, are also considered.

5. Water cycle [and effluents]

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
	1	Soil formation and fertility	2	Sabo House
	2	Photosynthesis and primary production	198	House like a Tree
	3	Nutrient cycling and waste treatment	220	Ausgrid Learning Centre
	4	Water cycling and regulation	18	Sidwell Friends Middle School
	5	Biodiversity and nursery habitats	40	Plaza Ecopolis
		02. REGULATING		
	6	Climatic regulation	76	Makino Museum of Plants and People
	7	Erosion control and hazard protection	232	Water Re-Balance Skyscraper
	8	Biological control & pollination	147	World Birding Center Headquarters
	9	Perceptive environmental modulation	186	Queens Botanical Garden Interpretation Center
		03. PROVISIONING		
	10	Food supply	14	Hous.E+ Project
	11	Water purification and fresh water supply	7	Living with Lakes Centre
	12	Raw materials, ornamental and medicinal resources	49	Perkins+Will New Atlanta Office
		04. CULTURAL		
	13	Significant species and ecosytem values	187	Marine and Freshwater Resources Institute
	14	Landscape aesthetic fruition	66	Gwinnett Environmental & Heritage Center
	15	Leisure, recreation and psychophysical health	100	Water squares

Figure 30. Local Ecosystem Integration and Environmental Balance: 5. Water cycle [and effluents]

5. Water cycle [and effluents].

The consumption of water, rain water harvest, waste water management, treatment and reuse within the project are the target of this architectural design parameter. The identified reference case studies evidence its predominant active and mutual role in the collaborative integration with on-site ecosystem services, and positive correlations are abundantly reported. Solution options emphasize project decisions at design and operation stages, and integration with on-site landscape and top envelope [blue and green roofs] are predominantly mentioned (but lateral, base envelope and enclosure are also cited).

6. Materials cycle [and waste].

This design parameter comprises the use of local, renewable and low impact materials, and its deconstruction, recycling and biodegradability potential. In the referenced case studies, it is noticeable its active role in the collaborative integration with on-site ecosystem services.

Project decisions at design stage are predominant, but at construction and operation stages are also stated. Integration with lateral and top envelope are comparable with on-site landscape.

6. Materials cycle [and waste]

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
●	1	Soil formation and fertility	120	Tree Tenant + Humus Toilet
●	2	Photosynthesis and primary production	37	House C
●	3	Nutrient cycling and waste treatment	101	A different brick
●	4	Water cycling and regulation	203	George 'Doc' Cavalliere Park
●	5	Biodiversity and nursery habitats	8	Crouch Hill Community Park
		02. REGULATING		
●	6	Climatic regulation	204	Burbank Water and Power EcoCampus
●	7	Erosion control and hazard protection	238	Dune
●	8	Biological control & pollination	227	Marks & Spencer Cheshire Oaks
○	9	Perceptive environmental modulation		
		03. PROVISIONING		
●	10	Food supply	115	New York City Steady State
●	11	Water purification and fresh water supply	198	House like a Tree
●	12	Raw materials, ornamental and medicinal resources	15	Minka farmhouses in Satoyama landscapes
		04. CULTURAL		
●	13	Significant species and ecosytem values	62	Bay Education Center
●	14	Landscape aesthetic fruition	202	National Renewable Energy Lab
○	15	Leisure, recreation and psychophysical health		

Figure 31. Local Ecosystem Integration and Environmental Balance: 6. Materials cycle [and waste]

7. Exterior areas and local pollution control

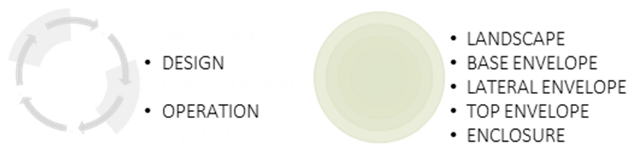
*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
●	1	Soil formation and fertility	73	Revival Fields I and II
●	2	Photosynthesis and primary production	167	Green Float
●	3	Nutrient cycling and waste treatment	73	Revival Fields I and II
●	4	Water cycling and regulation	130	Dormitories for ITRI Southern Taiwan Campus
●	5	Biodiversity and nursery habitats	38	Roku Museum
		02. REGULATING		
●	6	Climatic regulation	239	Putrajaya 2C5 Commercial Development
●	7	Erosion control and hazard protection	240	Grotão Community Center
●	8	Biological control & pollination	86	ZeroCO2 House
●	9	Perceptive environmental modulation	23	House on Pali Hill
		03. PROVISIONING		
●	10	Food supply	124	City Farm
●	11	Water purification and fresh water supply	40	Plaza Ecopolis
●	12	Raw materials, ornamental and medicinal resources	25	Maison Séoul
		04. CULTURAL		
●	13	Significant species and ecosytem values	60	Laketown "Miwa no Mori"
●	14	Landscape aesthetic fruition	50	Dockside Green
●	15	Leisure, recreation and psychophysical health	39	River remediation and development in Medina of Fez

Figure 32. Local Ecosystem Integration and Environmental Balance: 7. Exterior areas and local pollution control

7. Exterior areas and local pollution control.

This architectural design parameter encompasses the provision of landscape and amenities, control of light pollution, noise, heat island effect and glare. It is patent the predominant mutual character of the collaborative integration between this parameter with on-site ecosystem services. In the selected reference case studies, the leading life cycle stage for implementation of collaborative solutions is design, although operation stage is also mentioned. Collaborative solutions emphasize primarily integration with on-site landscape, and secondarily with base, lateral and top envelope.

8. Sustainable life-style support systems



*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
	1	Soil formation and fertility	63	Cheasapeake Bay Foundation
	2	Photosynthesis and primary production	142	Happy Habitats
	3	Nutrient cycling and waste treatment	58	EcoVillage Matsudo
	4	Water cycling and regulation	143	Shrubhill Works
	5	Biodiversity and nursery habitats	47	Masthusen Bo01 District development
		02. REGULATING		
	6	Climatic regulation	32	Center for Regenerative Studies
	7	Erosion control and hazard protection	44	Mountain Band-Aid
	8	Biological control & pollination	125	Ginza Honeybee Project
	9	Perceptive environmental modulation	47	Masthusen Bo01 District development
		03. PROVISIONING		
	10	Food supply	222	Edible Terrace + Edible Terrace2
	11	Water purification and fresh water supply	198	House like a Tree
	12	Raw materials, ornamental and medicinal resources	77	Satonokaze daytime workshop
		04. CULTURAL		
	13	Significant species and ecosytem values	206	Urban Savannah, Alley Midlands, Understory Dwellings
	14	Landscape aesthetic fruition	141	Matripolis
	15	Leisure, recreation and psychophysical health	224	Vertical Farm Arcology

Figure 33. Local Ecosystem Integration and Environmental Balance: 8. Sustainable life-style support systems

8. Sustainable life-style support systems.

The provision of adequate conditions for more sustainable behaviors and minimization of resource consumptions and life-styles (as spaces for on-site farming, compost, bicycle parking, and laundry line dry) defines the scope of this design parameter.

Through the identified case studies it is evident its predominant mutual and receptive role in the design integration with on-site ecosystem services. As other items grouped under Environmental Balance, this quality parameter is strongly linked with the provision of ecosystem services, as it relates with onsite sustainable food production systems and beneficiates from several other ecological functions. Collaborative solutions emphasize project decisions both at design and operation stages. Integration with on-site landscape and top envelope predominate, although enclosure and lateral envelope may be also stated.

6.4 Socio-Economic Relevance

Socio-Economic Relevance groups the architecture quality parameters that characterize the projects quality through its relation with social, cultural and economic factors: 9. Customization possibilities and operation, 10. Community participation and user's satisfaction, 11. Economic dynamics and lifecycle costs, and 12. Human health and well-being. The modes of ecosystem integration observed in the reference case studies, highlight the following connections of these architecture parameters with local ecosystem functions and services, as displayed on the following figures and text.

9. Customization possibilities and operation

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Reference Project [Sample]	
		01. SUPPORTING		
○	1	Soil formation and fertility		
●	2	Photosynthesis and primary production	188	Vertical Garden Kit
●	3	Nutrient cycling and waste treatment	42	Suginami-ku assembly hall
●	4	Water cycling and regulation	209	Symbiotic Existence Through Transactional Awareness
●	5	Biodiversity and nursery habitats	209	Symbiotic Existence Through Transactional Awareness
		02. REGULATING		
●	6	Climatic regulation	97	Yakushima Symbiotic Housing
○	7	Erosion control and hazard protection		
●	8	Biological control & pollination	194	Mediterranean window pots and gardens
●	9	Perceptive environmental modulation	174	Special NO 9 House
		03. PROVISIONING		
●	10	Food supply	162	Cascading Gardens
○	11	Water purification and fresh water supply		
●	12	Raw materials, ornamental and medicinal resources	107	Tokyo micro-greenery
		04. CULTURAL		
●	13	Significant species and ecosytem values	145	Rehabilitation
●	14	Landscape aesthetic fruition	126	Habitat 67
●	15	Leisure, recreation and psychophysical health	87	Amami hospital

Figure 34. Local Ecosystem Integration and Socio-Economic Relevance: 9. Customization possibilities and operation

9. Customization possibilities and operation.

This architectural design parameter comprises the possibilities of extension and modification of interior space, comfort and envelope control, by its users.

In the referenced projects and case studies, its role is mostly active and sometimes reciprocal in relation to on-site ecosystem services. The identified collaborative design solutions include generically: envelope and landscape customization possibilities anticipated by design or taken by user initiative [including the addition of micro and window greenery, trellis, pergolas, indoor partitions, etc.] offering comfort modulation and space personalization, while simultaneously contributing to support local ecosystem services.

Accordingly, collaborative solutions within architecture projects are taken mostly within design and operation stages, and integration with lateral and top envelope, on-site landscape, and less regularly at enclosure.

10. Community participation and user's satisfaction

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
	1	Soil formation and fertility	214	Le 56 – Ecointerstice
	2	Photosynthesis and primary production	235	Ekostaden Augustenborg
	3	Nutrient cycling and waste treatment	201	Scenic Hudson's Long Dock Park
	4	Water cycling and regulation	235	Ekostaden Augustenborg
	5	Biodiversity and nursery habitats	168	Phoenix Garden
		02. REGULATING		
	6	Climatic regulation	150	Kurimoto Millennium City
	7	Erosion control and hazard protection	240	Grotão Community Center
	8	Biological control & pollination	131	HK Farm / HK Honey
	9	Perceptive environmental modulation	42	Suginami-ku assembly hall
		03. PROVISIONING		
	10	Food supply	214	Le 56 – Ecointerstice
	11	Water purification and fresh water supply	39	River remediation and development in Medina of Fez
	12	Raw materials, ornamental and medicinal resources	95	Tsubaki [Camelia] Castle
		04. CULTURAL		
	13	Significant species and ecosytem values	53	Tree Mountain-a living time capsule
	14	Landscape aesthetic fruition	200	Phipps' Center for Sustainable Landscapes
	15	Leisure, recreation and psychophysical health	236	Ecobarrio Suerte 90

Figure 35. Local Ecosystem Integration and Socio-Economic Relevance: 10. Community participation and user's satisfaction

10. Community participation and user's satisfaction.

The inclusion of participatory processes, engagement with local communities and stakeholders and user adequacy are comprised by this architecture sustainability parameter. Through the identified reference cases, it is evident its active and predominantly mutual role in the collaborative integration with on-site ecosystem services. Collaborative strategies emphasize implementation at pre-design, design and operation stages, and integration of these actions within on-site landscape, secondarily on lateral and top envelope, and potentially also at enclosure.

11. Economic dynamics and lifecycle costs.

This architectural design parameter addresses the project economic impact and distribution, and the balance of initial investment with operation and end use costs. The collaborative integration with on-site ecosystem services is referred as beneficial and reciprocal towards this parameter, considering the possible positive impacts of different services to reduce occupancy and maintenance expenses.

Collaborative design options are most relevant at design and operation stages, and its integration within top envelope and on-site landscape (also lateral envelope, enclosure, - and in a lesser amount base envelope-, are also indicated).

11. Economic dynamics and lifecycle costs

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
●	1	Soil formation and fertility	158	East Hills Center
○	2	Photosynthesis and primary production		
●	3	Nutrient cycling and waste treatment	207	Urban Ecotones
●	4	Water cycling and regulation	163	Bronx Blue-and-Green Roof
●	5	Biodiversity and nursery habitats	145	Rehabilitation
		02. REGULATING		
●	6	Climatic regulation	152	Willow School
●	7	Erosion control and hazard protection	89	Research Institute for Humanity and Nature
●	8	Biological control & pollination	135	Lufa Farms
●	9	Perceptive environmental modulation	69	Stacking Green
		03. PROVISIONING		
●	10	Food supply	188	Vertical Garden Kit
●	11	Water purification and fresh water supply	152	Willow School
●	12	Raw materials, ornamental and medicinal resources	181	Painters Hall Community Center
		04. CULTURAL		
●	13	Significant species and ecosytem values	159	Nitshill Integrated Green Infrastructure
●	14	Landscape aesthetic fruition	50	Dockside Green
●	15	Leisure, recreation and psychophysical health	31	HighLine

Figure 36. Local Ecosystem Integration and Socio-Economic Relevance: 11. Economic dynamics and lifecycle costs

12. Human health and well-being

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
○	1	Soil formation and fertility		
●	2	Photosynthesis and primary production	136	FSMA Tower
●	3	Nutrient cycling and waste treatment	17	Treescraper Office Building of the Future
●	4	Water cycling and regulation	235	Ekostaden Augustenborg
●	5	Biodiversity and nursery habitats	30	Setagaya-ku Fukasawa Symbiotic Housing Complex
		02. REGULATING		
●	6	Climatic regulation	81	House of Outlook
●	7	Erosion control and hazard protection	109	Philipines mangrove coastal settlements
●	8	Biological control & pollination	194	Mediterranean window pots and gardens
●	9	Perceptive environmental modulation	157	CH2 [Council House 2]
		03. PROVISIONING		
●	10	Food supply	41	Pasona HQ Urban Farm
●	11	Water purification and fresh water supply	210	Prince Edward Island Ark
●	12	Raw materials, ornamental and medicinal resources	137	Symbiotic Office
		04. CULTURAL		
●	13	Significant species and ecosytem values	76	Makino Museum of Plants and People
●	14	Landscape aesthetic fruition	80	Nissan Advanced Technology Center
●	15	Leisure, recreation and psychophysical health	234	BedZED

Figure 37. Local Ecosystem Integration and Socio-Economic Relevance: 12. Human health and well-being

12. Human health and well-being.

The scope of this indicator is defined by project impacts on human health and well-being, including psycho-social aspects. The design integration with on-site ecosystem services, is mostly referred as beneficial towards it and less mentioned as an active subject, being amply documented.

Relevant life cycle stages to the implementation of collaborative integration solutions with this parameter include both design and operation stages. The integration with on-site landscape and top envelope are predominant, although lateral envelope, and particularly enclosure are noticeably more frequent than in other parameters average.

6.5 Conceptual Perceptive Quality

Conceptual and Perceptive Quality comprehends the architecture design [intrinsic] quality parameters that define and qualify the project's aesthetics and sensorial aspects: 13. Concept originality, innovation and creativity, 14. Visual, 15. Acoustics; and 16. Other senses: olfaction, tactility, motion perception.

The modes of ecosystem integration observed in the reference case studies, highlight the following connections of these architecture parameters with local ecosystem functions and services, as follows.

13. Concept originality, innovation and creativity

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
	1	Soil formation and fertility	51	Rice/Tree/Burial
	2	Photosynthesis and primary production	121	House Hundertwasser
	3	Nutrient cycling and waste treatment	74	Torre de Especialidades
	4	Water cycling and regulation	100	Water squares
	5	Biodiversity and nursery habitats	76	Makino Museum of Plants and People
		02. REGULATING		
	6	Climatic regulation	238	Dune
	7	Erosion control and hazard protection	114	Palisade Bay
	8	Biological control & pollination	172	The Magic Mountain
	9	Perceptive environmental modulation	38	Roku Museum
		03. PROVISIONING		
	10	Food supply	165	The Allotment
	11	Water purification and fresh water supply	2	Sabo House
	12	Raw materials, ornamental and medicinal resources	69	Stacking Green
		04. CULTURAL		
	13	Significant species and ecosytem values	94	Chashitsu
	14	Landscape aesthetic fruition	99	Loblolly House
	15	Leisure, recreation and psychophysical health	61	ACROS Fukuoka International Hall

Figure 38. Local Ecosystem Integration and Conceptual Perceptive Quality: 13. Concept originality, innovation and creativity

13. Concept originality, innovation and creativity.

The architectural quality values associated with artistic and conceptual valuation, innovation, contemporaneity, logic and purpose are indicated by this parameter.

In the referenced case studies it is possible to observe its predominant reciprocal role with on-site ecosystem services. Collaborative solutions emphasize project decisions at pre-design and design stages, and integration with on-site landscape, lateral and top envelope prevail, although base envelope [setting] and enclosure are also mentioned.

14. Visual

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
●	1	Soil formation and fertility	91	Kitakami Canal Museum
●	2	Photosynthesis and primary production	56	Regional Chamber of Commerce and Industry
●	3	Nutrient cycling and waste treatment	69	Stacking Green
●	4	Water cycling and regulation	186	Queens Botanical Garden Interpretation Center
●	5	Biodiversity and nursery habitats	59	Bird apartment
		02. REGULATING		
●	6	Climatic regulation	28	Miami Perez Art Museum
●	7	Erosion control and hazard protection	175	Mill Creek Canyon Earthworks
●	8	Biological control & pollination	161	K-abeilles Hotel for Bees
●	9	Perceptive environmental modulation	24	Reading room
		03. PROVISIONING		
●	10	Food supply	182	Edible Garden, Canopy Walk and Cascades Garden
●	11	Water purification and fresh water supply	22	Tara House
●	12	Raw materials, ornamental and medicinal resources	212	Europe in Bloom
		04. CULTURAL		
●	13	Significant species and ecosytem values	24	Reading room
●	14	Landscape aesthetic fruition	9	Ando Hiroshige Museum
●	15	Leisure, recreation and psychophysical health	119	Row house

Figure 39. Local Ecosystem Integration and Conceptual Perceptive Quality: 14. Visual

14. Visual.

This quality design indicator is defined by visual aesthetic elements as scale, rhythm and volume, colors and texture, transparency-opaqueness, light-shadow, and framing of exterior and interior views.

In the reference projects it is evident its major reciprocal and also beneficiary role in the collaborative integration with on-site ecosystem services.

The implementation of project options related with this parameter are accentuated at design stage. Surface integration is mostly mentioned regarding lateral and top envelope and on-site landscape, though enclosure is also relevant regarding provisioning services, and possibly also supporting and cultural.

15. Acoustics

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
●	1	Soil formation and fertility	92	Tanpopo [Dandelion] House
○	2	Photosynthesis and primary production		
○	3	Nutrient cycling and waste treatment		
●	4	Water cycling and regulation	191	Shishi-odoshi
●	5	Biodiversity and nursery habitats	227	Marks & Spencer Cheshire Oaks
		02. REGULATING		
○	6	Climatic regulation		
○	7	Erosion control and hazard protection		
○	8	Biological control & pollination		
●	9	Perceptive environmental modulation	199	901 Cherry Offices
		03. PROVISIONING		
○	10	Food supply		
●	11	Water purification and fresh water supply	116	Mãe d'Água Reservatory
●	12	Raw materials, ornamental and medicinal resources	20	Bosco Verticale
		04. CULTURAL		
○	13	Significant species and ecosytem values		
○	14	Landscape aesthetic fruition		
●	15	Leisure, recreation and psychophysical health	61	ACROS Fukuoka International Hall

Figure 40. Local Ecosystem Integration and Conceptual Perceptive Quality: 15. Acoustics

16. Other senses: olfaction, tactility, motion perception

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
●	1	Soil formation and fertility	175	Mill Creek Canyon Earthworks
○	2	Photosynthesis and primary production		
○	3	Nutrient cycling and waste treatment		
●	4	Water cycling and regulation	186	Queens Botanical Garden Interpretation Center
●	5	Biodiversity and nursery habitats	38	Roku Museum
		02. REGULATING		
●	6	Climatic regulation	104	Vine pergolas in South Europe
●	7	Erosion control and hazard protection	175	Mill Creek Canyon Earthworks
●	8	Biological control & pollination	79	Frontier Center for Environmental Symbiosis Technolog
●	9	Perceptive environmental modulation	166	Green Screen Home
		03. PROVISIONING		
●	10	Food supply	182	Edible Garden, Canopy Walk and Cascades Garden
●	11	Water purification and fresh water supply	76	Makino Museum of Plants and People
●	12	Raw materials, ornamental and medicinal resources	67	Cassia Coop Training Center
		04. CULTURAL		
●	13	Significant species and ecosytem values	55	House in Travessa do Patrocínio
●	14	Landscape aesthetic fruition	193	Commerce Square
●	15	Leisure, recreation and psychophysical health	175	Mill Creek Canyon Earthworks

Figure 41. Local Ecosystem Integration and Conceptual Perceptive Quality: 16. Other senses: olfaction, tactility, motion perception

15. Acoustics.

This architectural design parameter encompasses project qualities related to sound reflection, insulation and absorption, sounds from uses and materials.

The referenced case studies indicate some possible collaborative integration between it with on-site ecosystem services, although compared with other parameters, there are less references to this indicator [and also fewer ecosystem services addressed by it]. The existing mentioned connections tend to reciprocal or beneficiary from local ecological services.

The implementation of project options related with this parameter are most evident at design stage. Surface integration is although scattered, is mostly mentioned regarding top envelope and on-site landscape.

16. Other senses: olfaction, tactility, motion perception.

This indicator agglutinates sensorial qualities related with surfaces texture, pavement regularity and steepness and height levels, and scents from materials and uses.

Through the identified reference case studies it is observable its reciprocal role in the collaborative integration with on-site ecosystem services. Collaborative solutions emphasize project decisions at design and less frequently at operation stages, and integration with on-site landscape, lateral and top envelope (although enclosure might be also considered regarding provisioning and cultural services).

6.6 Comfort and Functionality

Comfort and Functionality aggregate the intrinsic architecture design parameters that characterize the project's quality in relation to functional aspects related to occupancy wellbeing and use adequacy: 17. Lighting, 18. Indoor air quality, 19. Humidity and temperature, and 20. Adequacy to function, occupancy and circulation.

The modes of ecosystem integration observed in the reference case studies, highlight the following connections of these architecture parameters with local ecosystem functions and services.

17. Lighting.

This parameter comprises the optimization of natural light sources, and adequacy of luminance to function and comfort levels. Its collaborative integration with on-site ecosystem services is expressed in the reference case studies by its active, reciprocal and passive (beneficiary) role, although relevant connections were not found with the totality of ecological criteria.

The introduction of design options related with this parameter typically occurs at design and operation stages, and surface integration is more frequently mentioned with on-site landscape, lateral envelope and enclosure.

17. Lighting

- DESIGN
- OPERATION

- LANDSCAPE
- LATERAL ENVELOPE
- TOP ENVELOPE
- ENCLOSURE

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
○	1	Soil formation and fertility		
●	2	Photosynthesis and primary production	83	BIQ
●	3	Nutrient cycling and waste treatment	48	Centre for Interactive Research on Sustainability
○	4	Water cycling and regulation		
●	5	Biodiversity and nursery habitats	48	Centre for Interactive Research on Sustainability
		02. REGULATING		
●	6	Climatic regulation	166	Green Screen Home
○	7	Erosion control and hazard protection		
○	8	Biological control & pollination		
●	9	Perceptive environmental modulation	166	Green Screen Home
		03. PROVISIONING		
●	10	Food supply	119	Row house
○	11	Water purification and fresh water supply		
●	12	Raw materials, ornamental and medicinal resources	117	Kanagawa Institute of Technology KAIT workshop
		04. CULTURAL		
●	13	Significant species and ecosytem values	76	Makino Museum of Plants and People
●	14	Landscape aesthetic fruition	80	Nissan Advanced Technology Center
○	15	Leisure, recreation and psychophysical health		

Figure 42. Local Ecosystem Integration and Comfort and Functionality: 17. Lighting

18. Indoor air quality

- DESIGN
- OPERATION

- LANDSCAPE
- LATERAL ENVELOPE
- TOP ENVELOPE
- ENCLOSURE

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
○	1	Soil formation and fertility		
●	2	Photosynthesis and primary production	41	Pasona HQ Urban Farm
●	3	Nutrient cycling and waste treatment	118	APS - Active Phytoremediation System
○	4	Water cycling and regulation		
●	5	Biodiversity and nursery habitats	71	DiGi Technical Office
		02. REGULATING		
●	6	Climatic regulation	113	Jean-Marie Tijbaou Cultural Center
○	7	Erosion control and hazard protection		
○	8	Biological control & pollination		
○	9	Perceptive environmental modulation		
		03. PROVISIONING		
●	10	Food supply	41	Pasona HQ Urban Farm
○	11	Water purification and fresh water supply		
●	12	Raw materials, ornamental and medicinal resources	218	Umow Lai's Melbourne Office
		04. CULTURAL		
○	13	Significant species and ecosytem values		
○	14	Landscape aesthetic fruition		
○	15	Leisure, recreation and psychophysical health		

Figure 43. Local Ecosystem Integration and Comfort and Functionality: 18. Indoor air quality

18. Indoor air quality.

This architectural design indicator addresses project indoor air quality aspects including air renovation, elimination of volatile organic compounds, and filter of dust particles.

Within the referenced cases studies it is perceptible its predominant receptive role with local ecosystem services integration, although relevant connections could not be detected with the totality of ecological criteria.

The referred collaborative solutions emphasize project decisions at design and operation stages, and predominant integration with enclosure (although, lateral and top envelope, and on-site landscape are also mentioned).

19. Humidity and temperature

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
●	1	Soil formation and fertility	112	Iceland turf houses
●	2	Photosynthesis and primary production	118	APS - Active Phytoremediation System
●	3	Nutrient cycling and waste treatment	196	A Recipe To Live
●	4	Water cycling and regulation	108	Real Alcázar of Seville
●	5	Biodiversity and nursery habitats	70	Solaris
		02. REGULATING		
●	6	Climatic regulation	65	Institute for Forestry and Nature Research
○	7	Erosion control and hazard protection		
○	8	Biological control & pollination		
●	9	Perceptive environmental modulation	21	Palmyra House
		03. PROVISIONING		
●	10	Food supply	210	Prince Edward Island Ark
●	11	Water purification and fresh water supply	211	Meandering Greenway
●	12	Raw materials, ornamental and medicinal resources	42	Suginami-ku assembly hall
		04. CULTURAL		
●	13	Significant species and ecosytem values	24	Reading room
○	14	Landscape aesthetic fruition		
●	15	Leisure, recreation and psychophysical health	65	Institute for Forestry and Nature Research

Figure 44. Local Ecosystem Integration and Comfort and Functionality: 19. Humidity and temperature

19. Humidity and temperature.

The present design quality parameter is defined by the hygrothermal comfort through daily and annual cycles within project. In the identified cases it is evident its predominant beneficiary and sometimes reciprocal role in the collaborative integration of on-site ecosystem services.

The application of project options related with this indicator is mentioned particularly at design stage, and also at pre-design and operation stages. The integration with on-site landscape and top envelope are predominant, although lateral envelope, and particularly enclosure are noticeably more frequent than in other parameters average.

20. Adequacy to function, occupancy and circulation

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
●	1	Soil formation and fertility	64	Forestech
○	2	Photosynthesis and primary production		
○	3	Nutrient cycling and waste treatment		
●	4	Water cycling and regulation	233	Infill Aquifer
●	5	Biodiversity and nursery habitats	36	Dancing Trees, Singing Birds
		02. REGULATING		
●	6	Climatic regulation	130	Dormitories for ITRI Southern Taiwan Campus
●	7	Erosion control and hazard protection	89	Research Institute for Humanity and Nature
○	8	Biological control & pollination		
●	9	Perceptive environmental modulation	38	Roku Museum
		03. PROVISIONING		
●	10	Food supply	229	Living Tower
●	11	Water purification and fresh water supply	91	Kitakami Canal Museum
●	12	Raw materials, ornamental and medicinal resources	90	House & Garden
		04. CULTURAL		
●	13	Significant species and ecosytem values	68	Pedras Salgadas Eco-Resort
●	14	Landscape aesthetic fruition	146	Sharp Centre for Design
●	15	Leisure, recreation and psychophysical health	19	Interactive Museum of History

Figure 45. Local Ecosystem Integration and Comfort and Functionality: 20. Adequacy to function, occupancy and circulation

20. Adequacy to function, occupancy and circulation.

This architectural quality indicator comprehends the project's functional and program organization, including the arrangement of circulation flows.

The referenced study cases evidence its predominant reciprocal and active role in the collaborative integration with local ecosystem services. Observed collaborative solutions indicate project decisions at design stage, and surface integration comprises base, lateral and top envelope, with emphasis to on-site landscape, and some potential connections with enclosure.

6.7 Building Construction

Building Construction groups the intrinsic architecture design parameters that define the project's quality regarding its structural and production aspects: 21. Details and finishes, 22. Execution quality and process management, 23. Structure stability and design, 24. Durability & maintenance of systems and materials.

The modes of ecosystem integration observed in the reference case studies, highlight the following connections of these architecture parameters with local ecosystem functions and services, as presented by figures and text.

21. Details and finishes

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
● (orange)	1	Soil formation and fertility	37	House C
● (green)	2	Photosynthesis and primary production	13	Green Cast
● (green)	3	Nutrient cycling and waste treatment	74	Torre de Especialidades
● (orange)	4	Water cycling and regulation	169	Patio de los Naranjos
● (orange)	5	Biodiversity and nursery habitats	5	World Wide Fund Offices
		02. REGULATING		
● (green)	6	Climatic regulation	29	Sony's Osaki Building
○	7	Erosion control and hazard protection		
● (green)	8	Biological control & pollination	71	DiGi Technical Office
● (orange)	9	Perceptive environmental modulation	102	Shimane Arts Center
		03. PROVISIONING		
● (orange)	10	Food supply	93	Nira House
● (green)	11	Water purification and fresh water supply	179	Physalia
● (orange)	12	Raw materials, ornamental and medicinal resources	92	Tanpopo [Dandelion] House
		04. CULTURAL		
● (green)	13	Significant species and ecosytem values	189	Nests in tile roof eaves
● (green)	14	Landscape aesthetic fruition	183	San Telmo Museum Extension
● (green)	15	Leisure, recreation and psychophysical health	36	Dancing Trees, Singing Birds

Figure 46. Local Ecosystem Integration and Building Construction: 21. Details and finishes

22. Execution quality and process management

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
● (green)	1	Soil formation and fertility	204	Burbank Water and Power EcoCampus
● (green)	2	Photosynthesis and primary production	27	Caixa Forum
● (orange)	3	Nutrient cycling and waste treatment	18	Sidwell Friends Middle School
● (green)	4	Water cycling and regulation	163	Bronx Blue-and-Green Roof
● (green)	5	Biodiversity and nursery habitats	226	Welsh Assembly Government Offices
		02. REGULATING		
● (green)	6	Climatic regulation	152	Willow School
● (green)	7	Erosion control and hazard protection	127	Tassafaronga Village
● (green)	8	Biological control & pollination	82	The Shimizu Institute of Technology
○	9	Perceptive environmental modulation		
		03. PROVISIONING		
● (green)	10	Food supply	41	Pasona HQ Urban Farm
● (green)	11	Water purification and fresh water supply	18	Sidwell Friends Middle School
● (green)	12	Raw materials, ornamental and medicinal resources	205	National Exhibition Centre
		04. CULTURAL		
● (green)	13	Significant species and ecosytem values	201	Scenic Hudson's Long Dock Park
● (green)	14	Landscape aesthetic fruition	85	Pola Museum of Art
● (green)	15	Leisure, recreation and psychophysical health	61	ACROS Fukuoka International Hall

Figure 47. Local Ecosystem Integration and Building Construction: 22. Execution quality and process management

21. Details and finishes.

This design quality indicator evaluates the coherence, quality and attributes of details and finishing materials applied in the project. The positive correlations between this factor and on-site ecosystem services are expressed by its active and mutual role towards local ecosystem integration, through adequate detailing and selection of envelope materials and finishes that are supportive of different ecological functions [including living walls and roofs, landscape ground cover surfaces, application of nanomaterials, integration of nests and shelters, water surfaces, cladding materials properties and species selection]. The relevant project life-cycle stages for application of these strategies include design, operation and potentially, construction, while surface design integration is equally relevant at lateral and top envelope and on-site landscape.

22. Execution quality and process management.

The precision of construction methods, on-site management during life cycle and quality control employed in the project are addressed by this design parameter. In the identified reference case studies it is apparent its predominant active role in the collaborative integration with on-site ecosystem services. The life-cycle phases emphasized for application of collaborative measures with this parameter are predominantly construction and operation stages. The spatial integration of these measures encompasses lateral and top envelope, and on-site landscape [although enclosure is also referenced within supporting and provisioning ecosystem services].

23. Structure stability and design

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
●	1	Soil formation and fertility	6	VanDusen Botanical Garden Visitor Centre
●	2	Photosynthesis and primary production	121	House Hundertwasser
●	3	Nutrient cycling and waste treatment	231	Propagate Skyscraper
●	4	Water cycling and regulation	62	Bay Education Center
●	5	Biodiversity and nursery habitats	61	ACROS Fukuoka International Hall
		02. REGULATING		
●	6	Climatic regulation	98	Kagoshima Museum of Environment
●	7	Erosion control and hazard protection	76	Makino Museum of Plants and People
○	8	Biological control & pollination		
●	9	Perceptive environmental modulation	126	Habitat 67
		03. PROVISIONING		
●	10	Food supply	221	60 Richmond Housing Cooperative
○	11	Water purification and fresh water supply		
●	12	Raw materials, ornamental and medicinal resources	139	Trees Building for ABBANK
		04. CULTURAL		
●	13	Significant species and ecosytem values	35	Crystal Palace
●	14	Landscape aesthetic fruition	187	Marine and Freshwater Resources Institute
●	15	Leisure, recreation and psychophysical health	122	Thermal Village Blumau Rolling Hills

Figure 48. Local Ecosystem Integration and Building Construction: 23. Structure stability and design

23. Structure stability and design.

The structure design quality and its resistance to regular use and loads are addressed within the present architecture parameter, Structure stability and design.

In the compiled reference database, the identified correlations between this parameter and the provision of on-site ecosystem services are indicative of its active and sometimes mutual role. Collaborative solutions emphasize project options relevant at design and construction stages, and integration with lateral, base and tope envelope [on-site landscape is less significant in this case].

24. Durability & maintenance of systems and materials

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS		Reference Project [Sample]
		01. SUPPORTING		
●	1	Soil formation and fertility	170	Moos Water filtration plant
●	2	Photosynthesis and primary production	164	California Academy of Sciences
○	3	Nutrient cycling and waste treatment		
○	4	Water cycling and regulation		
●	5	Biodiversity and nursery habitats	164	California Academy of Sciences
		02. REGULATING		
○	6	Climatic regulation		
●	7	Erosion control and hazard protection	89	Research Institute for Humanity and Nature
●	8	Biological control & pollination	113	Jean-Marie Tijbaou Cultural Center
●	9	Perceptive environmental modulation	199	901 Cherry Offices
		03. PROVISIONING		
●	10	Food supply	115	New York City Steady State
○	11	Water purification and fresh water supply		
●	12	Raw materials, ornamental and medicinal resources	64	Forestech
		04. CULTURAL		
○	13	Significant species and ecosytem values		
○	14	Landscape aesthetic fruition		
○	15	Leisure, recreation and psychophysical health		

Figure 49. Local Ecosystem Integration and Building Construction: 24. Durability & maintenance of systems and materials

24. Durability & maintenance of systems and materials.

This architectural parameter is qualified by project long life cycles of systems and materials, ease of substitution or repair, and local maintenance.

Relatively to other architecture indicators, few positive interactions between this parameter and ecosystem services and functions were indicated by the examined project sources. In those cases, the role of this indicator is beneficiary or mutual regarding collaborative integration with on-site ecosystem services. Applicable options are mostly relevant at design and operation stages, and surface integration is referred predominantly towards on-site landscape, lateral and top envelope. [No indicated references for cultural services integration was noted.]

6.8 Cumulative Results

In this section are described the total results obtained in reference database. From the correlation framework, resulted a matrix of 360 possible correlations, from which the referred study cases presented 308 possible positive collaborative interaction, and 52 non-identified positive correlations. Through this analysis, it was evidenced criteria, within ecosystem functions and services and architecture design parameters with greater potential explored through the selection of study cases, regarding ecosystem design integration, whose combined results are represented in the following Figure 50.

ARCHITECTURE QUALITY PARAMETERS / LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	01. SUPPORTING	1 Soil formation and fertility	2 Photosynthesis and primary production	3 Nutrient cycling and waste treatment	4 Water cycling and regulation	5 Biodiversity and nursery habitats	02. REGULATING	6 Climatic regulation	7 Erosion control and hazard protection	8 Biological control & pollination	9 Perceptive environmental modulation	03. PROVISIONING	10 Food supply	11 Water purification and fresh water supply	12 Raw materials, ornamental and medicinal resources	04. CULTURAL	13 Significant species and ecosytem values	14 Landscape aesthetic fruition	15 Leisure, recreation and psychophysical health
01. MACRO-LOCAL RELATIONS																			
1 Adaption to eco-physical values and restraints		34	215	201	237	85		144	114	200	36		32	180	53		72	1	175
2 Sense of place and cultural identity		112	107	215	147	140		108	53	194	104		222	39	110		103	113	88
3 Transports and functional articulation w/ context		1	31	178	207	72		47	109	o	143		132	219	155		202	173	141
02. ENVIRONMENTAL BALANCE																			
4 Energy cycle [and atmospheric emissions]		164	16	185	154	70		239	o	o	48		223	129	42		24	106	167
5 Water cycle [and effluents]		2	198	220	18	40		76	232	147	186		14	7	49		187	66	100
6 Materials cycle [and waste]		120	37	101	203	8		204	238	227	o		115	198	15		62	202	o
7 Exterior areas and local pollution control		73	167	73	130	38		239	240	86	23		124	40	25		60	50	39
8 Sustainable life-style support systems		63	142	58	143	47		32	44	125	47		222	198	77		206	141	224
03. SOCIO-ECONOMIC RELEVANCE																			
9 Customization possibilities and operation		o	188	42	209	209		97	o	194	174		162	o	107		145	126	87
10 Community participation and user's satisfaction		214	235	201	235	168		150	240	131	42		214	39	95		53	200	236
11 Economic dynamics and lifecycle costs		158	o	207	163	145		152	89	135	69		188	152	181		159	50	31
12 Human health and well-being		o	136	17	235	30		81	109	194	157		41	210	137		76	80	234
04. CONCEPT & PERCEPTIVE QUALITY																			
13 Concept originality, innovation and creativity		51	121	74	100	76		238	114	172	38		165	2	69		94	99	61
14 Visual		91	56	69	186	59		28	175	161	24		182	22	212		24	9	119
15 Acoustics		92	o	o	191	227		o	o	o	199		o	116	20		o	o	61
16 Other senses: olfaction, tactility, motion perception		175	o	o	186	38		104	175	79	166		182	76	67		55	193	175
05. COMFORT AND FUNCTIONALITY																			
17 Lighting		o	83	48	o	48		166	o	o	166		119	o	117		76	80	o
18 Indoor air quality		o	41	118	o	71		113	o	o	o		41	o	218		o	o	o
19 Humidity and temperature		112	118	196	108	70		65	o	o	21		210	211	42		24	o	65
20 Adequacy to function, occupancy and circulation		64	o	o	233	36		130	89	o	38		229	91	90		68	146	19
06. BUILDING CONSTRUCTION																			
21 Details and finishes		37	13	74	169	5		29	o	71	102		93	179	92		189	183	36
22 Execution quality and process management		204	27	18	163	226		152	127	82	o		41	18	205		201	85	61
23 Structure stability and design		6	121	231	62	61		98	76	o	126		221	o	139		35	187	122
24 Durability & maintenance of systems and materials		170	164	o	o	164		o	89	113	199		115	o	64		o	o	o

Figure 50. Cumulative Results of the Reference Database presented in TI[L]ES Table

Some of the positive correlations between architecture quality parameters and local ecosystem services that are more recurrent in the general set of study cases are for instance: associations between water and effluents [A5] and biodiversity and nursery habitats [E5], nutrient cycling and waste treatment [E3] and raw materials, ornamental and medicinal resources [E12], and water purification [E11], through forms of stormwater retention and purification, bioremediation of effluents [either in wetlands or indoor living machines], and xeriscaping.

Even though, the cumulative results of the study case references indicate however that ecosystem functions and services present a considerable correlation rate with architecture design parameters. Most of the indicators can be related with more than half of the architecture quality parameters. An emphasis is noticed on provisioning services, denoting possibly not only the capacity of several architecture design parameters to increase their production, but also their fundamental importance into architectural criteria at diverse levels. Cultural services are understandably more promoted through architecture criteria than the inverse, in urban areas. Denoting possible constraints of micro urban scale and inherent land uptake in urban ecosystems, diverse functions associated with soil formation and fertility, erosion control and nutrient cycling score the lowest collaborative interactions with design parameters.

Regarding architecture quality parameters, relevant correlations are found in the ones related to macro local relations, environmental balance, and perceptive and conceptual quality. Socio-economic relevance, comfort and functionality and building construction areas present a higher fluctuation, through individual indicator. Environmental sustainability and comfort parameters present a high degree of potential cooperation, either in ecosystem and architectural assistance directions. Simultaneously, the design strategies of building envelope surface and form, usage of materials, and community involvement assume relevance to provide and restore additional ecosystem functions, by water and greenery surfaces, habitat provision, and collaboration with provisioning and regulating processes.

Among the total referenced study cases, were registered 308 *Identified Positive Correlations* within the Ti[l]es matrix, corresponding to 85,6% of the total 360 criteria intersections. [From these resulting 52 *Not Identified Positive Correlations,* corresponding to 14,4% of the Ti[l]es framework].
Although, *all* the architecture design parameters and *all* the local ecosystem services and functions may be involved in ecosystem integration, only 8 architecture design parameters [1/3 of total] present positive correlations with all ecosystem services: A1-Adaption to eco-physical values and restraints, A2- Sense of place and cultural identity; A5- Water cycle [and effluents]; A7-Exterior areas and local pollution control; A8- Sustainable life-style support systems; A10- Community participation and user's satisfaction; A13- Concept originality, innovation and creativity; and A14- Visual. These parameters emphasize extrinsic architecture design parameters, as Macro-Local Relations and Environmental Balance, and to a lesser extent Socio-

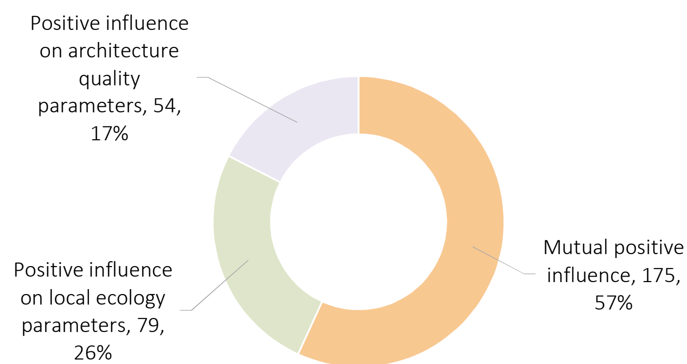
Economic Balance and Concept and Perceptive Quality areas.

Regarding local ecosystem services, only 2 of them [E5-Biodiversity and nursery habitats and E12- Raw materials, ornamental and medicinal resources], from Supporting and Provisioning function areas, present positive correlations with all architecture design parameters.

In general terms, the variation of the percentage of positive correlations found among the reference database, through architectural design quality and local ecosystem services classification areas emphasize lower results towards Comfort and Functionality, and Regulating ecosystem services, as presented in the following Figures 51 and 52.

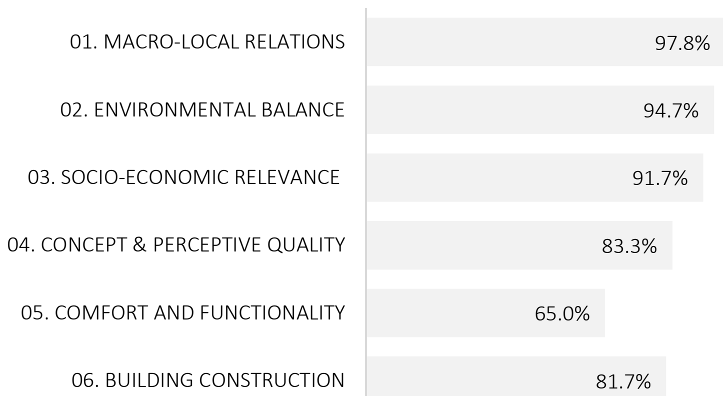
Positive Correlations in Reference Database

Positive correlations characterization:



Positive Correlations in Reference Database

1) in Architecture Quality Areas:



2) in Local Ecosystem Classes:

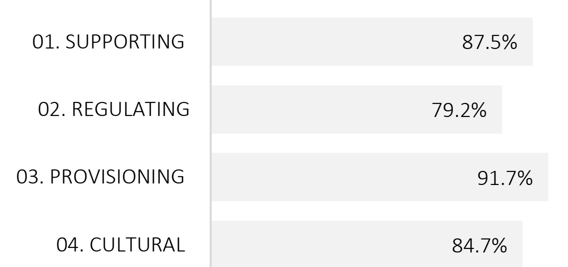
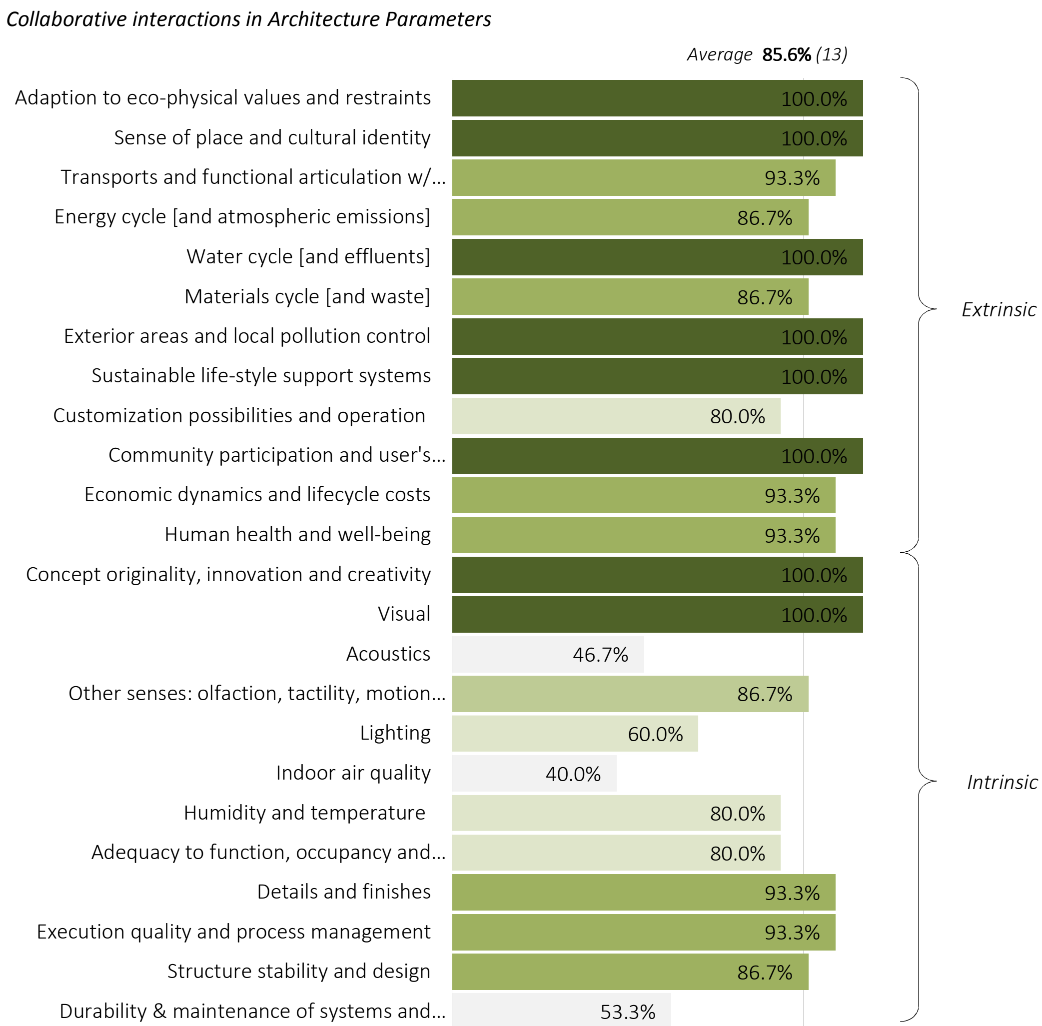


Figure 51. Reference Database Cumulative Results



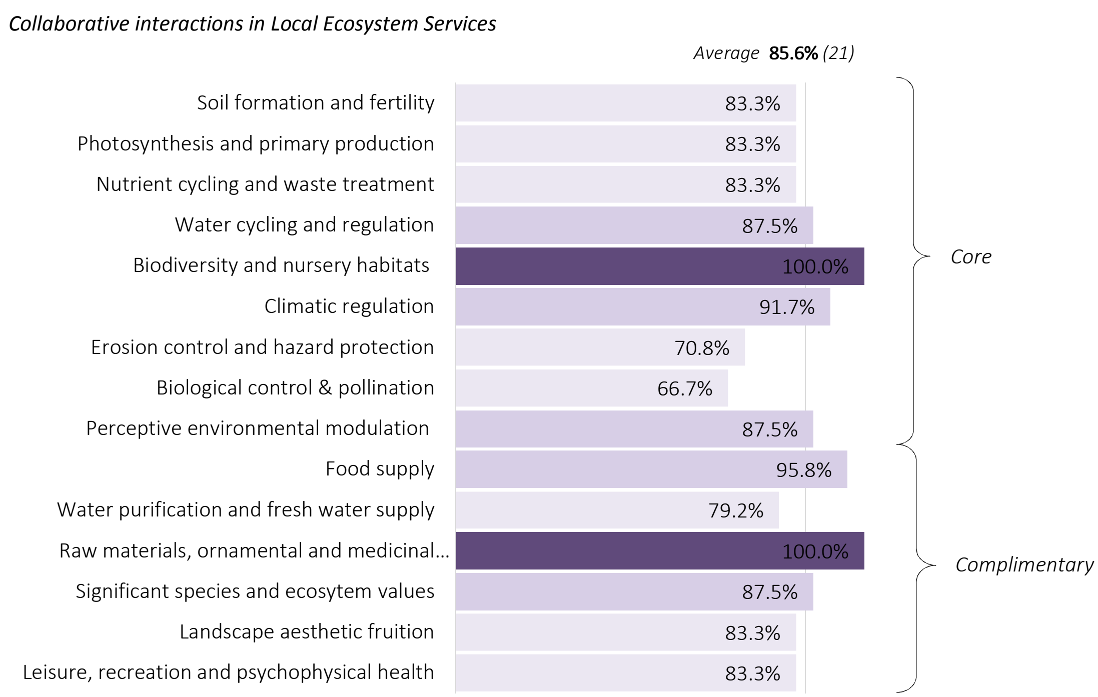


Figure 52. Reference Database Cumulative Results: number of collaborative interactions per individual criteria

7.1 General Reference Case Studies Characterization

The referenced projects align mainly with 3 regional focus: Europe, North America and Japan/Australia [developed countries with prevalence of environmental assessment methods]. Other less numerous cases "orbit" geographically around these, in emerging and developing countries in Asia, Africa, and Pacific, forming 3 geographical clusters 1. America-Pacific; 2. Europe-Africa-Middle East; 3. South and East Asia-Oceania.

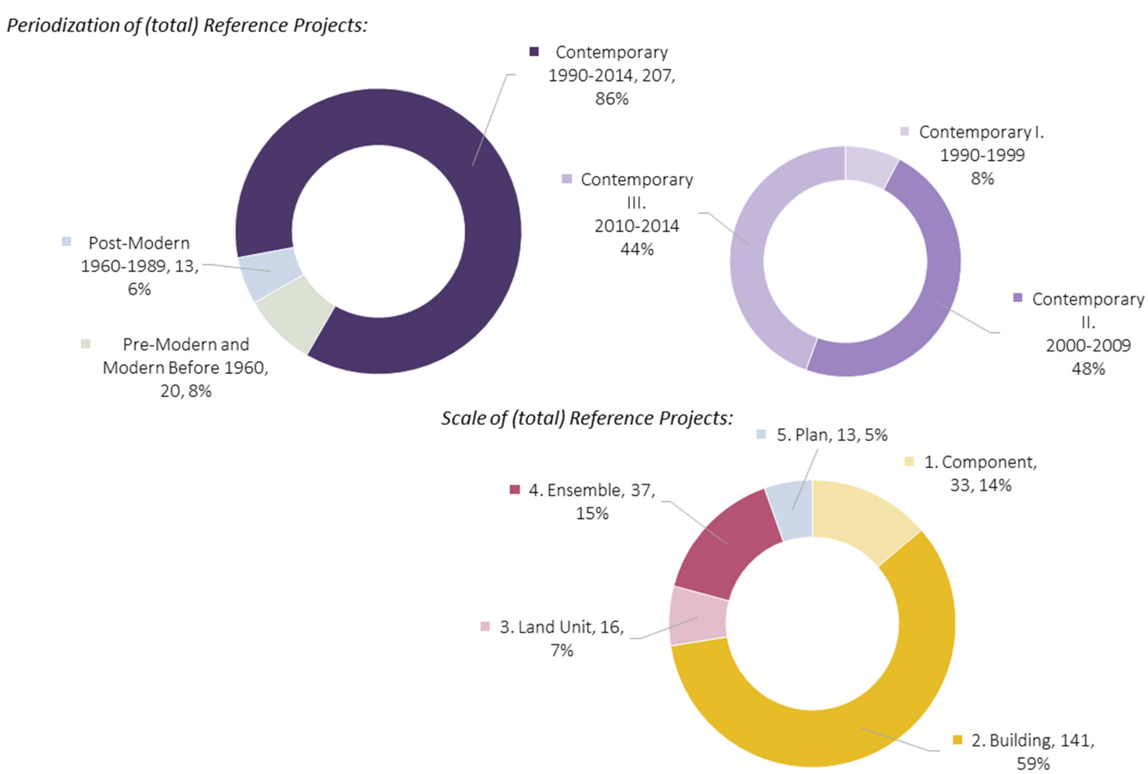


Figure 53. Periodization, Project Scale and Use|Function of the totality of Reference Projects

The overall portrait of the general reference study cases, regarding periodization, scale and function are shown in the Figures 53-56.

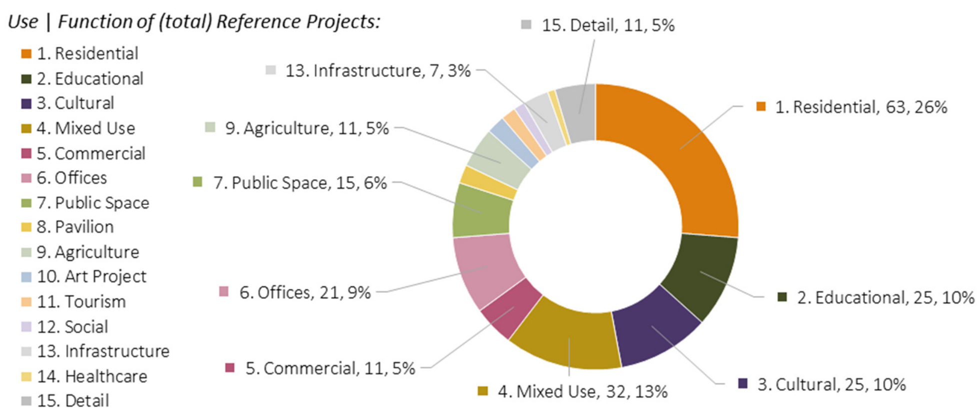


Figure 54. Use|Function of the totality of Reference Projects

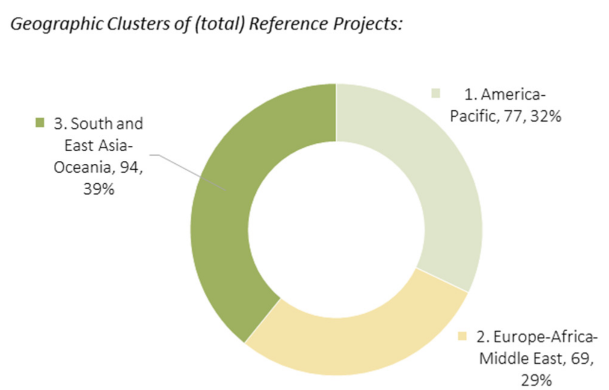


Figure 55. Geographical Location [clusters] of the totality of Reference Projects

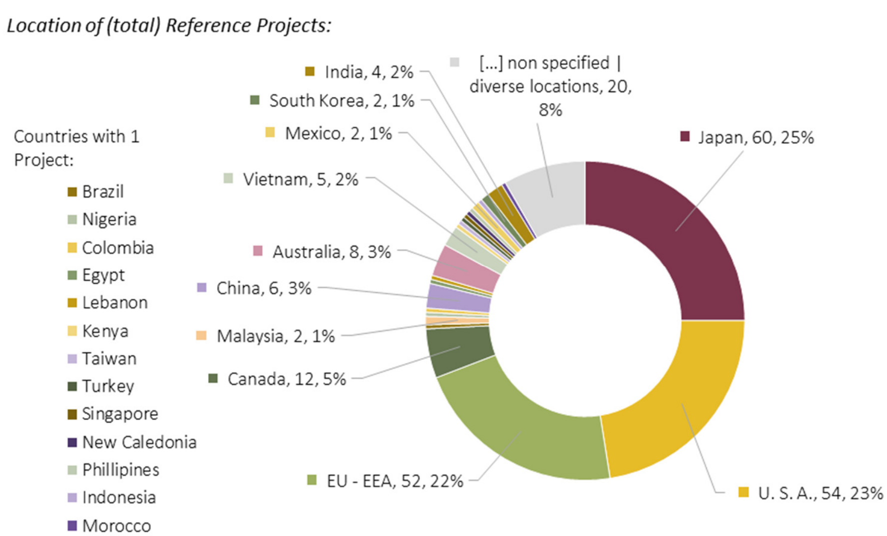


Figure 56. Geographical Location [countries] of the totality of Reference Projects

On Figure 56, it is observable the relative importance of projects located in Japan, within other locations, with emphasis on the United States of America and countries of the European Union - European Economic Area. Due to a diversity of reasons, including sources and socio-economic development context, the majority of all the reference study cases are located in the northern hemisphere. Regarding the international contemporary building and ensembles projects [built or designed from 1990-2014] used in this study, their general characterization, regarding periodization, concretization, scale, function, and environmental assessment is depicted in Figure 57.

Figure 57. Overall Characterization of the Reference Study Cases

Regarding their concretization, the referenced samples of collaborative interactions are predominantly realized building projects, however this selection also includes non-built references. Typically, non-built projects fall into 2 different categories: an idealistic-visionary one, and a detailed more practical oriented one. In both cases, the focus of architectural relation with ecosystem services tends to generically emphasize aspects related with environmental balance, even though the project is communicated with a strong visual-form character, few describe interactions with other sensorial or perceptive aspects, or even with comfort, construction, and social parameters.

Regarding the objectivity and quantitative environmental back-up analysis of its ecosystem services integration, the examined study cases are of three types: Environmental Assessment Certified Project [Contemporary, Built, and Certified]; Speculative Future Visions [Non Built, Non certified, and with idealized technologies], and Intermediate cases [Built, Contemporary, Non certified]. In the context of local ecosystem integration, what differentiates an environmental or sustainability certified project is its overall accountancy of environmental impacts across lifecycle, of each the support or benefits towards local ecosystem services is just a part.

Regarding their relation with local ecosystem services, the majority of the reference projects evidenced specific positive interactions with local ecology but few combine multiple synergies for overall ecosystem regeneration. The nature of these integrations seems, frequently, to define a theme for each project, which is conductive to trace affinities or typological groups between them: simulation and substitution of ecosystem services [with different focus on regulating and supporting services], remediation [with emphasis on supporting services, as soil, nutrient and water cycles, habitats, and also erosion and hazard protection], reproduction of biotopes [with diverse forms of surface integration, including landscape and green roofs, with or without assistance to water management, addition of thermal mass and other benefits to building environmental performance, and other extrinsic and intrinsic design quality parameters], enclosed reproduction of biotopes [as arks], and preservation of existing local ecological elements and services [with resource to layout and setting decisions], among others.

Dissecting the diverse design and project approaches of ecosystem integration found in the reference database, were determined as primary modes of local ecosystem services integration: *emulation* [substitution or mimicry of ecological services and functions through artificial systems], *preservation* [conservation of local existing eco-services], *regeneration* [improvement of local ecological functions and services], *fruition* [use of on-site ecological resources for project benefit; ex. materials, landscape], *support* [creation of specific conditions for the provision of specific eco-system services; ex. green walls, urban farms] *reproduction* [approximate reproduction of natural habitats]. From the combination of these diverse modes may finally emerge *cooperation* [mixed use solutions for fruition, support and regeneration]. An example of modes of local ecosystem services integration found in some of the contemporary projects in Japan are depicted on Figure 58.

CODE	Project Name	Author	Mode	Supporting	Regulating	Provisioning	Cultural	[Surface] Integration
1	Okinawa Institute of Science and Technology	**Nikken Sekkei** + Kornberg Associates	➨PRESERVATION REGENERATION SUPPORT ➨FRUITION REPRODUCTION EMULATION	■	□	□	■	➨base envelope lateral envelope top envelope enclosure ➨landscape
2	Sabo House	**Nikken Sekkei** [Environmental Design Competition]	PRESERVATION REGENERATION ➨SUPPORT ➨FRUITION REPRODUCTION ➨EMULATION	■	■	□		➨base envelope ➨lateral envelope top envelope ➨enclosure landscape
30	Setagaya-ku Fukasawa Symbiotic Housing Complex	**Iwamura Atelier**	PRESERVATION ➨REGENERATION ➨SUPPORT ➨FRUITION REPRODUCTION EMULATION	■	■	■	□	base envelope ➨lateral envelope ➨top envelope enclosure ➨landscape
36	Dancing Trees, Singing Birds	**Hiroshi Nakamura**	PRESERVATION REGENERATION ➨SUPPORT ➨FRUITION REPRODUCTION EMULATION	□	■		■	base envelope ➨lateral envelope top envelope enclosure ➨landscape
41	Pasona Group Urban Farm	**KONO Designs**	PRESERVATION REGENERATION ➨SUPPORT ➨FRUITION REPRODUCTION EMULATION		□	■	□	base envelope ➨lateral envelope ➨top envelope ➨enclosure landscape
61	ACROS Fukuoka Prefectural International Hall	**Emilio Ambasz + Nihon Sekkei** Landscape Architecture: Takenaka Corporation	PRESERVATION REGENERATION ➨SUPPORT FRUITION ➨REPRODUCTION EMULATION	■	□	□	■	base envelope ➨lateral envelope ➨top envelope enclosure landscape
76	Makino Museum of Plants and People	**Naito Architects and Associates** + Takenaka corporation	➨PRESERVATION ➨REGENERATION SUPPORT ➨FRUITION ➨REPRODUCTION EMULATION	■	■	□	■	➨base envelope lateral envelope top envelope enclosure ➨landscape
82	The Shimizu Institute of Technology, urban research center	**Shimizu Corporation**	PRESERVATION REGENERATION ➨SUPPORT ➨FRUITION ➨REPRODUCTION EMULATION	■	■	□	□	base envelope ➨lateral envelope ➨top envelope enclosure ➨landscape
89	Research Institute for Humanity and Nature	**Nikken Sekkei**	➨PRESERVATION ➨REGENERATION SUPPORT ➨FRUITION REPRODUCTION EMULATION	□	■	□	□	➨base envelope lateral envelope top envelope enclosure landscape
119	Row house	**Junya Ishigami**	PRESERVATION REGENERATION ➨SUPPORT ➨FRUITION REPRODUCTION EMULATION	□		■	□	base envelope lateral envelope top envelope ➨enclosure ➨landscape
150	Kurimoto Millennium City	**Hiroshi Iguchi** Fifth World Architects	➨PRESERVATION REGENERATION ➨SUPPORT ➨FRUITION ➨REPRODUCTION EMULATION	■	■	□		base envelope lateral envelope top envelope ➨enclosure ➨landscape
166	Green Screen Home	**Hideo Kumaki Architect Office**	PRESERVATION REGENERATION ➨SUPPORT ➨FRUITION REPRODUCTION EMULATION	□	■	□	□	base envelope ➨lateral envelope top envelope enclosure landscape

Figure 58. Modes of local ecosystem services integration in diverse contemporary projects in Japan

Within the Japanese context, were included among the reference database 45 contemporary building projects case studies. In addition to these 45, other 15 complementary references, comprehending non contemporary architecture, vernacular strategies, components and large scale urban planning projects were also used for contextualization. The total number of projects within the territory of Japan that were included in the main database was 60, depicted on Figures 60 and 61. The characterization of the 45 contemporary building and ensemble projects, considered in the study, is represented in the Figure 59.

Figure 59. Characterization of Contemporary Reference [Building and Ensembles] Projects in Japan

Periodization of Reference Projects in Japan:

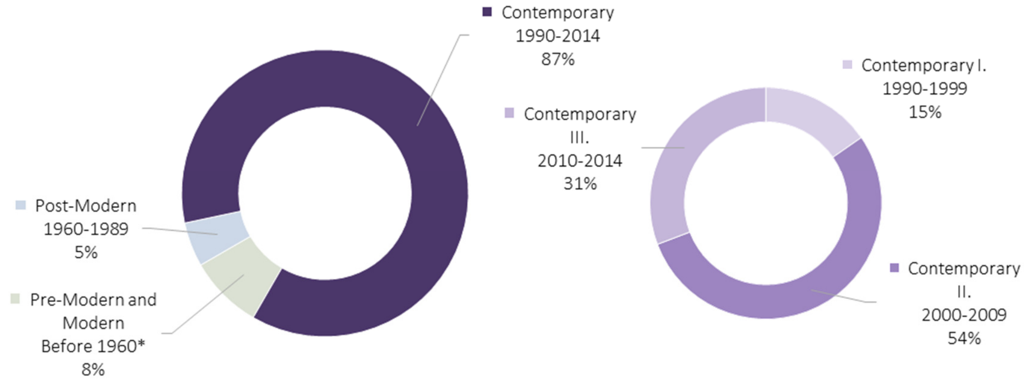


Figure 60. Periodization of the totality of Reference Projects in Japan

Scale of Reference Projects in Japan:

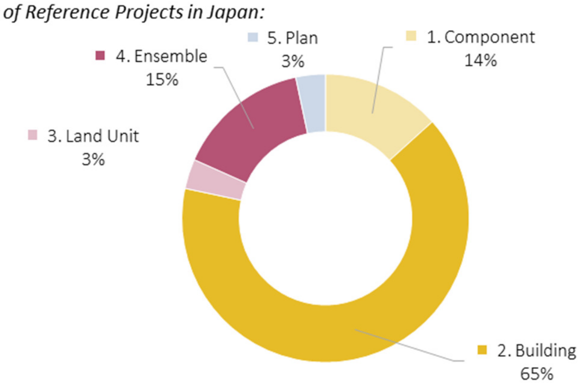


Figure 61. Scale of the totality of Reference Projects in Japan

7.2 Case 1. Dancing Trees, Singing Birds

Figure 62. Dancing Trees, Singing Birds

Dancing Trees, Singing Birds is a private housing complex, located in Meguro ward, a central urban area in Tokyo. The project was designed by Hiroshi Nakamura & NAP Architects, and the construction of the building was completed in 2007. The structure, made of reinforced concrete and steel, has three floors above ground, and accommodates six individual apartments (targeted at upper class tenants). The project doesn't have an environmental assessment certification, and was featured at several international design magazines (Darco Magazine, in 2010; Detail [Japan], in 2007, and Detail [international] in 2009; Metropolis, in 2008), besides being portrayed in the digital portal ArchDaily in 2012, and in Nakamura's own monography *Microscopic Designing Methodology* (2010).

The building is withdrawn to the interior of the plot boundaries, and most of its landscape views face the south-east boundary – where a tree grove occupies a narrow stretch of steep slope terrain -, opposite to the street entrance, or towards itself, through interior facing terraces. The most distinct portrayed characteristic of the project is its south-east façade, cladded in wood, and composed by several irregular protruding volumes, that appear immerse "in the forest", among tree branches and a dense leave canopy.

The project is located in urban context, among urban center area (transept T5). The property is situated in a residential secondary street, with isolated buildings ranging typically from 2 floors above ground, and with an increasing slope towards south-southwest. It belongs to the *satoyama* ecosystem cluster of Kanto-Chubu. The context ecosystem structure is essentially urban, in the vicinity of coastal urbanized areas. Habitat connectivity features include the tree grove along the south limit "valley" of the site, and urban vegetation [private gardens, street trees, balconies, and "green walls"]. Despite its location on a central urban area, inside the lot, it is easily perceptible the existence of diverse insects [mosquitos, cicada, ants and butterflies] and small vertebrates [including birds].

Figure 63. Context and Setting of the project Dancing Trees, Singing Birds

Figure 64. Site Plan of the project Dancing Trees, Singing Birds

Some of the stated design interpretations of local ecosystem, that were found on press release and media reviews and articles about the *Dancing Trees, Singing Birds* project were the following:

- Preservation and proximity to the existent tree grove [with more than 20m high], inside and outside the site area
- Allocation of 6 birdhouses [for *parus major*] on the wooden façade
- Structure and circulation design attending to roots of trees and to branch movement in case of strong winds
- Landscape influence on volume shape [interplay with trees], material textures, and visual mimic between birdhouses and huts
- Immersion in nature, for users: protruding "huts" close to the trees, semi-outdoor spaces, and landscape views from the interior
- Knowledge and environmental education opportunities
- Architecture concept of cohabitation of habitat species [trees, humans, birds]

- Water features [outdoor pool and pond] on ground and first floor: reflections and cooling breeze to apartments
- Patch of balcony greenery on rooftop
- Semi-pervious pavement on access areas

Figure 65. Aspects of the project Dancing Trees, Singing Birds
[From top left to bottom right: a) entrance, b) south view, c) huts, d) north limit, e-g) details of fence, birdhouse and apartment entrance, h) outdoor pool, i) tree grove on south limit]

The architectural design integration of ecosystem services and functions, within the plot, is translated into the project, through setting and volume configuration, with consequences to circulation, and guided by structure design, framing and views, and program articulation. The result of site specific research and poetic concept translates into an iconic design.

Below it is provided a brief summary of the analysis of architectural quality parameters, its relevance and design options that relate with local ecosystem services:

a) *Macro-local relations.*

A1 Adaptation to Eco-Physical Values & Restraints: Building setting and footprint.

A2 Sense of Place and Cultural Identity: Immersion in landscape [trees] + proximity to living spaces.

A3 Functional Articulation with Context: Not relevant.

b) *Environmental Balance.*

A4 Energy Cycle [and Atmospheric Emissions]: Role of vegetation to filter direct sunlight and provide insulation buffer.

A5 Water Cycle [and Effluents]: Not relevant.

A6 Materials Cycle [and Waste]: Cladding materials for landscape integration.

A7 Exterior Areas and Local Pollution: All landscape organization and amenities.

A8 Sustainable Life-Style Support: Laundry lines in some open air spaces + gardening terrace.

c) *Socio-Economic Relevance*.

A9 Customization and Operation: Not relevant.

A10 Community Participation and User Satisfaction: No information.

A11 Economic Dynamics and Lifecycle Costs: Influence of qualified green and landscape areas in real estate.

A12 Human Health and Well Being: Positive effects on human health from air purification, sights, and other contact with natural elements.

d) *Concept & Perceptive Quality*.

A13 Concept Originality and Innovation: Building design and concept [nests and huts around the trees].

A14 Visual: Volumes, views and landscape framing + pervious pavement design.

A15 Acoustics: Intentional proximity of trees [habitat support features] for appreciation of biotic and abiotic sounds.

A16 Olfaction, Tactility & Motion Perception: Smell of trees, movement of branches and leaves.

e) *Comfort and Functionality*.

A17 Lighting: Filter of light through tree canopy.

A18 Indoor Air Quality: Not relevant.

A19 Humidity and Temperature: Effects of micro-climate control [through dense vegetation] into more stable ground temperatures.

A20 Adequacy to Function, Occupancy & Circulation: Building spatial organization and setting.

f) *Building Construction*.

A21 Details and Finishes: Pervious pavement + Bird boxes + Cladding.

A22 Execution Quality & Process Management: No information.

A23 Structure Stability and Design: Structure design to not interfere with branches and roots and yet stay near to trees, and provide outdoor leisure areas [terrace, balconies and water surfaces].

A24 Durability & Maintenance: No information.

The results from the collected data are represented in the following figures 66-68, representing respectively the Integration Results in TI[L]ES Table, the Visualization of TI[L]ES Results – Interactions between Local ecosystem services and Architecture Quality and the numerical TI[L]ES Results expressing : Number, Diversity and Range.

- 🟠 Mutual positive influence
- 🟢 Positive influence on local ecology parameters
- 🟣 Positive influence on architecture quality parameters
- ○ Not relevant
- _ No information
- ● Relevant parameter

ARCHITECTURE QUALITY PARAMETERS	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS																		
	01. SUPPORTING	1 Soil formation and fertility	2 Photosynthesis and primary production	3 Nutrient cycling and waste treatment	4 Water cycling and regulation	5 Biodiversity and nursery habitats	02. REGULATING	6 Climatic regulation	7 Erosion control and hazard protection	8 Biological control & pollination	9 Perceptive environmental modulation	03. PROVISIONING	10 Food supply	11 Water purification and fresh water supply	12 Raw materials, ornamental and medicinal resources	04. CULTURAL	13 Significant species and ecosytem values	14 Landscape aesthetic fruition	15 Leisure, recreation and psychophysical health
01. MACRO-LOCAL RELATIONS		●	●	●	●	●		●	●	_	●		_	○	●		●	●	●
1 Adaption to eco-physical values and restraints	●	🟠	🟢	🟢	○	🟠		🟢	_	_	🟢		_	○	🟢		🟠	🟠	○
2 Sense of place and cultural identity	●	○	○	○	○	🟣		○	○	_	🟠		_	○	🟣		🟣	🟣	🟣
3 Transports and functional articulation w/ context	○	○	○	○	○	○		○	○	_	○		_	○	○		○	○	○
02. ENVIRONMENTAL BALANCE																			
4 Energy cycle [and atmospheric emissions]	●	○	🟣	○	○	○		🟣	○	○	🟣		_	○	🟣		_	○	○
5 Water cycle [and effluents]	○	○	○	○	○	○		○	○	_	○		_	○	○		○	○	○
6 Materials cycle [and waste]	●	○	○	○	○	○		○	○	_	○		_	○	○		○	🟢	○
7 Exterior areas and local pollution control	●	🟢	🟠	🟠	🟢	🟠		🟠	🟣	_	🟣		_	○	🟢		🟠	🟠	🟢
8 Sustainable life-style support systems	●	○	○	○	○	○		○	○	_	○		_	○	○		○	🟠	_
03. SOCIO-ECONOMIC RELEVANCE																			
9 Customization possibilities and operation	○	○	○	○	○	○		○	○	_	○		_	○	○		○	_	_
10 Community participation and user's satisfaction	_	_	_	_	_	_		_	_	_	_		_	○	_		_	_	_
11 Economic dynamics and lifecycle costs	●	○	○	○	○	_		○	○	_	_		_	○	_		_	🟣	○
12 Human health and well being	●	○	🟣	🟣	○	🟣		🟣	○	_	🟣		_	○	🟣		🟣	🟣	🟣
04. CONCEPT & PERCEPTIVE QUALITY																			
13 Concept originality, innovation and creativity	●	○	🟠	🟠	○	🟠		🟢	○	_	🟠		_	○	🟠		🟠	🟠	🟠
14 Visual	●	○	🟣	○	🟠	🟠		○	○	_	🟣		_	○	🟠		🟠	🟣	🟠
15 Acoustics	●	○	○	○	_	🟣		○	○	○	_		○	○	_		○	○	_
16 Other senses: olfaction, tactility, motion perception	●	○	○	○	○	🟣		○	○	_	🟣		_	○	_		🟣	_	_
05. COMFORT AND FUNCTIONALITY																			
17 Lighting	●	○	○	○	○	○		○	○	_	🟣		_	○	🟣		○	🟣	○
18 Indoor air quality	○	○	○	○	○	○		○	○	_	○		_	○	○		○	○	○
19 Humidity and temperature	●	○	○	○	○	○		🟣	○	_	🟣		_	○	🟣		○	○	○
20 Adequacy to function, occupancy and circulation	●	○	🟢	🟢	○	🟠		○	🟢	_	🟣		_	○	🟢		🟢	🟢	🟢
06. BUILDING CONSTRUCTION																			
21 Details and finishes	●	○	○	○	🟢	🟢		○	○	_	○		_	○	○		🟢	🟢	🟢
22 Execution quality and process management	_	_	_	_	_	_		_	_	_	_		_	○	_		_	_	_
23 Structure stability and design	●	○	○	○	○	🟠		_	🟣	_	○		_	○	🟠		🟠	🟠	🟢
24 Durability & maintenance of systems and materials	_	_	_	_	_	_		_	_	_	_		_	○	_		_	_	_

Figure 66. *Dancing Trees, Singing Birds* Design Integration Results in TI[L]ES Table.

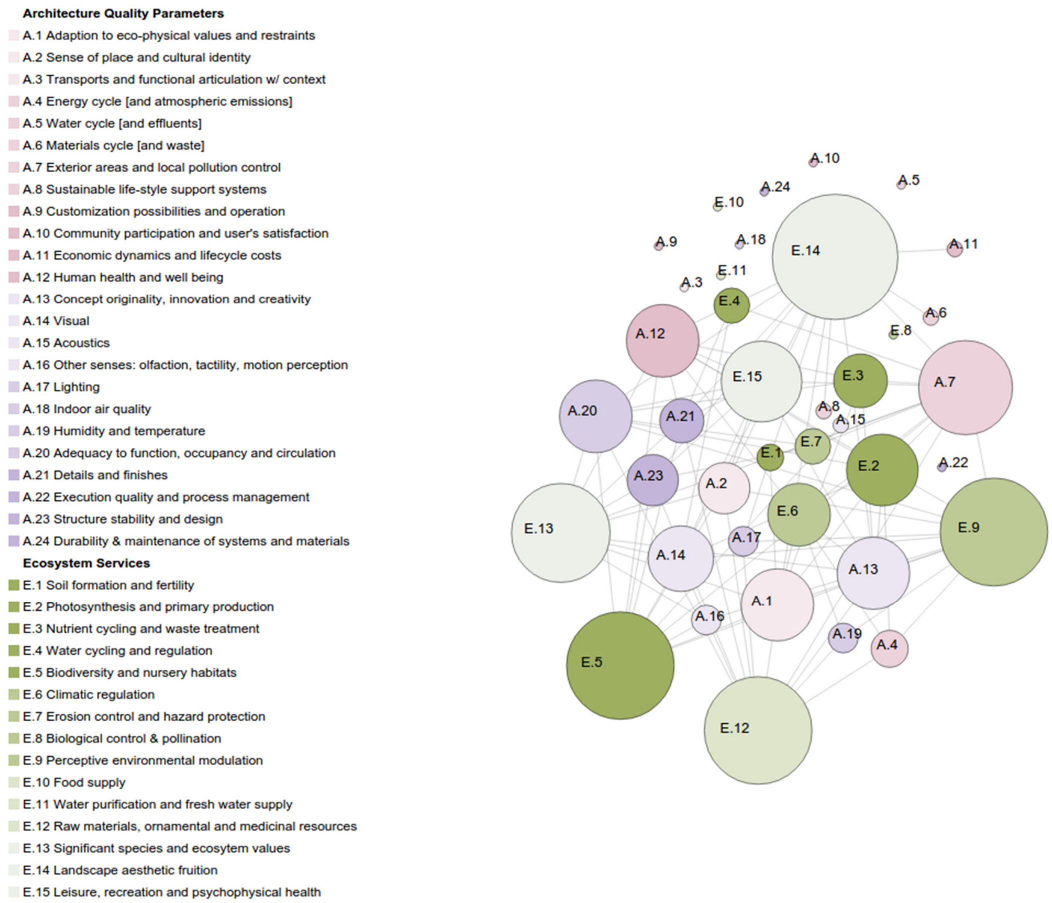


Figure 67. *Dancing Trees, Singing Birds* Visualization of TI[L]ES Results – Interactions between Local ecosystem services and Architecture Quality

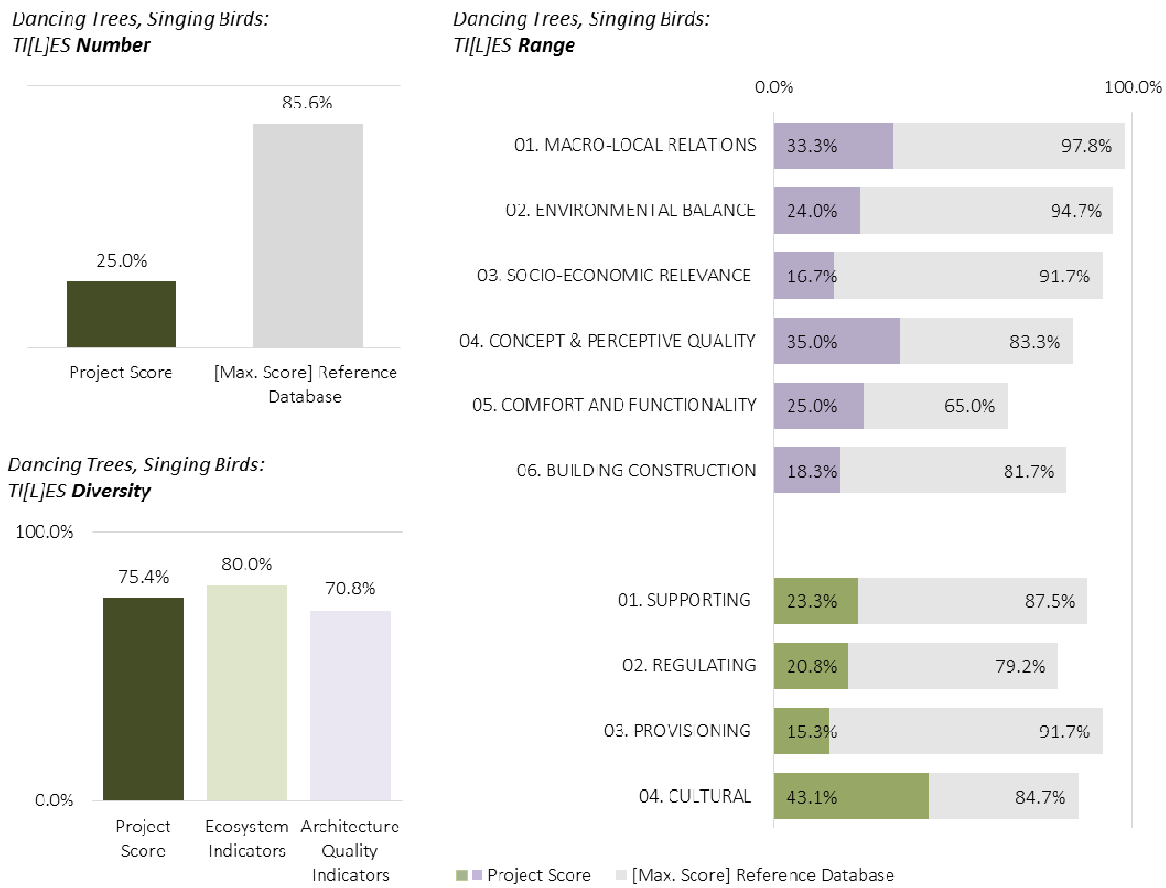


Figure 68. *Dancing Trees, Singing Birds* Visualization of TI[L]ES Results: Number, Diversity and Range

7.3 Case 2. Makino Museum of Plants and People

Figure 69. Makino Museum of Plants and People

The *Makino Museum of Plants and People* holds the function of botanical garden administration and exhibition space and is located in the south of Shikoku Island, in the vicinity of the city of Kochi, atop Mt. Godai. The project was designed by Hiroshi Naito & Associates, and its construction finalized in 1999. The Makino Museum of Plants and People consists of two independent buildings, with structure of reinforced concrete and steel, and roof frames of laminated wood.

This public facility, owned by Kochi prefecture, is one of the visitor attraction points of the city. The project has environmental assessment certification, with a rating of 2.9 in CASBEE New Construction (2004 Edition) being one of the first projects to be certified by CASBEE methodology. The project was portrayed internationally, and subject of its own monography, detailing its design and construction process.

The building structures have one to two floors above ground, adapting to the local topography, and is characterized by its prominent 2 shingle curved and metal clad roofs, encircling each one an open courtyard filled with vegetation. The project is located in non-urban context, among natural area (transept T1). It belongs to the *satoyama* ecosystem cluster of Western Japan. The context ecosystem structure is mainly characterized by forest and woodlands, in close proximity to coastal and urban areas. In the vicinity of the project, is set the Chikurinji Temple, the 31st sacred precinct in Shikoku's 88 temples pilgrimage route.

Figure 70. Context and Setting of Makino Museum of Plants and People

Figure 71. Aspects of Makino Museum of Plants and People
[From top left to bottom right: a)museum courtyard at entrance level, b) water collection ponds, c) museum courtyard at library level, d) exhibition hall courtyard, e) exhibition hall exterior, f) courtyard cooling ponds, g) roof view]

Figure 72. Site Plan of Makino Museum of Plants and People

Some of the stated design interpretations of local ecosystem, that were found on press release and media reviews and articles about the *Makino Museum of Plants and People* project were the following:

- Landscape design exclusively with diverse native plant species, and introduction of more than 500 trees
- Transplantation of trees and plants in order to avoid construction impacts
- Form design [setting, circulation, volume and height] in order to blend in with the landscape and alter as less as possible the topography
- Creation of biotope courtyards and microclimate control through vegetation, wind flows and water surfaces
- External air cooling system for energy efficiency using deciduous trees shade
- Reuse and filtering of rain water for roof sprinklers and water circulation in the Exhibition building courtyard
- Reuse of rubble excavated from the site as building material
- Reuse of rainwater and filtering through ponds for water species exhibition on the Musem Building
- Iconic design, visual form and varied views of landscape/nature from the interior and courtyards
- Scientific-educational learning opportunities and outdoor recreation leisure amenities
- Roof structure design, in alliance with trees and rock mounds, in order to minimize wind patterns alteration, and preparedness for typhoons
- Bioclimatic design with deep eaves, vegetation and reflective roof materials
- Use of locally (municipality) produced cedar and cypress wood

Below it is provided a brief summary of the analysis of architectural quality parameters, its relevance and design options that relate with local ecosystem services, within this project:

a) *Macro-local relations.*

A1 Adaptation to Eco-Physical Values & Restraints: Building setting and footprint, with minimal alteration of topography.

A2 Sense of Place and Cultural Identity: Immersion in landscape [trees], and creation of biotopes-courtyards.

A3 Functional Articulation with Context: Not relevant.

b) *Environmental Balance.*

A4 Energy Cycle [and Atmospheric Emissions]: Bioclimatic design with vegetation and water surfaces in biotope courtyard, use of water sprinklers, air cooling ducts.

A5 Water Cycle [and Effluents]: Rainwater collection and treatment in biodiversity ponds and bioclimatic pools; reduction of storm water runoff.

A6 Materials Cycle [and Waste]: Use of on-site rubble for masonry around outer walls and wind protection.

A7 Exterior Areas and Local Pollution: All landscape organization and amenities.

A8 Sustainable Life-Style Support: Not relevant.

c) *Socio-Economic Relevance*.

A9 Customization and Operation: Not relevant.

A10 Community Participation and User Satisfaction: Client commission role, and effect on local populations.

A11 Economic Dynamics and Lifecycle Costs: No information.

A12 Human Health and Well Being: Positive effects on human health from air purification, sights, and other contact with natural elements.

d) *Concept & Perceptive Quality*.

A13 Concept Originality and Innovation: Building design, low-circular volumes.

A14 Visual: Form; Framings, and visual interplay with bamboo courtyard and biotope courtyard; water plants and surfaces.

A15 Acoustics: No information.

A16 Olfaction, Tactility & Motion Perception: Smells of fruit trees and other species; water reflections.

e) *Comfort and Functionality*.

A17 Lighting: Filtering of light in bamboo-library courtyard, etc.

A18 Indoor Air Quality: Not relevant.

A19 Humidity and Temperature: Use of [local, but non on-site] cedar wood to maintain humidity-temperature constant levels in archive rooms; courtyard microclimate control.

A20 Adequacy to Function, Occupancy & Circulation: Building plans and setting and program organization.

f) *Building Construction*.

A21 Details and Finishes: Selection of cladding materials; support for climbing plants and stone walls that allow vegetation.

A22 Execution Quality & Process Management: Measures during construction [plant transplantation] and operation.

A23 Structure Stability and Design: Structure design to support strong winds and integration in the landscape; use of topography, rock mounds and trees to absorb wind flows.

A24 Durability & Maintenance: No information.

The results from the collected data are represented in the following figures 73-75, representing respectively the Integration Results in TI[L]ES Table, the Visualization of TI[L]ES Results – Interactions between Local ecosystem services and Architecture Quality and the numerical TI[L]ES Results expressing : Number, Diversity and Range.

- 🟠 Mutual positive influence
- 🟢 Positive influence on local ecology parameters
- 🟣 Positive influence on architecture quality parameters
- ○ Not relevant
- _ No information
- ● Relevant parameter

ARCHITECTURE QUALITY PARAMETERS \ LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	01. SUPPORTING	1 Soil formation and fertility	2 Photosynthesis and primary production	3 Nutrient cycling and waste treatment	4 Water cycling and regulation	5 Biodiversity and nursery habitats	02. REGULATING	6 Climatic regulation	7 Erosion control and hazard protection	8 Biological control & pollination	9 Perceptive environmental modulation	03. PROVISIONING	10 Food supply	11 Water purification and fresh water supply	12 Raw materials, ornamental and medicinal resources	04. CULTURAL	13 Significant species and ecosytem values	14 Landscape aesthetic fruition	15 Leisure, recreation and psychophysical health
01. MACRO-LOCAL RELATIONS		●	●	●	●	●		●	●	●	●		●	●	●		●	●	●
1 Adaption to eco-physical values and restraints	●	🟢	🟢	🟢	🟢	🟠		🟢	🟠	○	🟢		○	○	🟢		🟠	🟠	🟢
2 Sense of place and cultural identity	●	○	○	○	🟣	🟠		🟣	○	🟣	🟣		○	🟣	🟣		🟣	🟠	🟠
3 Transports and functional articulation w/ context	○	○	○	○	○	○		○	○	○	○		○	○	○		○	○	○
02. ENVIRONMENTAL BALANCE																			
4 Energy cycle [and atmospheric emissions]	●	○	🟣	○	🟣	🟣		🟣	○	○	🟣		○	○	🟣		🟣	○	○
5 Water cycle [and effluents]	●	🟣	🟢	🟠	🟠	🟢		🟢	🟢	_	🟢		○	🟠	🟢		🟢	🟢	🟢
6 Materials cycle [and waste]	●	○	○	○	_	○		○	🟢	_	○		○	○	🟣		○	○	○
7 Exterior areas and local pollution control	●	🟠	🟠	🟠	🟣	🟠		🟠	🟢	🟠	🟠		🟢	🟠	🟠		🟠	🟠	🟢
8 Sustainable life-style support systems	○	○	○	○	○	○		○	○	○	○		○	○	○		○	○	○
03. SOCIO-ECONOMIC RELEVANCE																			
9 Customization possibilities and operation	○	○	○	○	○	○		○	○	○	○		○	○	○		○	○	○
10 Community participation and user's satisfaction	●	_	_	_	_	🟢		_	_	_	_		_	_	🟢		🟠	🟠	🟢
11 Economic dynamics and lifecycle costs	_	_	_	_	_	_		_	_	_	_		_	_	_		_	_	_
12 Human health and well being	●	○	🟣	🟣	🟣	🟣		🟣	○	_	🟣		○	🟣	🟣		🟣	🟣	🟣
04. CONCEPT & PERCEPTIVE QUALITY																			
13 Concept originality, innovation and creativity	●	○	🟠	🟠	🟠	🟠		🟠	🟠	○	🟢		○	🟠	🟠		🟠	🟠	🟢
14 Visual	●	○	🟠	🟣	🟢	🟠		🟣	○	○	🟣		○	🟣	🟠		🟠	🟠	🟢
15 Acoustics	_	_	_	_	_	_		_	_	_	_		_	_	_		_	_	_
16 Other senses: olfaction, tactility, motion perception	●	○	○	○	🟣	🟣		○	○	🟣	🟠		🟣	🟠	🟣		🟠	🟢	🟢
05. COMFORT AND FUNCTIONALITY																			
17 Lighting	●	○	🟣	○	○	🟣		○	○	○	🟣		○	○	🟣		🟣	○	○
18 Indoor air quality	○	○	○	○	○	○		○	○	○	○		○	○	○		○	○	○
19 Humidity and temperature	●	○	○	○	🟣	○		🟣	○	○	🟣		○	○	🟣		○	○	○
20 Adequacy to function, occupancy and circulation	●	🟢	○	○	🟢	🟠		🟠	🟢	○	🟠		○	🟣	🟠		🟠	🟢	🟢
06. BUILDING CONSTRUCTION																			
21 Details and finishes	●	○	○	○	🟢	🟢		🟢	○	○	🟢		○	🟢	○		○	🟢	🟢
22 Execution quality and process management	●	_	🟢	_	_	🟢		_	_	🟢	○		_	🟢	🟢		🟢	_	🟢
23 Structure stability and design	●	_	○	○	○	_		🟣	🟠	○	○		○	○	🟣		🟢	🟠	○
24 Durability & maintenance of systems and materials	_	_	_	_	_	_		_	_	_	_		_	_	_		_	_	_

Figure 73. *Makino Museum of Plants and People* Design Integration Results in TI[L]ES Table.

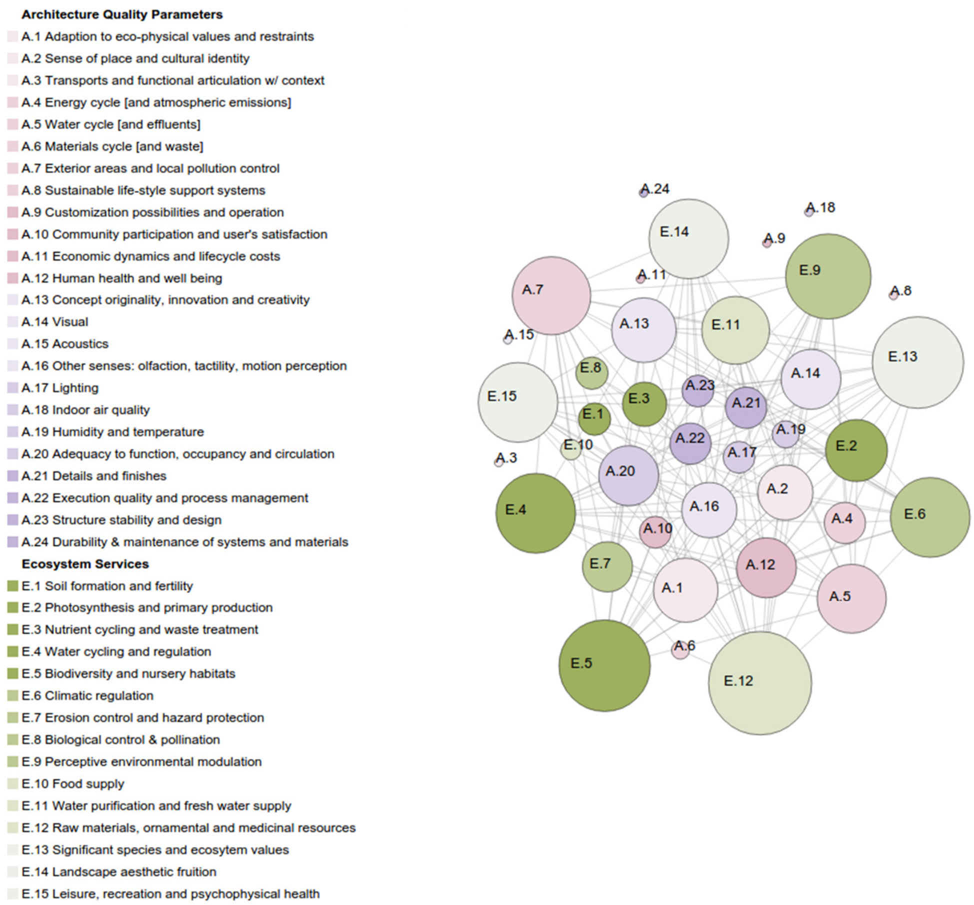
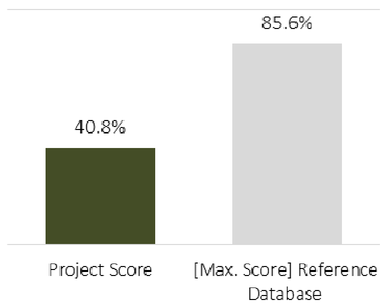
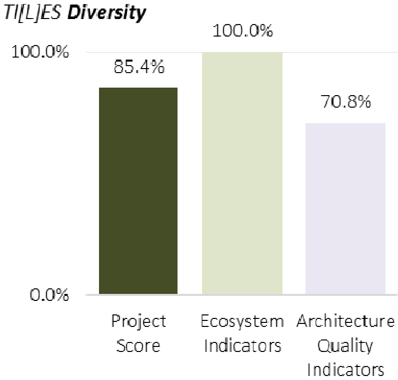


Figure 74. *Makino Museum of Plants and People* Visualization of TI[LI]ES Results – Interactions between Local ecosystem services and Architecture Quality

Makino Museum of Plants and People:
TI[L]ES ***Number***



Makino Museum of Plants and People:
TI[L]ES ***Diversity***



Makino Museum of Plants and People:
TI[L]ES ***Range***

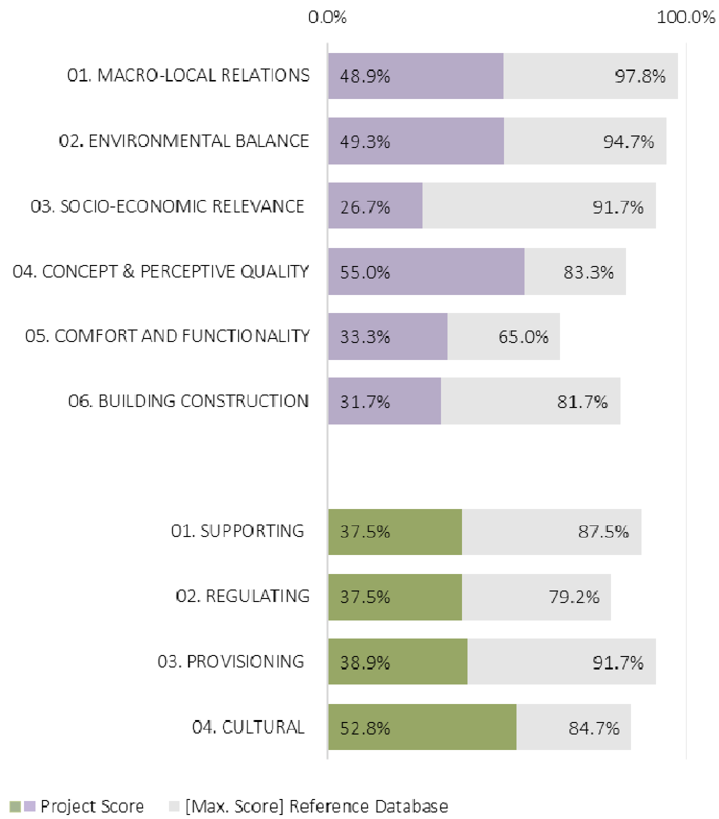


Figure 75.*Makino Museum of Plants and People* Visualization of TI[L]ES Results: Number, Diversity and Range

7.4 Case 3. Pasona Urban Farm

Figure 76. Pasona Urban Farm

Pasona Urban Farm is a privately owned office building, headquarters of the Pasona human resources company, in Tokyo. It is situated in Otemachi, a high density central city district. The renovation project was designed by Kono Designs, and the completion of the construction works finalized in 2010. The building has nine floors above ground, recuperating the existing structure in reinforced concrete and steel.

The project doesn't have any kind of environmental assessment certification, being featured by different media (as the digital portals Architizer, and TreeHugger,) and specialized blogs (as Tokyo Green Space).

The project is located in urban context, among urban core area (transept T6). It belongs to the *satoyama* ecosystem cluster of Kanto-Chubu. The context ecosystem structure is essentially urban, in the vicinity of coastal urbanized areas.

Figure 77. Context and Setting of Pasona Urban Farm

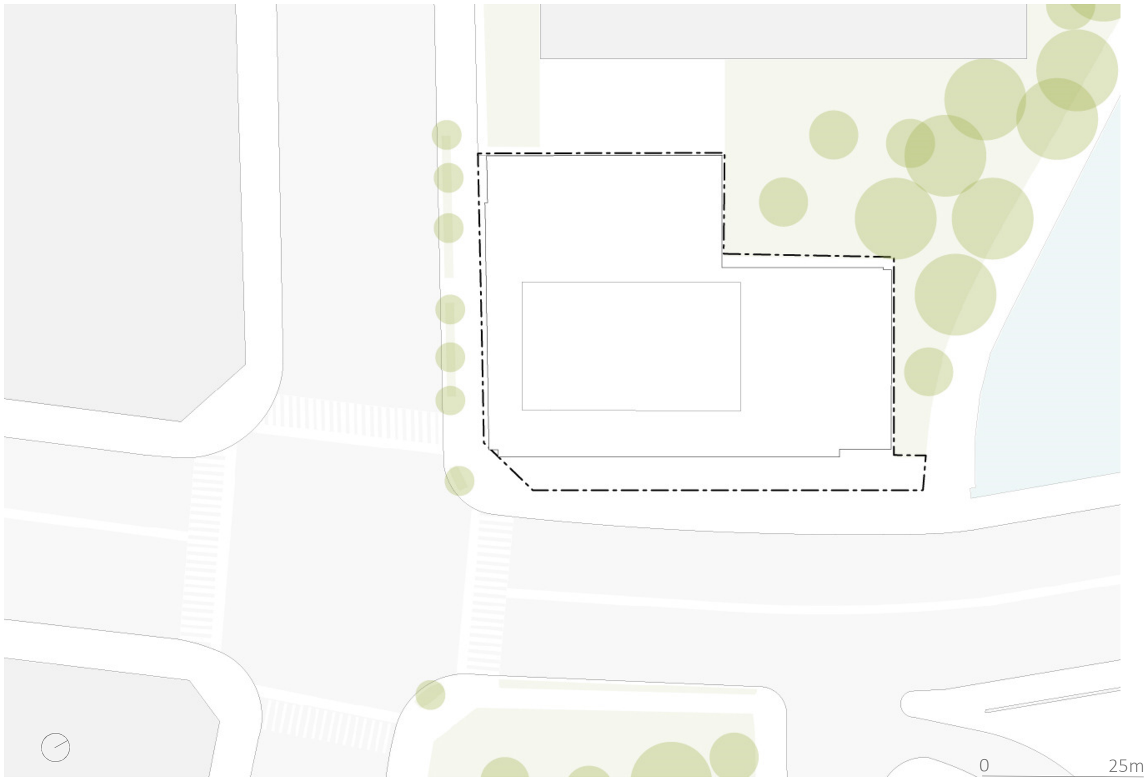


Figure 78. Site Plan of the project Pasona Urban Farm

Figure 79. Aspects of the project Pasona Urban Farm
[From top left to bottom right: a) street view, b) living wall, c) offices interior, d) indoor farm, e) offices hallway, f) rooftop]

Some of the stated design interpretations of local ecosystem, that were found on press release and media reviews and articles about the *Pasona Urban Farm* project were the following:

- Preservation and renovation of existing building structure
- Green rooftop with leisure areas
- Promotion of traditional and urban farming, knowledge and environmental education opportunities
- Local food supply provision within the building with ~200 diverse vegetal species, for consumption on cafeterias for employees and general public
- Green wall balconies with seasonal flowering climbing plants, towards South, providing microclimate and environmental modulation
- Indoor vegetation improvement on working environment, quality of space and air quality
- Iconic urban design and influence on corporate identity
- User participation in the maintenance and harvesting of crops, and envelope control through operable windows
- Interaction of urban population with farming activities and boost of agriculture economic dynamics

Below it is provided a brief summary of the analysis of architectural quality parameters, its relevance and design options that relate with local ecosystem services, within this project:

a) *Macro-local relations.*

A1 Adaptation to Eco-Physical Values & Restraints: Not relevant.

A2 Sense of Place and Cultural Identity: Icon impact in urban area, changing of landscapes with seasons (exterior), and crop rotation (interior).

A3 Functional Articulation with Context: Influence of on-site food supply on the reduction of transport loads.

b) *Environmental Balance.*

A4 Energy Cycle [and Atmospheric Emissions]: Role of vegetation [greenery in balconies] to filter direct sunlight and provide insulation buffer, reducing eventually cooling and heating loads.

A5 Water Cycle [and Effluents]: No information.

A6 Materials Cycle [and Waste]: Use of existing building superstructure and part of envelope.

A7 Exterior Areas and Local Pollution: Double-skin green façade | Green roof (with potential absorption of storm water runoff).

A8 Sustainable Life-Style Support: Associated with food production and some ornamental-medicinal species.

c) *Socio-Economic Relevance*.

A9 Customization and Operation: Green customizable balconies with operable windows.

A10 Community Participation and User Satisfaction: Role of client commission | Participation of employees in the maintenance and harvesting of crops, encouraging social interaction.
A11 Economic Dynamics and Lifecycle Costs: No information.
A12 Human Health and Well Being: Influence of indoor plants on physical health (workplace environments) and psycho-social well-being [air purification, sights, and other contact with natural elements].

d) *Concept & Perceptive Quality*.
A13 Concept Originality and Innovation: Rehabilitation of existing building with green wall, green roof and indoor urban farm.
A14 Visual: Visual integration and design of indoor and outdoor vegetation and its support systems.
A15 Acoustics: No information.
A16 Olfaction, Tactility & Motion Perception: Scents and textures from climbing plants flowers and other indoor crops.

e) *Comfort and Functionality*.
A17 Lighting: No information.
A18 Indoor Air Quality: Improvement of air quality by carbon sequestration and volatile organic compound removal by indoor plants.
A19 Humidity and Temperature: Maintenance of adequate temperature and humidity for indoor plant growth | Green wall buffer to indoor spaces.
A20 Adequacy to Function, Occupancy & Circulation: Integration of food supply and ornamental/medicinal species in diverse workplace layouts and organization, and balconies space.

f) *Building Construction*.
A21 Details and Finishes: Detail of indoor planting supports and integration [hanging ceiling platforms and vertical partitions, furniture integration].
A22 Execution Quality & Process Management: Automatized plant care irrigation and climate control systems & monitoring.
A23 Structure Stability and Design: Structure adaptation to accommodate double-skin green façade, and green roof.
A24 Durability & Maintenance: No information.

The results from the collected data are represented in the figures 80-82, representing respectively the Integration Results in TI[L]ES Table, the Visualization of TI[L]ES Results – Interactions between Local ecosystem services and Architecture Quality and the numerical TI[L]ES Results expressing : Number, Diversity and Range.

- 🟠 Mutual positive influence
- 🟢 Positive influence on local ecology parameters
- 🟣 Positive influence on architecture quality parameters
- ○ Not relevant
- _ No information
- ● Relevant parameter

ARCHITECTURE QUALITY PARAMETERS / LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	01. SUPPORTING	1 Soil formation and fertility	2 Photosynthesis and primary production	3 Nutrient cycling and waste treatment	4 Water cycling and regulation	5 Biodiversity and nursery habitats	02. REGULATING	6 Climatic regulation	7 Erosion control and hazard protection	8 Biological control & pollination	9 Perceptive environmental modulation	03. PROVISIONING	10 Food supply	11 Water purification and fresh water supply	12 Raw materials, ornamental and medicinal resources	04. CULTURAL	13 Significant species and ecosytem values	14 Landscape aesthetic fruition	15 Leisure, recreation and psychophysical health
01. MACRO-LOCAL RELATIONS		○	●	●	○	●		●	○	●	●		●	○	●		○	●	●
1 Adaption to eco-physical values and restraints	○	○	○	○	○	○		○	○	○	○		○	○	○		○	○	○
2 Sense of place and cultural identity	●	○	🟠	○	○	🟠		○	○	🟣	○		🟠	○	🟣		○	🟢	🟣
3 Transports and functional articulation w/ context	●	○	○	○	○	○		○	○	○	○		🟣	○	🟣		○	○	○
02. ENVIRONMENTAL BALANCE																			
4 Energy cycle [and atmospheric emissions]	●	○	🟣	○	○	🟠		🟣	○	○	○		○	○	🟣		○	○	○
5 Water cycle [and effluents]	_	○	○	_	○	○		○	○	○	○		_	○	_		○	○	○
6 Materials cycle [and waste]	●	○	○	○	○	○		○	○	○	○		_	○	🟣		○	○	○
7 Exterior areas and local pollution control	●	○	🟠	🟠	_	🟠		🟠	○	🟠	🟠		○	○	🟠		○	🟢	🟠
8 Sustainable life-style support systems	●	○	🟠	🟢	○	○		○	○	🟣	○		🟠	○	🟢		○	○	🟢
03. SOCIO-ECONOMIC RELEVANCE																			
9 Customization possibilities and operation	●	○	○	○	○	○		🟠	○	○	🟣		○	○	🟣		○	🟢	○
10 Community participation and user's satisfaction	●	○	○	○	○	_		_	○	_	_		🟠	○	🟠		○	○	_
11 Economic dynamics and lifecycle costs	_	_	_	_	○	_		_	○	_	_		_	○	_		_	_	_
12 Human health and well being	●	○	🟣	🟣	○	🟣		🟣	○	_	🟣		🟣	○	🟣		○	_	🟠
04. CONCEPT & PERCEPTIVE QUALITY																			
13 Concept originality, innovation and creativity	●	○	🟠	🟢	○	🟢		🟢	○	🟢	🟢		🟠	○	🟢		○	🟢	🟢
14 Visual	●	○	🟠	○	○	🟠		○	○	🟣	🟣		🟠	○	🟠		○	○	🟢
15 Acoustics	_	_	_	_	○	_		_	○	_	_		_	○	_		_	_	_
16 Other senses: olfaction, tactility, motion perception	●	○	○	○	○	🟠		○	○	🟠	🟣		_	○	🟣		○	_	_
05. COMFORT AND FUNCTIONALITY																			
17 Lighting	_	○	_	○	○	_		_	○	○	_		_	○	_		○	_	_
18 Indoor air quality	●	○	🟣	🟣	○	○		○	○	○	○		🟣	○	🟣		○	○	○
19 Humidity and temperature	●	○	○	○	○	○		🟣	○	○	🟣		🟢	○	🟢		○	○	○
20 Adequacy to function, occupancy and circulation	●	○	○	○	○	🟢		○	○	○	🟢		🟠	○	🟠		○	○	🟢
06. BUILDING CONSTRUCTION																			
21 Details and finishes	●	○	🟢	🟢	○	🟠		🟢	○	○	🟠		🟠	○	🟠		○	🟢	🟢
22 Execution quality and process management	●	○	🟢	_	○	○		_	○	_	○		🟢	○	🟢		○	○	_
23 Structure stability and design	●	○	○	○	○	🟢		🟢	○	○	🟢		○	○	🟢		○	○	🟢
24 Durability & maintenance of systems and materials	_	_	_	_	○	_		_	○	_	_		_	○	_		○	_	_

Figure 80. *Pasona Urban Farm* Design Integration Results in TI[I]ES Table.

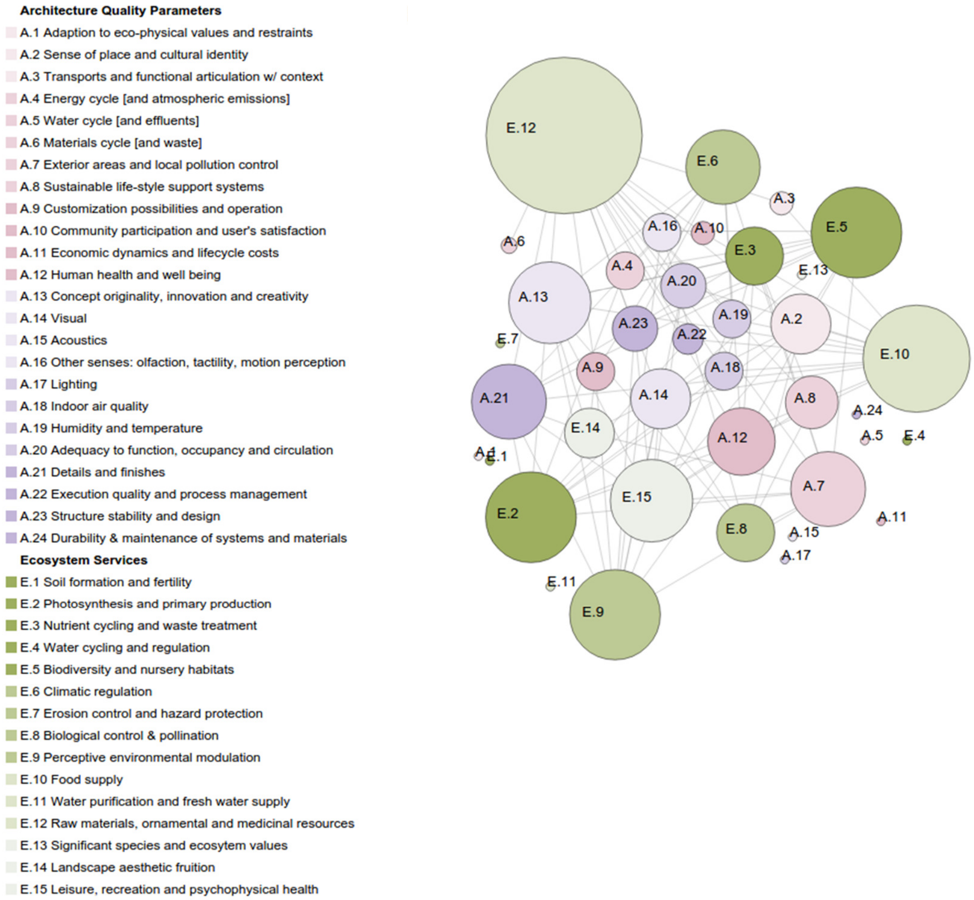


Figure 81. *Pasona Urban Farm* Visualization of TI[L]ES Results – Interactions between Local ecosystem services and Architecture Quality

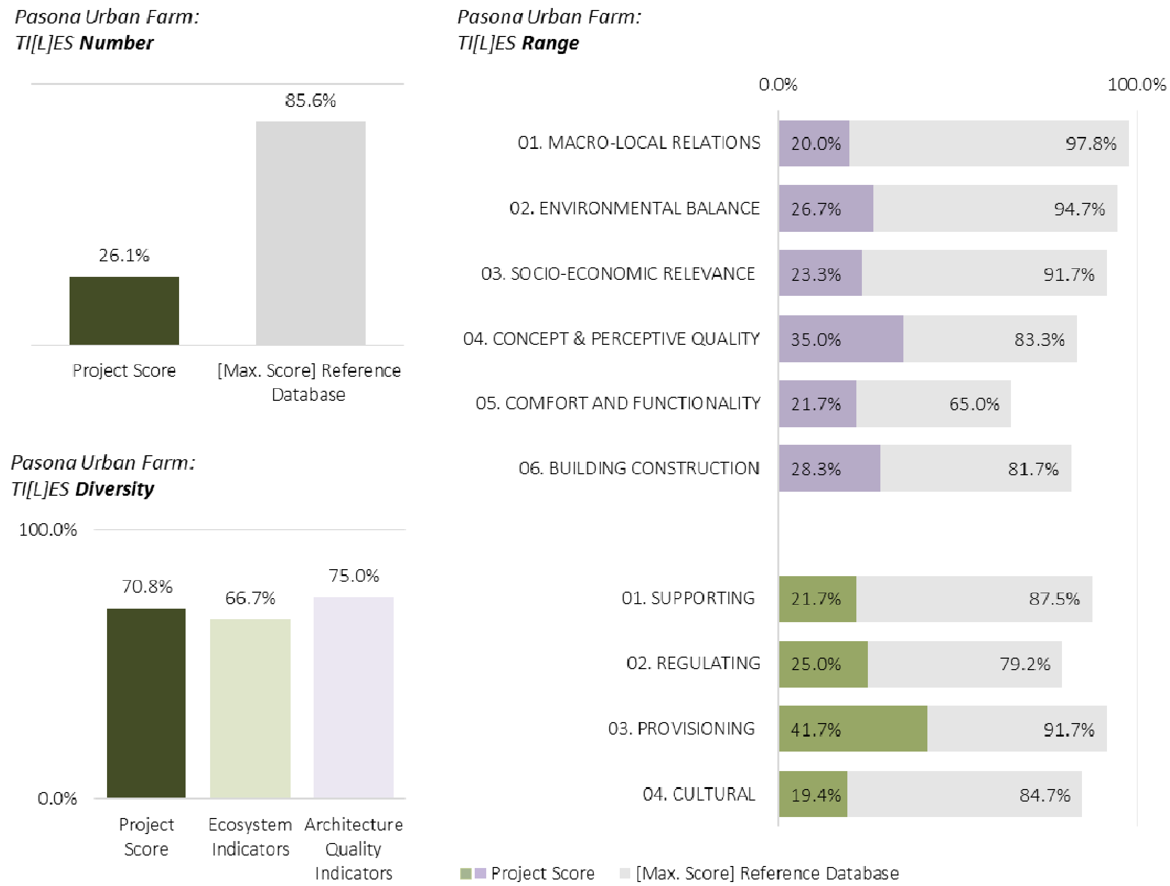


Figure 82.*Pasona Urban Farm* Visualization of TI[L]ES Results: Number, Diversity and Range

7.5 Comparative Summary

Although it can be observed a certain participation of local ecosystem services in the previously examined project targets, the application of the TI[L]ES methodology demonstrates a relatively low score in all cases, as compared with reference database cumulative results.

Even though these projects integrate a diversity of local ecosystem services and architecture design parameters, with the exception of Case 2 (Makino Museum of Plants and People) - that present more distributed results -, the interdependence between local ecosystem services and architecture design criteria is tendentiously polarized.

Nevertheless, a detailed scrutiny of the obtained results could possibly corroborate an existing correlation between local ecosystem services quantitative performance with the descriptors contained in the TI[L]ES framework, as exemplified by the cross comparison between biodiversity indicators assessment with the design integration qualitative analysis performed through TI[L]ES in the 3 specific target projects.



	Project	DANCING TREES, SINGING BIRDS	MAKINO MUSEUM OF PLANTS AND PEOPLE	PASONA URBAN FARM
	Total Floor Area [m2]	685	7360	20000
	Constructed Area [m2]	424	5700	2250
	Ecosystem Promotion			
Biodiversity	Total number of [identified] species	8	151	81
	Native Species per Total Number of Species	**63%**	**91%**	**27%**
	Number of Species per [100 m2] of Floor Area	**1.17**	**2.05**	**0.41**
	Number of Species per [100 m2] of Constructed Area	0.02	0.02	0.04
TI[L]ES	Project Score [Number]	25,0%	40,8%	26,1%
	Project Score [Diversity]	**75, 4%**	**85,4%**	**70,8%**
	Project Score [Diversity of E. S.]	**80,0%**	**100,0%**	**66,7%**
	E5. (Biodiversity) Positive Correlations	11	14	10
	Urban Transept	T5. Urban Center Area	T1. Natural Area	T6. Urban Core Area
	Context	Urban	Mountain -Forest [natural park]	Urban
	Satoyama ecosystem cluster:	Kanto-Chubu	Western Japan	Kanto-Chubu

Figure 83. Comparison of Local ecosystem services quantitative assessment with design integration qualitative assessment through TI[L]ES in Target Projects

08. MULTIPLE USER QUALITATIVE VARIATIONS

8.1 Assessing the Design Integration of specific projects through Qualitative data surveys

The present chapter presents the results of the application of the suggested interpretation framework by multiple users. As previously indicated in Chapter 5, qualitative data surveys to assess and improve the application of the proposed Tool for Integration of Local ecosystem services (Ti[l]es), were implemented, focusing on the analysis of specific projects, including: 1. an initial pilot research survey, 2. interviews conducted with design team members, and 3. a final research questionnaire.

8.2 Experimental Application of the TI[L]ES Framework: Pilot Research Survey

As part of the development of the framework to interpret the Design Integration of Local Ecosystem Services in Architecture Projects, a short pilot study was implemented to test and refine the tool. The project case of Sidwell Friends Middle School, designed by KieranTimberlake Associates, was used as object of analysis by a restricted sample of users, which independently filled the provided questionnaire [presented in Appendix IV], according to their interpretations, under the conditions previously described in Chapter 5.

Within this experiment, there was data collected formally and informally. Formal data collection pertain with the answers provided by the users within the close ended questionnaire. Informal data collection registered questions, suggestions and observations related with the questionnaire format and the provided consultation materials.

Formal data collection

The background of the respondents in this trial is comparatively similar, consisting of individuals of European nationality, with approximately the same age [between 30 and 40 years old], with a graduate degree in architecture [and urban planning] and more than 5 years of practice in the field. Regarding the degree of knowledge of the specific project, the majority of the respondents didn't knew it previously to the questionnaire, therefore relying on the given information materials.

The respondents' perspectives on architecture design quality and its relation with local ecology are depicted in the following Figure. Regarding the areas more relevant to define architecture design quality, the variation between respondents is reduced, attributing generally to all areas values between 4 and 5 [on a scale of 0 to 5, being 0 = not important and 5 = extremely important], with the exception of Construction, to which respondent 1 attributed the lowest score [2 = somewhat important]. Regarding the relation of these areas with local ecology, the answers show more variation, although Environmental Balance has unanimity of answers [5 = extremely important]. Comfort, Functionality and Perceptive Quality are attributed the lowest scores and simultaneously more discrepancy within the answers. Nevertheless, all respondents agree that the integration of local ecology regeneration strategies can beneficiate overall architecture design quality.

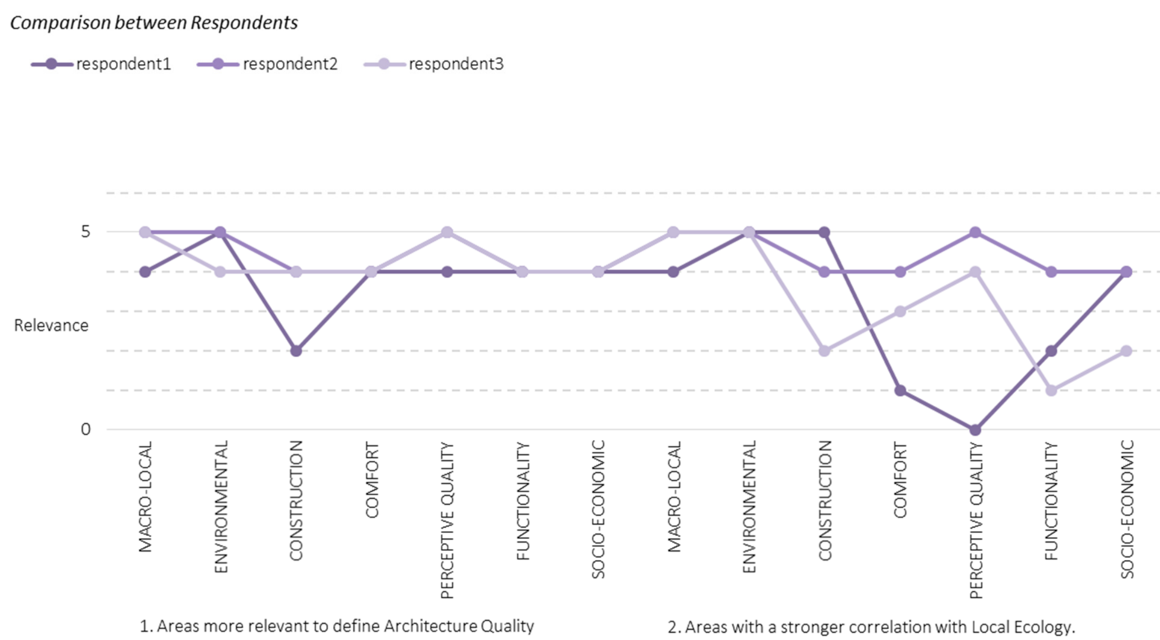


Figure 84. Pilot Survey: Respondents perspective on architecture design quality areas and their relation with local ecology

Regarding the assessment of the project through the preliminary Ti[l]es matrix, the answers and the differences between multiple users are synthetized in Figures 85.

The architecture design criteria that had shown positive consistency, in this experimental test, were: Adaption to eco-physical values and restraints, Sense of place and cultural identity, Water [and effluents], Materials [and solid waste], Customization possibilities and operation, Community participation and user's satisfaction, Human health and well-being, Acoustics, Olfactory, Acoustics II, Lighting, Indoor air quality, Humidity and temperature, Exterior areas, Ergonomy, accessibility and universal design, Details and finishes, Execution quality and process management, and Structure quality and stability.

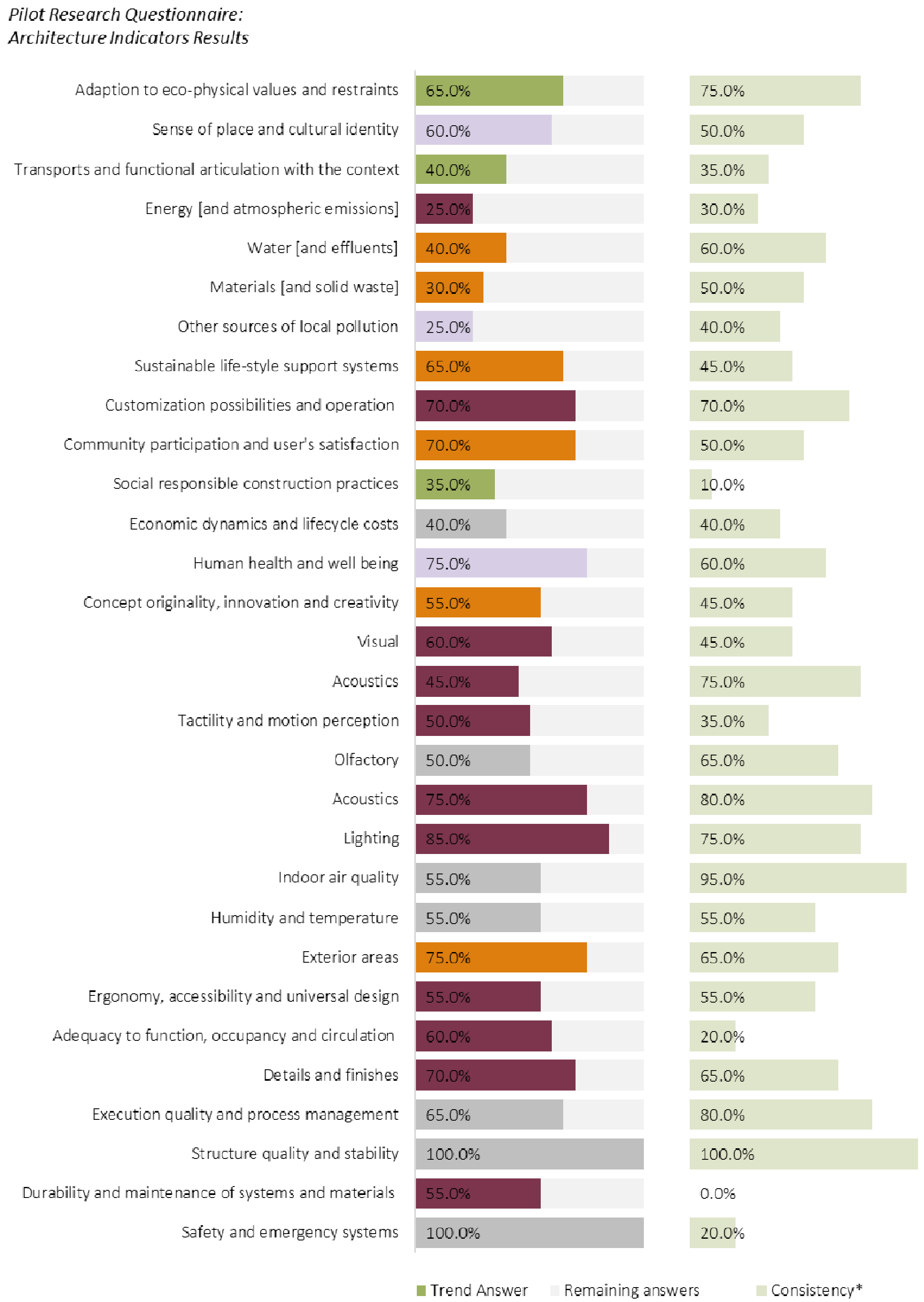


Figure 85. Answer variation between respondents in Experimental Research Questionnaire
[Trend Answer Legend: Green: positive correlation towards local ecosystem parameters; Violet: positive correlation towards architecture design parameters; Orange: mutual positive correlation; Grey: No information; Dark purple: No relevant positive correlation; *Consistency with the author of the thesis]

On the other hand, the following architecture quality parameters difficultly had similarity of answers among the observers: Transports and functional articulation with the context, Energy [and atmospheric emissions], Social responsible construction practices, Tactility and motion perception, Adequacy to function, occupancy and circulation, and Durability and maintenance of systems and materials.

Other indicators with some indirect consistency include: Other sources of local pollution, Sustainable life-style support systems, Economic dynamics and lifecycle costs, Concept originality, innovation and creativity, Visual, and Safety and emergency systems.

As final observations, all the respondents considered that a design support tool for local ecology integration could be useful during design process, and agreed that the reasoning raised by the application of the support tool enhanced their perception of ecosystem regeneration potentialities within architectural design.

Informal data collection

In order to compile information necessary to improve future applications and develop the format of the TI[L]ES framework, the respondents were asked to contribute with suggestions and critiques to the implementation of the method. Regarding the average communicated time required to reply to this pilot survey it was reported as about 5 hours, divided by two consecutive or non-consecutive days, which was considered somewhat impractical in different circumstances. From the dialogue established with the respondents about the survey format and the information materials delivered, the following observations were also registered:

1) *Reduce the questionnaire extension*. Shorten the length and the number of questions in the correlation matrix, which could be solved by some of the suggestions: break up the matrix by modules, and eventually distribute it through 2 or 3 partial questionnaires, or present optional questions.

2) *Provide references*. It was argued that to provide concrete reference examples to illustrate the different possible correlations between local ecology and architectural parameters [ex: from reference database] could ease the comprehension and filling of the survey.

3) *Clarify limits (scale and boundaries of analysis, and scope of indicators)*. Eliminate redundancies related with similar criteria indicators, and specify scale and boundaries of analysis of local ecosystem services and functions and architectural design parameters.

4) *Ease the answer input*. Provide the information materials in a separate presentation format, and supply a more dynamic process for questionnaire answering [through online or digital forms].

Some of these suggestions were taken into account for the implementation of the TI[L]ES framework with a broader range of users, into the analysis of the 3 selected case studies within the context of Japan, as described afterwards. Regarding a possible simplification of the answer process and a suggestion for visualization of the results, one of the respondents [respondent 2] also proposed an abridged version of the correlations matrix, and provided an alternative answer in that format [Figure 86].

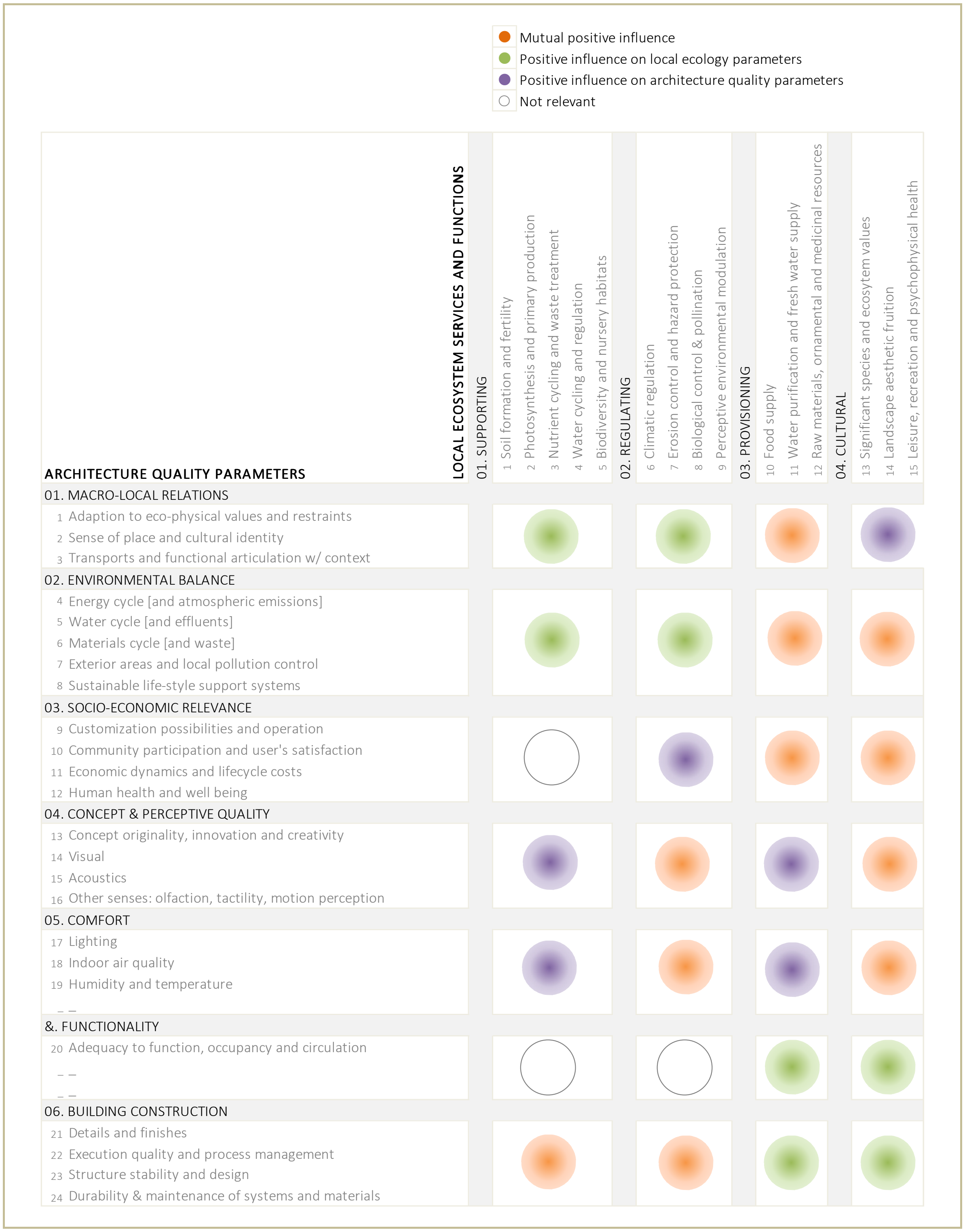


Figure 86. Alternative suggestion for simplification of answering format.

8.3 The perspective of Design Teams [individual interviews]

Regardless of their personal approach, the results on their own projects, the degree of eco-literacy, or concordance with others points of view, the designers interviewed, answered without exception, to consider very relevant the promotion of local ecosystem services and functions within architecture projects. Also, they replied by unanimity, to define the relations between local ecosystem criteria and architecture quality parameters as a mutual positive influence. Regarding their own specific project [study case], they also replied to define the overall influence of their project on the promotion of local ecosystem criteria, as very important.

Regarding the definition of the importance of different factors towards Architecture Design Quality, some of the interviewees have claimed that it varies according to the specificity of the project.

Through a simplified way, the interviewees were also asked to express their perspective and reply within the collaborative interactions Ti[l]es framework, regarding relevant involved indicators, and the selection of the more relevant collaborative interactions between ecosystem and architecture criteria, in their project, in their opinion. Besides the closed structure inquiry form, the respondents had the opportunity to further comment on their answers, and explain aspects of the design process, at their will.

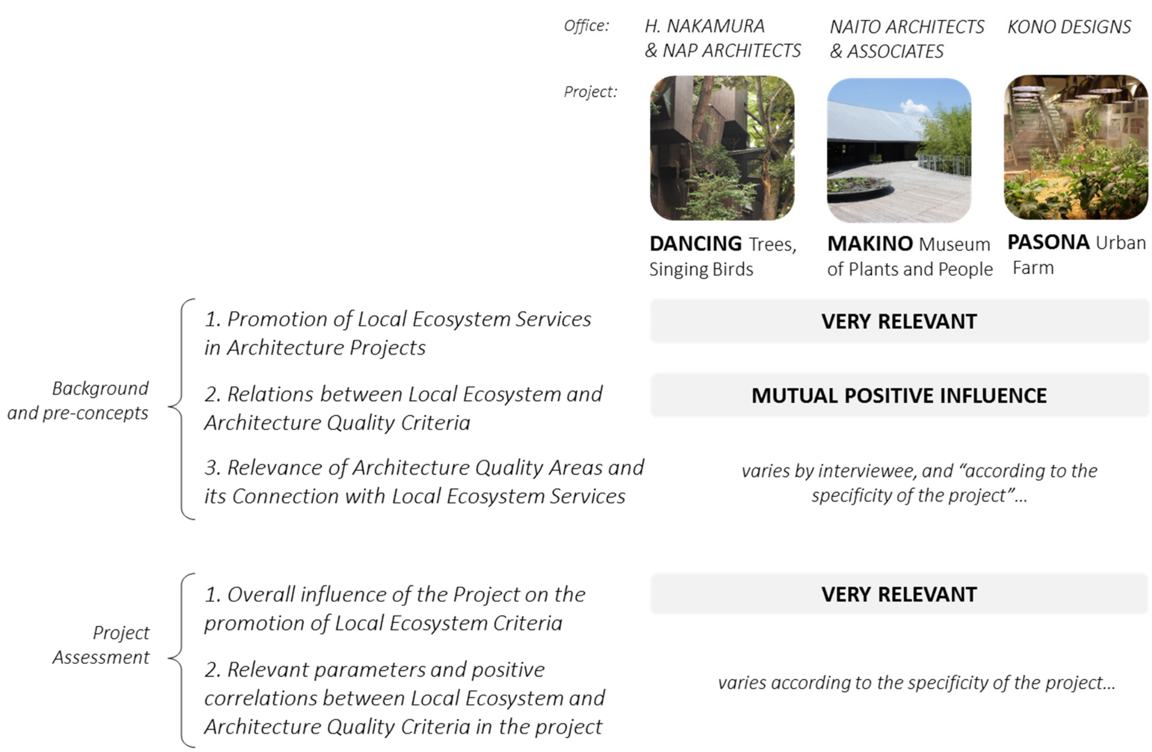


Figure 87. Comparison between answers from the Inquiry to Design Teams

Dancing Trees, Singing Birds

[although the author of this project didn't comment orally other information regarding the design process of this project, diverse writings were provided, from which the following observations were extracted].

Hiroshi Nakamura's designs follow more than one direction regarding design process and themes. In *Microscopic Designing Methodology*, Nakamura identifies 4 main themes in his work: body, materials, nature, and society. Within these themes, also different approaches, relative to project specificities, emerge. The project of *Dancing Trees, Singing Birds* is particularly devoted to Nakamura's design research within the themes of architecture relation with the human body and nature.

The preservation and fruition of existing ornamental/biodiversity/environmental modulation services is strongly linked in this design with concept/visual/and building layout.

For this project, a comprehensive survey of the local existing trees was carried as pre-design. Each individual on-site tree was measured with a method developed by NAP, resulting in a tridimensional model of the respective tree trunks and main branches, which later was analyzed with simulations regarding prospective tree growth and movement under the action of extreme winds/weather conditions. The intention of this analysis was to find the spatial possibilities to insert projecting rooms from the structural wall facing south-east limit, (human nests) among the trees. "*I want to shorten the distance between trees and human beings. So I observe the motions of trees with extreme accuracy*." (Nakamura, 2010, p.112)

A similar design approach regarding trees proximity and passive design [climatic and perceptive regulation] was also put into practice by Hiroshi Nakamura in other projects, as Roku Museum.

Makino Museum of Plants and People

Tetsuya Kombayashi [associate director from Hiroshi Naito & Associates] has been working in Naito Architects & Associates for 20 years. He has participated on the draft of the project of Makino Museum of Plants and People, and stayed on the construction site for 2 years, monitoring the work. He recalls the experience as an intense but satisfactory experience. ["it was hard", said Kombayashi].

From Pre-Design to Design the project changed considerably [although already initially departing from a set of parallel roofs with courtyards], evolving to a more organic shape, as they were influenced by Dr. Makino's botanical drawings. The process was supported by extensive research and consulting, particularly about wind forces and impact on roof, and with landscape design specialists and the curators of museum and botanical garden. Tetsuya Kambayashi named his favorite space of the project the open auditorium/amphitheatre - in close relation with the courtyard – "it's the most interesting space".

When asked about the articulation of spaces and the authorship of design within the botanical garden he explains that Naito & Associates have been responsible mainly for architectural design [sitting of the two buildings and the canopy that connects them], while the renowned landscape architect, Jun-ichi Inada, has been responsible to design an overall master plan of the botanical garden. Frontier areas [as building courtyards] were decided by the architects team "by discussing with the curators of the botanical garden"/and Inada.

Kombayashi has summarized the main factors affecting the design of Makino Museum of Plants and People as: 1. the botanical drawings by Tomitaro Makino; 2. the site specific conditions; 3. the weather and climate conditions; 4. the program ("building use", functions and organization); and 5. Sustainability.

The fact that the drawings of Makino were influential of the design expression relate immediately with the importance of the program/client, and with the cultural significance of ecosystem elements, translated in the work of Makino himself. "[…] Naito got inspired from this elegance of the details and the organic forms and developed the image of whole building." Kombayashi draws the attention to Makino drawing skills and the "very tiny curves" drawn with mouse hair brush, referring how the design staff got so surprised with his botanical illustrations, marking the "start of all".
In another moment, Kombayashi expresses the importance of Tomitaro Makino's persona in the decision of building shape, although he has passed away in 1957. "So Naito imagined Makino's feeling like that if he were Dr.Makino, he would have done so."

The second influential factor is related with site conditions. As the design team developed fieldwork in Kochi, "[…] we were impressed at very deep green colour of the mountain". Thick woods and forest covered the site, and "[…] we would like to preserve as many woods as possible without cutting down." With the decision to preserve significant local ecosystem values, setting, volumetry and height were shaped. "So what we imagined was Mt. Godai where are mountain and woods and we had to make flat space there for constructing the architecture, but the height should be below the height of woods as embedding, such as hiding. […] Moreover 10 or 20 years later, woods will get bigger and finally we won't almost see the building."

The topographic conditions of the site, characterized by the mountain slope, has also influenced the layout and design [particularly of the Exhibition Hall building]. Because of it, "The floor of the building is like stairs. And there are woods, right? So, we wondered what is most naturally looking shelter as the way of building. And we intended to design roof as sheltering slope and stairs. […]So we caught up with the image of organic form as sheltering the slope."

[Earlier drafts and models of the project show the presence of the roofs, and the stair-like setting of the building, with a more linear, straight language. It has evolved towards a more organic shape, “after the process of organic design and wind simulation. It means, after the process of structural simulation and study.” These earlier sketches have never been published or shown before. “You are first one to see this photo.”]. Pre-design stage took about 6 months, and the final [execution/practical] design, 1 year. An earlier sketch hand-drawn by Hiroshi Naito shows the building “buried in the green of Mt. Godai”. “Even though we changed the shape, the concept had been the same from that time […]”. [The roof type is Kiritsuma Roof (Gable roof)]

The third influential factor of design referred in the interview were the local weather and climate conditions, having building design to respond to specific circumstances as the probability of typhoon strike and extreme heating caused by strong sunlight exposure. The curling shape of the building addresses these factors, creating sheltered conditions within the courtyards, accommodating inner garden, shop and other functions. As roof ends were more vulnerable to wind strikes, also they were designed to almost touch the ground, and around the setting of the building mounds of boulders and soil has been placed to protect the structure from strong winds, with landscape elements. [The analysis of wind loads in structural design has implied physical model simulations and filled more than 1000 pages of calculations, with seldom use of computers. “Wind sensor are installed with this surface and wind load is given to this real model, then the contour of wind strength are generated […]. The strongest part of wind are loaded in the upper direction. Then we use such a wood which can be resistant against the strength.”]

The building structure consists of steel columns, reinforced concrete as basement/foundations and structural wood [laminated wood] for roof rafters, which is covered by metal roof.

The most important points of the building structure are the points of start and end, that “we called “landing”” [the points where the roof ends and lowers], and that are “made of that massive concrete and absorbs all the power of earthquake”.

Roof eaves are extended, protecting the building against rain and sunlight, and creating an intermediate area that “We called […] “semi outdoor space” between inner space and outdoor space.” “This semi outdoor space connects inner and botanical world” and it is referred as the most important theme of this design by Kambayashi. In this space, building and garden are unified. The idea of convergence arises to the discourse as he explains the rainwater catchment systems, and the water collection from roof that is canalized to the basins [a specific design element in this project, that is also a “botanical pot”], and then directed to the inner gardens, contributing to the creation of micro-climate. “It’s possible to connect inner and outdoor by making many of microclimates in semi art space. Plus, it unifies building and this garden.”

Regarding the materials of the building, although main structural wood is white pine wood imported from Canada, and secondary rafters from Kanto island, the greatest volume of wood are cedar roof boards locally sourced in Kochi. [that don't have structural resistance to withstand roof structural functions, but permeate the air with characteristic cedar scent].

Sustainability studies, and those related with CASBEE certification, were developed during pre-design stage. The central points of environmental sustainability are designated during interview as the singular air conditioning/HVAC system design designed for this project, the rain water collection system, the roof design, and the selection of materials and volume.

In order to decrease energy consumption and diminish running costs of the building during operation stage, underground air ducts were installed. The uptake of the exterior air [done in an area of deciduous trees, with natural climate control] and circulates underground where -4°C (in summer) or +4°C (in winter) are achieved. "I guess that many buildings apply this system now, but here is first case study to apply it." Where this system couldn't be installed, the air conditioned is vented from the floor, also saving energy. [Another common technique today, but pioneer at the time of construction].

The building is also well insulated with glass wool, and tightened/sealed in order to prevent air and heat from outside to penetrate the building. Compact building shape, and roof eaves are other passive design strategies of the project. Another passive design and climate regulation focus are the 4 square basins in courtyard garden, designed for air cooling, that help cool down the exterior/intermediate areas, through evaporation, and creating cool breezes. While the oval basins collect and purify rainwater that is stored in an underground tank, and distributed to courtyard. The rain water is collected and cleaned in an underground tank, under the exhibition hall courtyard, with capacity of 100 m3. And afterwards it is sprinkled over the botanical garden. [On the museum building, the collected rain water is discharged to the ground and slope directly, without further storage]. The system is also connected with water and effluents environmental performance, as "we set up the water circulation not to let drainage and dirty stuff back into the nature and to clean them".

This system concept is original to Naito architects, as Kambayashi explains and it also entails a more ambiguous, abstract meaning: "But this woods, this botanical area is like "live" world. In "live" world. And "death" world as counter part of "live" world. Naito wanted to express life and death in this area. Here is life world and here is death world. He wanted to express it." [Probably the contrast between the vegetated areas and the flat surfaces and materials of square basins, or the building itself.] The design team has also collaborated with the local artist from Kochi, Kyoji Takubo (1949 -), who often collaborates with architects. [He has designed cast iron pavement blocks for some of the square ponds in the Exhibition Hall courtyard garden. "First mold was shaped by stone, then it mold iron into stone shape of cast iron."]

Regarding the actual image of the inner garden of the Research Building, Kambayashi recognizes that the bamboos [the vegetation] have become the main actors and icon of the project. Although they were still quite small at the time of construction [in 2000], 14 years later the "plants are main casts of this building. The building is sub-character and the plants are main." co-existing and harmonizing together.

The intention to harmonize building and natural environment is a very important factor in this project, as Kombayashi explains, referring to the insertion of the museum complex within the mountain. But as he refers, "even in the case of the town, we, designers, have to think about how to harmonize the building and its surrounding ambient." The development of the project had this rule in consideration.
Kombayashi summarizes the more relevant Local Ecosystem Services and Functions taken in account in this project as: Water cycling and regulation, Biodiversity and nursery habitats, Perceptive environmental modulation [particularly Light], and Landscape aesthetic fruition. And the related Architecture quality parameters as: Energy cycle and Water cycle [Sustainability], Concept originality [particularly of shape], innovation and creativity, Humidity and temperature, Structure stability and design, Durability and maintenance of systems and materials.

He emphasizes that Humidity and temperature is a very important factor in this specific project, due to the functions/program as museum, and the requirements for exhibition space. He reiterates the dominant influence of wind [calculations] in the design process, and adds the relevance of maintenance and durability of materials, to respond to a harsh environment, with heavy wind and rain, and interaction with plants. "If resin outcomes from tree, it erodes the metal. […]. We paid most careful attention to choose material for this part."
He also interprets the impact of the project in terms of Sustainable Life-style support systems: "[…] this building located on Mt. Godai san is a part of the nature and a factor of mountain environments. So we cared that the building doesn't insist its own existence and tries to be modest against nature. It might be different from life style, but as the attitude of the building, it's a part of nature. […] Looking from the bottom of the mountain, we can see the building as a part of scene. It means that this scene exists here as everybody's property and scene in daily life, so the scene of Mt. Godai san and this building is Kochi people, everybody's property. So we thought a great deal of this beautiful scenery."

Pasona Urban Farm
Yoshimi Kono [president and founder of Kono Designs in 2000] has been living abroad, for 25 years and has settled his practice in New York. He has designed and followed the construction and post-occupancy of the project of Pasona Urban Farm, with regularity, travelling to Japan "Depending on the projects. Maybe every other month."

The project derives from an early urban agriculture experience of Pasona's Group in its Otemachi headquarters: PASONA O2, an Urban Underground Farm, active between 2005-2009, with 1000 m2 of underground farming, that as attracted numerous visitors. As Kono explains the concept of urban farming it was already a pre-requisite in the client's brief/program, when the firm invited and contracted the design team, to renovate the existing 50 year old building. The design process was then supported by extensive resource to "all different consultants, and professionals from agriculture", regarding design decisions about "which vegetables and where to grow", the place, mode of display, cultivation and irrigation and connection with other functional spaces and requirements.

Kono states that "it was an interesting exercise as architect, to build such a building." Kono introduces the project with a perspective on its social and economic impacts, rather than its environmental sustainability, stressing the importance of the fact the client is a human resources company. In a scenario where the number of farmers is decreasing in Japan, "we are trying to cultivate the farmers for the future." But "When you look at this building, we are spending energy." he says with self-awareness.

Yoshimi Kono names the rice field as his favorite part of the project, although it has been removed, in the aftermath of the great 2011 Tohoku earthquake and subsequent energy saving policy. Installed in the entrance lobby area, "the rice field was the main feature of the project", but the consumption of light to feed it, was about 7000lux, conflicting with the electricity saving *setsuden* [節電] in the summer of 2011. [He then points to the corn field – also lighted with metal-halide lamps - as his second choice, where he is photographed].

The conciliation between the technical requirements of contemporary office space and urban farm, with the constraints of the existing building structure, and available budget, and with the sought design aesthetics played important roles in this project. Kono confesses with a laugh "It is a difficult project for me.", when asked about the conciliation of his minimalist approach, present in other projects, with the integration of vegetation either in building envelope as indoors. Referring to the technical support needed for plant growth indoors, he assumes "in the beginning, I tried to hide everything." For instance, in the meeting room, where tomato plants cover the ceiling, it was attempted to avoid the installation of humidifiers and adopted a mist pulverization system that would regularly spread mist over the crops, but which later was proven insufficient. Soil substrate planters, hydroponics and aeroponics fixtures, as well as irrigation means were carefully avoided from sight or integrated in furniture.

Another concern for indoor urban farms was the selection and location of lighting systems [varying from LED, metal halide, and fluorescent], according to plant needs, and "also the distance between the plant and the light source", which Kono states he has learned with this project. [metal halide, which consume a great extent of energy, with powerful light, allow a greater distance, like in the corn or rice field; close distance fluorescent lights can be use in certain conditions, like in ceiling crops; while LED can be used, with energetic efficiency advantage, for plants that don't require abundant light sources, such as salad leaves, as lettuces, that grown in Plant Factory room]. Also, it was also necessary to adapt not only brightness but radiance and light color [color temperature].

Another central aspect was to accommodate and adapt the existing building structure to basic program and comfort requirements, with its large beams and low ceiling. Not even referring to the urban farm requirements, Kono's first impressions of the building were that "it was impossible to design". For instance, in office areas, it was difficult to find space to integrate all the HVAC ducts that didn't not exist previously. In some cases, it was impossible to install the HVAC systems within the ceilings in order not to lower the limited room height ["Maybe we just lowered 5 cm […]"], and all the ducts were installed within the walls, that were made thicker. Budget restrictions also have impeded over indoor finishes in private office floors [sometimes leading to leave bare ceilings and walls, with just a coat of paint – that allow to "see this is an old building, and the history of the building. […] how many times they changed in the past 50 years…", leaving fixture holes at sight.

Extensive consultation was necessary to decide which vegetables and edible plants could be installed and where. Also, there was limitations to what possible structural loads could be impose on the building with soil planters, so deep soil cultures were avoided, and shallow soil options utilized, sometimes with the addition of extruded polystyrene foam, or with coconut mats to hold plants roots. In addition, irrigation pipes had to be installed all over the building, with monitored drip irrigation systems, according with plant irrigation.

The interaction between food crops and organization of office spaces and other program functions was a fundamental part of design. Regarding having plants growing amidst working spaces, Kono refers that it is much easier to combine it in the meeting rooms and areas in the 1st and 2nd floors [Urban Farm exhibition], rather than in the other floors. "At first, we wanted to have some plants growing in the middle of the office areas, but after they grow, they need someone to pick them up." and the regular maintenance of the crops would end up interfering with the office work, as Kono explains. "We had the plan to grow [plants] on the ceiling here, before, but we have not done yet because of the maintenance. Very difficult to do it. Because people are using it during the day time, but you have to take care of the plants, so someone have to come early in the morning, or late in afternoon, you know, late night."

Besides of the necessary articulation of lighting levels, the installation of plants over walking areas and permanence spaces is more difficult, due to the regular mist to humidify the plants, as tomatoes.

However, other spaces integrate non-edible plants: as the cafeteria, the balconies, and every elevator landing.

Regarding water cycle, Yoshimi Kono confirms that there is no rain water collection or treatment system installed in the building, although it was planned in the beginning but cut out for financial and legislative reasons. Then, the water for plant irrigation adds to the building water consumption, although sometimes a recirculation system of water and nutrients is possible, as in the case of salad leaves growing in trays [water circulating from top tray to bottom, and then reversely].

Regarding, the benefits to health and wellbeing of the building occupants, Kono refers to the air quality measurements taken in post-occupancy, that show evidence of better air levels in spaces with plants. However he stresses that "most of the benefits is that you see the growing vegetables every day, from 9h to 5h", and that it is very difficult to quantify both contributions to human health.

Another mentioned contribution is the impact of the building in Tokyo urban landscape, to passersby and inhabitants: "[…] the great thing here, this is in the middle of the metropolitan Tokyo and business district, and usually people are walking very seriously. But after this building is finished, people were looking at it, and smiling, and talking about the flowers. […] And people enjoy the changing of the seasons." In this point, the exterior green wall, acts as a prolongation from the indoor urban farm, and species, as *fuji* (wisteria), with its purple blooming in spring, mark with its specific colors the passage of the seasons. "[…] today, some plants continue to grow up [at one level can see the plants for the floor below]. Visually it looks like a big mountain!"

Although, the green wall is seen as an achievement on the exterior, Kono shows some reluctance to accept the necessary changes to the initial plan: "Of course we would like to install these [planters] on top of these [beams on the balcony]. But the building required […] something not necessarily fancier, because of the management company." And "Actually, initially, we had the plan to cover everything [on balcony floor]. And that we had outside plants, and the inside plants, both. […] But there was lack of the budget, we could not afford these." The mist irrigation system was nonetheless installed: "In the morning, not only gives you water, but also all that dust that accumulates on the top of the leaves, they clean it up, like rain. So, because we had the plan to plant more greens in this [balcony inside] area, that's why there is the mist here. But in this [outside climbing plants] area, there is rain, so they don't need it."

Social aspects, and the different interaction with building users are also central in Pasona Urban Farm.
Conflicts between design team and user customization occasionally arise in Kono discourse, as the blend between food supply production and the habit of the company owner to grow flower plants [as in the

rooftop]: “personally, I would just stay with all the vegetables, to give the a concept clearly… but the mixture of the flowers and vegetables, sometimes, doesn’t make any sense, you know, as a urban farm.”

“In the beginning, every floor should have all different kinds of vegetables, also, it is easier to grow just seeds. In this area [referring to the elevator landings], there is not enough light, but we can grow some of the seeds, and then pulling them to the next place, where there is enough light. But that was on the program that we were trying to achieve, but sometimes it is difficult for them to maintain the same program.” Maintenance and continuous project management is referred as necessary for this urban farm program, however “[…] if the person who is in charge […] has a more professional skill for the vegetables, not aesthetically”, it is possible that the aesthetic, organization, and cleanliness projected by the design team might be gradually lost.

The green rooftop, is occasionally available as leisure area for some of the users (including employees), and as a public space for events, and it also has the function to temporarily store some plants that regularly need to be taken out, under sunlight. From the rooftop, skylights open to the floor below, providing natural indirect light.

Project self-assessment through the Ti[l]es framework

The self-evaluation of the projects *Dancing Trees Sing Birds*, *Makino Museum of Plants and People*, and *Pasona Urban Farm* by the respective design team members, through the application of the proposed framework, comprised the indication of the relevant indicators implicated in the design integration of local ecosystem services and functions, and the enunciation of the more relevant collaborative interactions between pairs of ecosystem and architecture criteria.

The results obtained with this inquiry are displayed in the following Figures 88, 90, and , followed by the respondent *a priori* concepts regarding the relevance of the six architecture criteria areas comprised in the TI[L]ES framework towards design quality and the potential connection with local ecosystem services (Figures 89, 91, and 93).

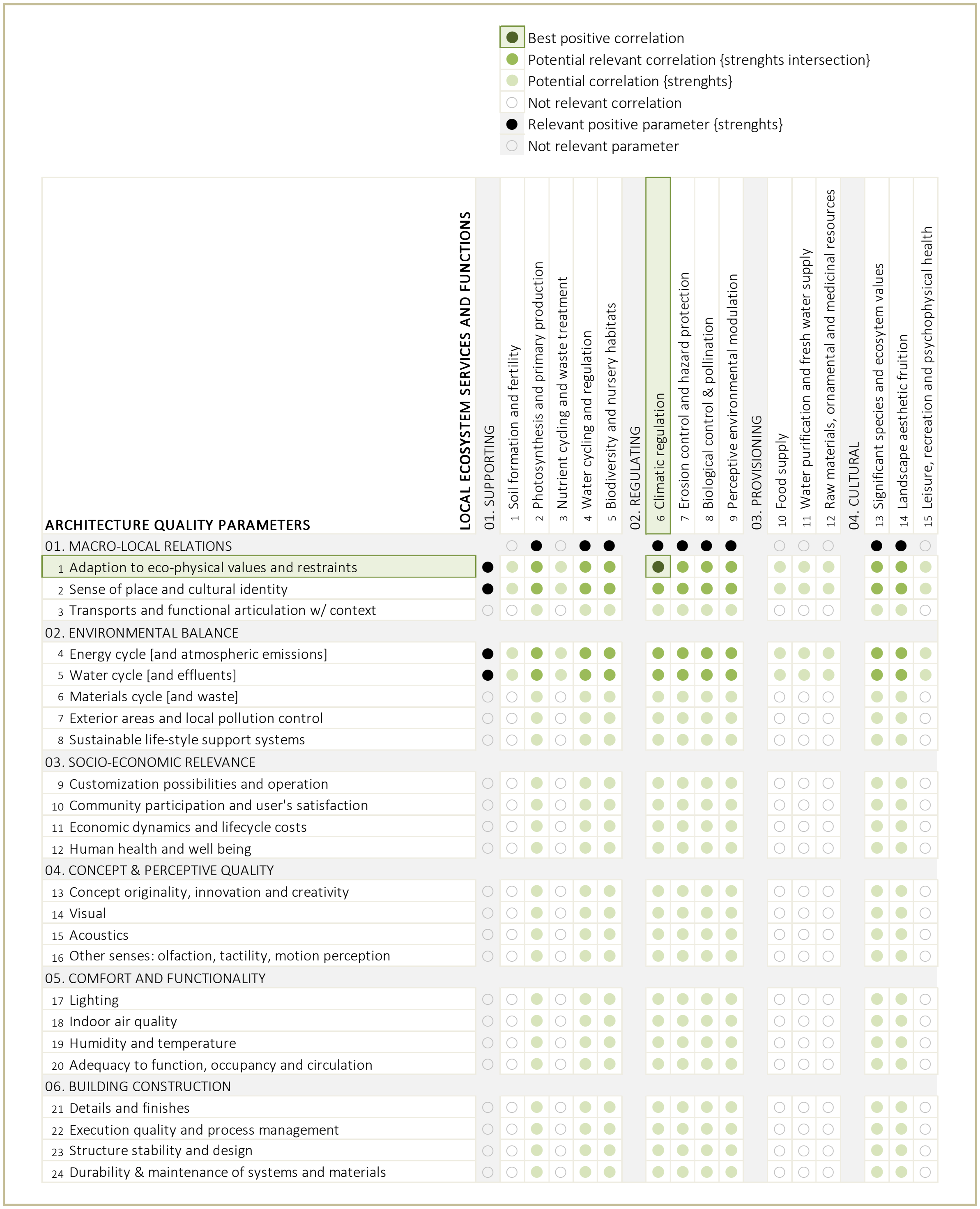


Figure 88. *Dancing Trees, Singing Birds* Interpretation Profile from Interview with Hiroshi Nakamura

1) Relevance of Architecture Quality Areas and 2) Connection with Local Ecosystem Services:

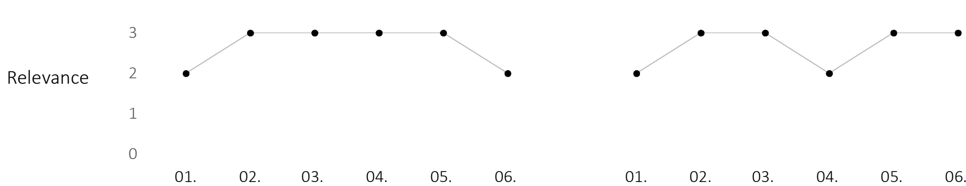


Figure 89. Interview with Hiroshi Nakamura: respondent pre-concepts

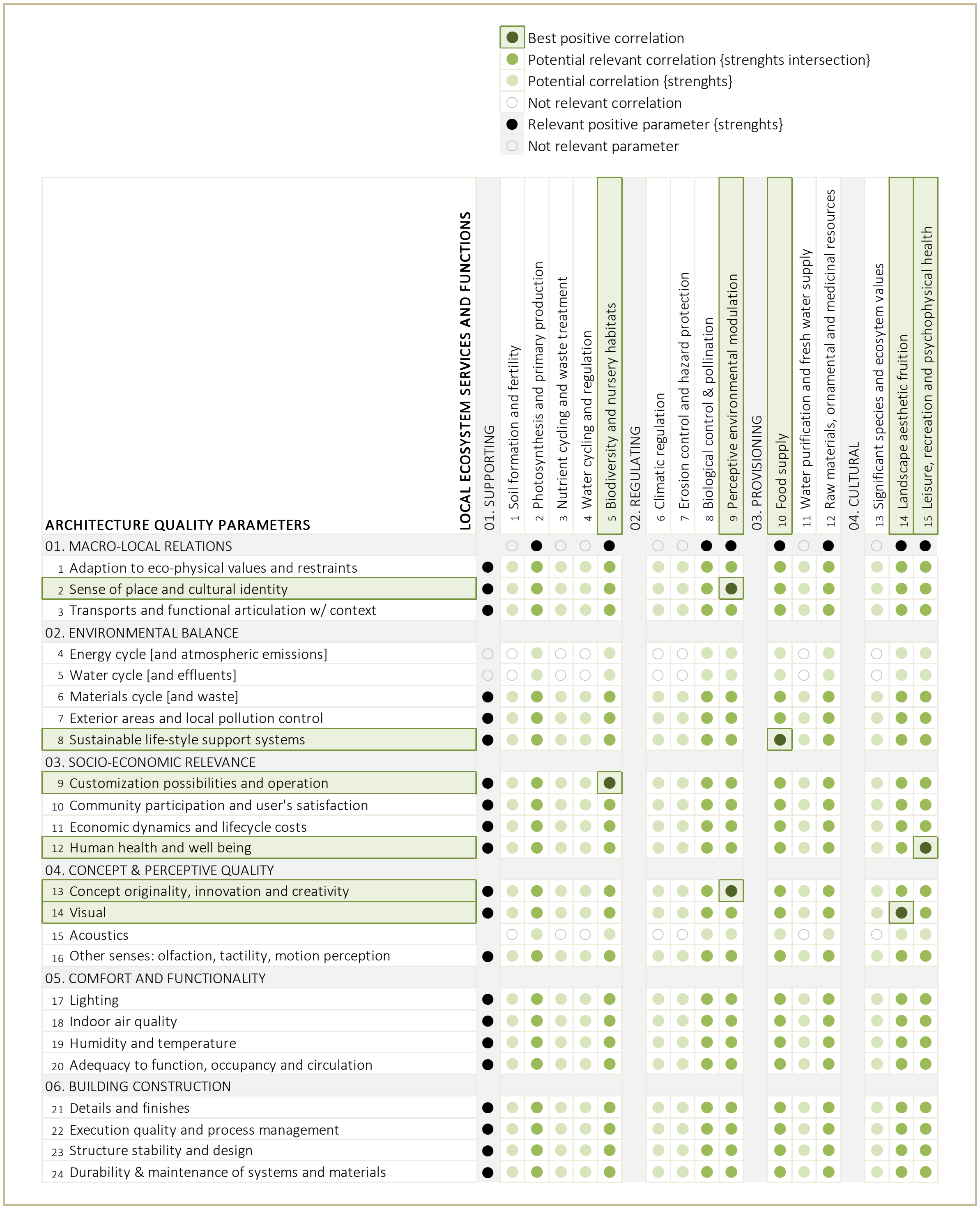


Figure 90. *Pasona Urban Farm* Interpretation Profile from Interview with Yoshimi Kono

1) Relevance of Architecture Quality Areas and 2) Connection with Local Ecosystem Services:

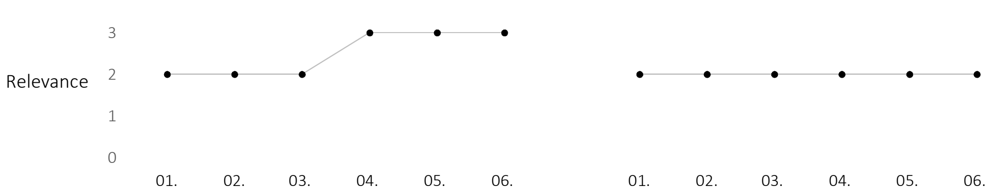


Figure 91. Interview with Yoshimi Kono: respondent pre-concepts

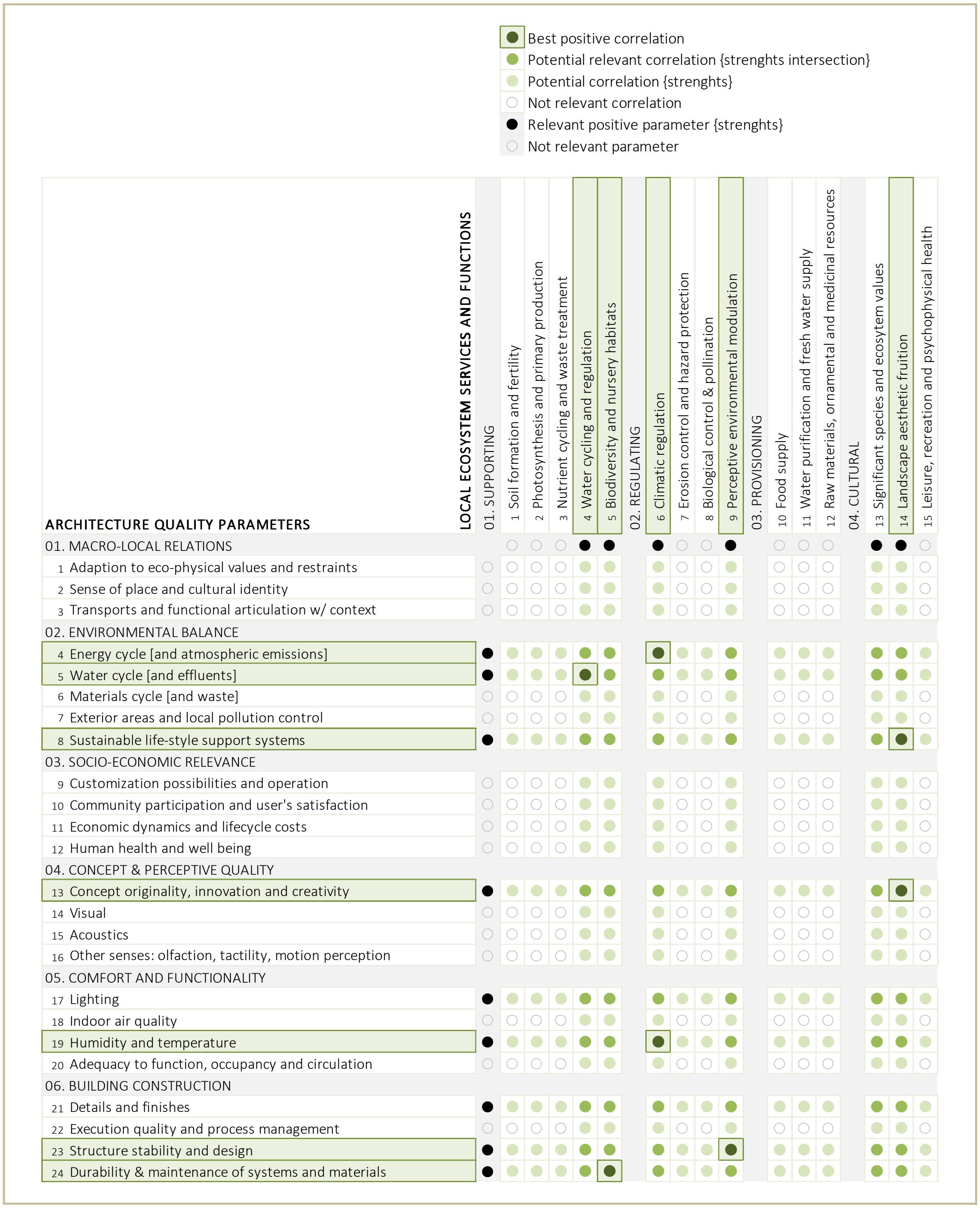


Figure 92. *Makino Museum of Plants and People* Interpretation Profile from Interview with Tetsuya Kombayashi

1) Relevance of Architecture Quality Areas and 2) Connection with Local Ecosystem Services:

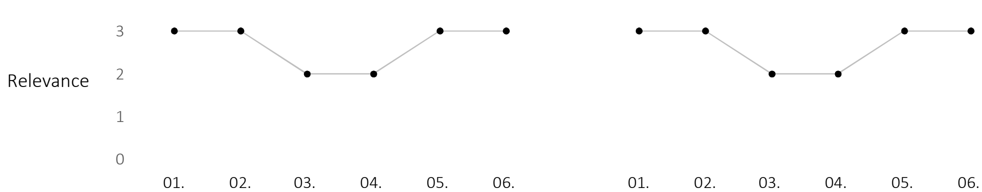


Figure 93. Interview with Tetsuya Kombayashi: respondent pre-concepts

8.4 Application of TI[L]ES framework by Multiple Users: Final Research Survey

The background information collected on the respondents to this survey resulted in a characterization profile of the inquired panel and on its particular perspectives on Architecture Quality and Local Ecology.

1. Background Information | a. Profile of the respondents

a) *Field of Study*. The inquired panel of respondents originate from the following interrelated specialization fields: Architecture Design, Urban Planning, Landscape Design, History of Architecture and Environmental Sciences (including Environmental Engineering, Climate Change and Ecology). The mode of the respondents study field (63%) is Architecture Design.

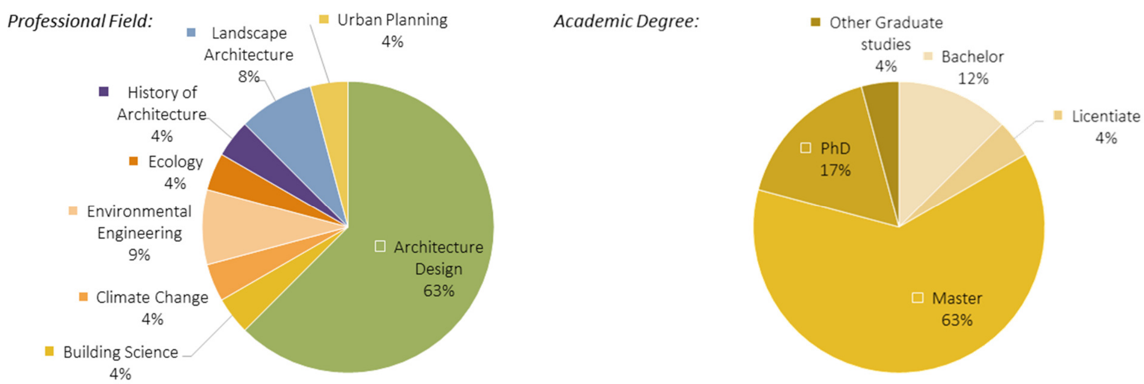


Figure 94. Professional Specialization Field and Academic Degree of the Respondents

b) *Academic Degree.* The educational background of the inquired panel is exclusively of higher education, ranging from: Bachelor, Licentiate, Master, Doctor and other Graduate Studies. The mode of the respondents' academic degree (63%) is Master.

c) *Work Experience.* The time of work practice attained by the respondents range from 0 to 20 years. The average and median of work experience detained by the inquired panel is 7 years.

d) *Present Occupation.* The present occupation of the respondents ranges from academic to practice positions, including: Architect, Consultant, Professor, Researcher, Graduate Student and Others (non-specified or non-related activities. The mode of the respondents (29,2%) is Architect. Academic positions account for 46,6% while professional practice positions share 41,7% of the total.

e) *Country.* The inquired panel include respondents from 12 countries in Asia, Europe and American continents, with predominance of European Union (EU).

The typical profile of the respondent is a Master in Architecture Design, with an average of 7 years of work practice [or between 4 and 8 years of practice], and currently working as an Architect.

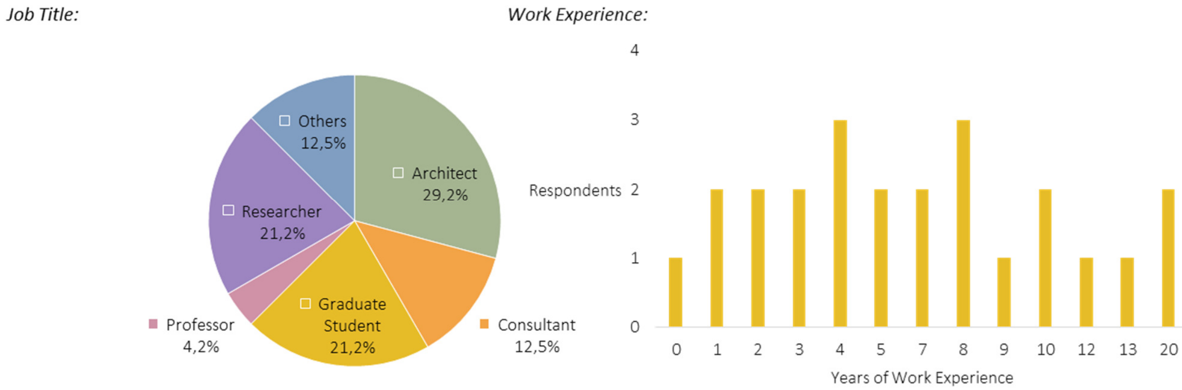


Figure 95. Present Job Positon and Time of Work Practice of the Respondents

Figure 96. Country of Origin the Respondents

f) *Selected Project.* The 24 obtained responses within the inquired panel are nearly evenly distributed per selected project, with a slight preference for Dancing Trees, Singing Birds [37,5%]; followed by Makino Museum of Plants and People [33,3%], and Pasona Urban Farm [29,2%].

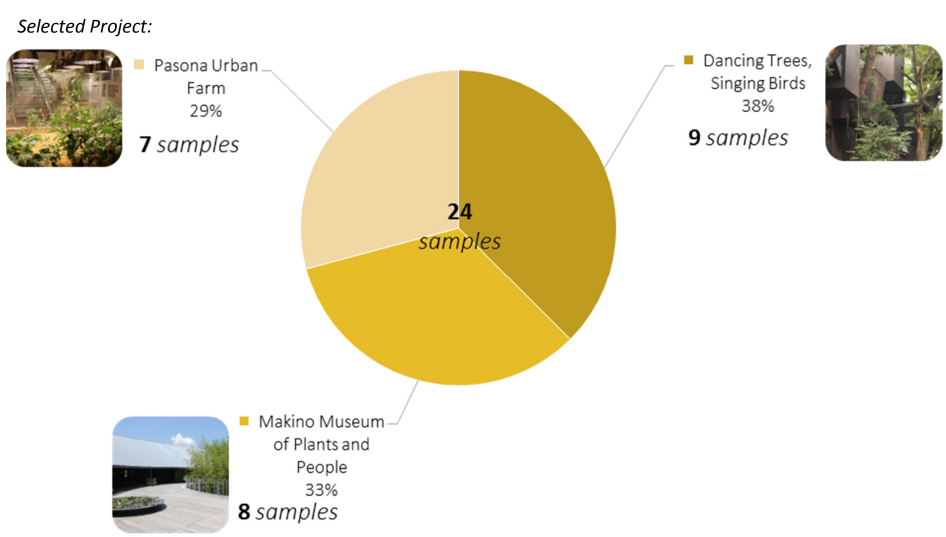


Figure 97. Selected Project by the Respondents for application of TI[L]ES questionnaire

g) *Previous Knowledge of Selected Project.* The majority of the inquired professionals demonstrate no previous knowledge of the case study (75%), while only 25% of the respondents knew previously the selected project. In the case of previous knowledge of the case study, the most common form of stated information was "from magazines, books or online sources" [3], while less respondents knew the case study "from direct observation on site" [2], and "from technical design materials or case study sheets" [1].

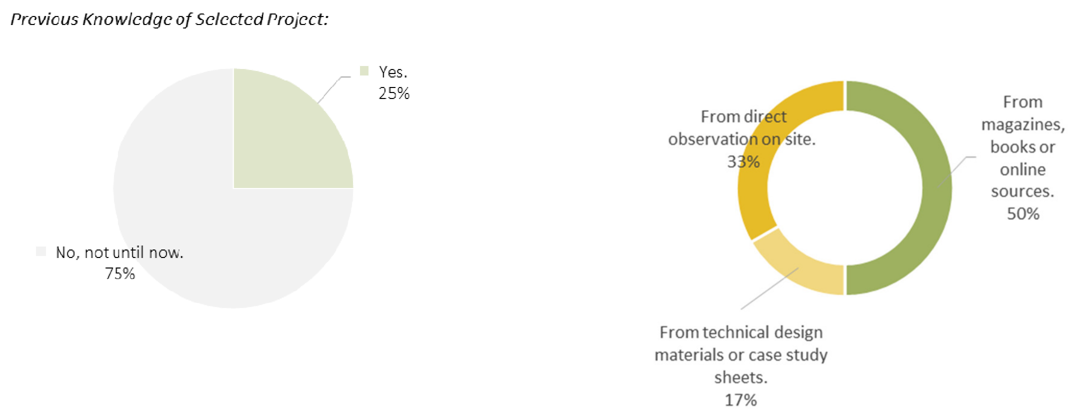


Figure 98. Previous Knowledge of the Respondents about their Selected Project

1. Background Information | b. Perspectives on Architecture Quality and Local Ecology

a) *Perspective on Architecture Quality.* The inquired panel attributed in general, medium to high relevance to all the areas of architecture quality parameters. Intrinsic Architecture Quality (AQ) Areas have scored higher relevance values, overall, than Extrinsic Architecture Quality Areas [although Environmental Balance and Concept and Perceptive Quality received similar intermediate values]. In addition, Extrinsic Quality Factor Areas also show more dispersion in the answers.

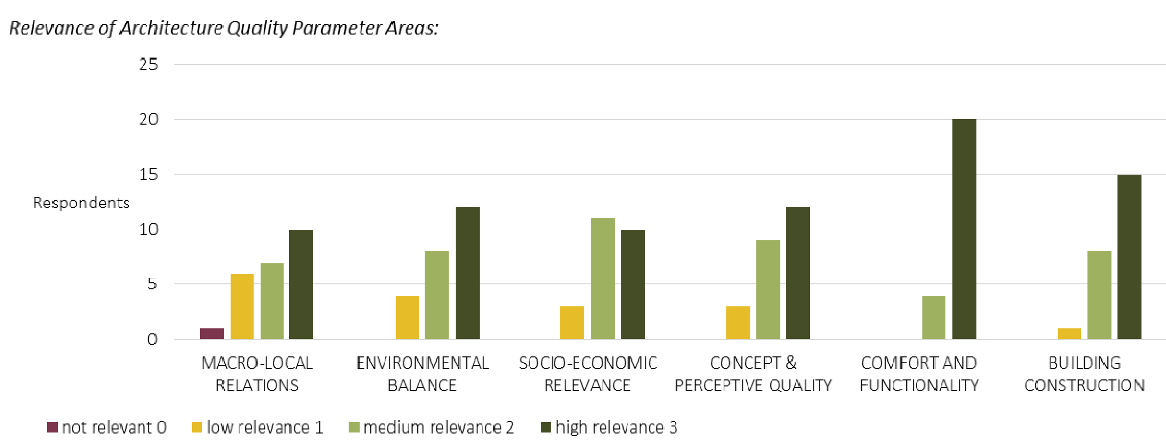


Figure 99. Relevance attributed by the Respondents to Architecture Quality Areas

Comfort and Functionality (followed by Building Construction) is the area that scored the highest relevance with 20 answers attributing it level 3 (high relevance), with mean relevance level of 2,83.

b) *Connection of Architecture Quality Areas with Local Ecosystem.* The replies show an almost inversion of the patterns in the previous question, with predominance of higher relevance values given to Extrinsic Architecture Quality Areas, including Environmental Balance and Macro-Local Relations. Intrinsic Quality Factor Areas also show here more dispersion in the answers. Concept and Perceptive Quality has very polarized results, either towards low and high relevance.

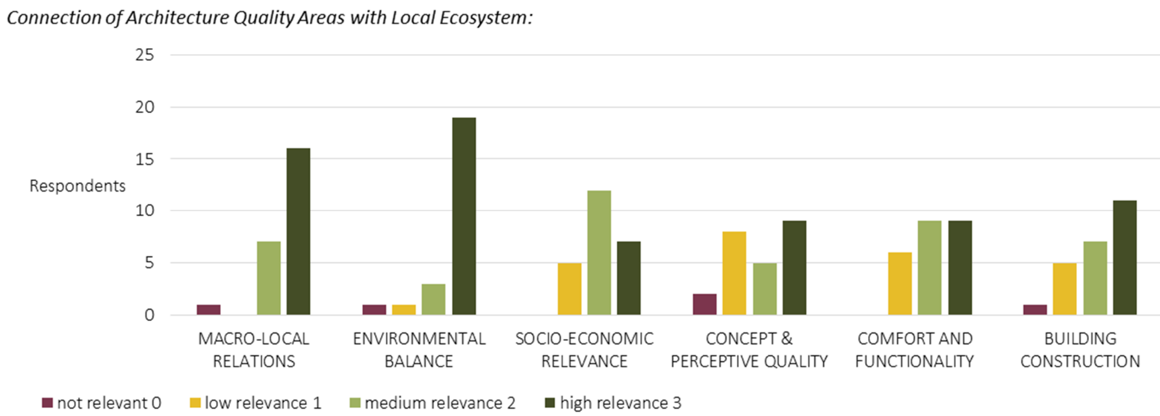


Figure 100. Architecture Quality Areas with relevant potential connection with Local Ecosystem

Environmental balance (followed by Macro-local relations), is the area to which is attributed a higher relevance in the connection with local ecosystem. In both this and the previous question, Socio-Economic Relevance has a very similar answer profile, towards medium relevance.

c) *Relevance of the Promotion of Local Ecosystem Services and Functions within Architecture Projects*. When inquired about the degree of importance of the promotion of Local ecosystem services and functions in Architecture projects, the majority of answers indicated Medium to High relevance, with slight predominance of high relevance (54,2%), followed by medium relevance (41,7%). No respondent answered not relevant, and a short segment answered low relevance (4,2%).

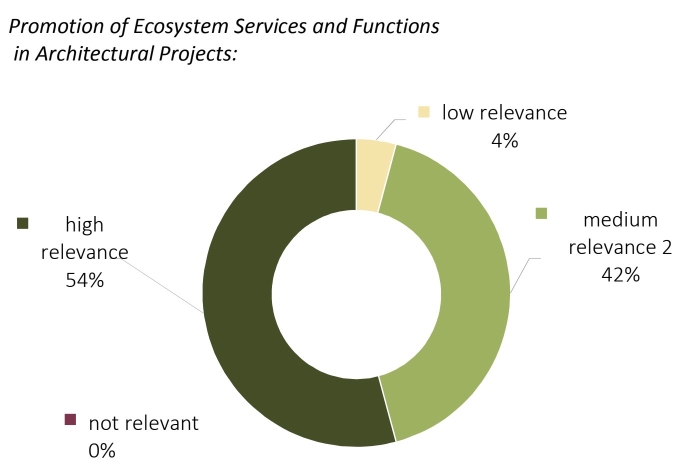


Figure 101. Relevance of the Promotion of Local Ecosystem Services and Functions within Architecture Projects

d) *Comparative Analysis between Groups of Respondents*

In the Figure below are tracked the differences in the groups of individuals that answered to each project, regarding their perspectives towards architecture design quality and the connection of these parameter areas with local ecosystem services and functions.

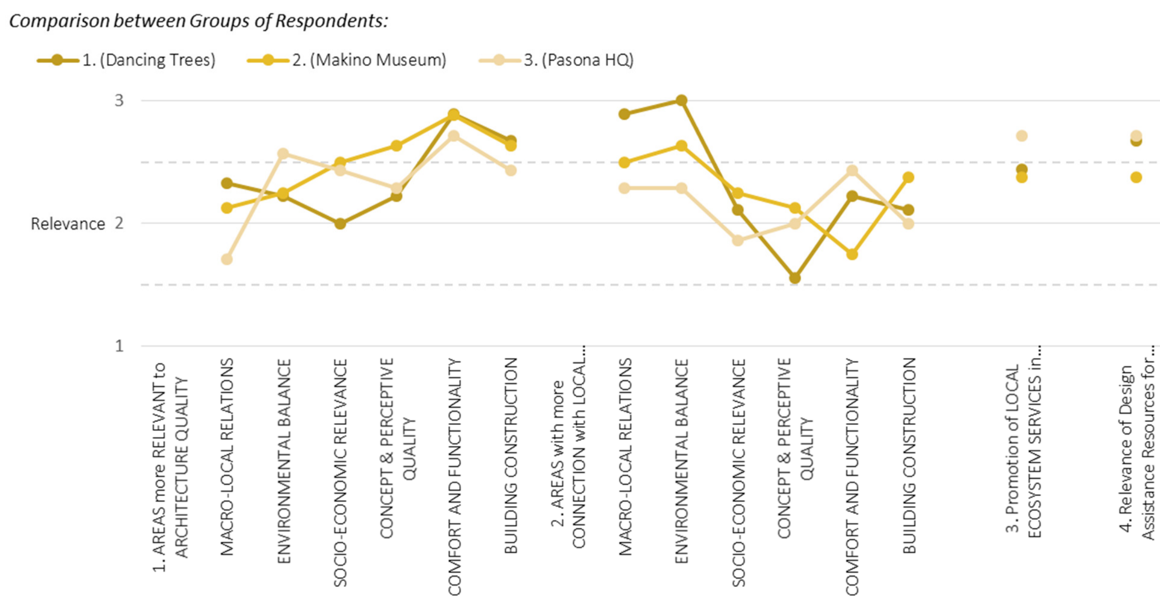


Figure 102. Comparison between groups of respondents regarding their overall perspectives towards ecosystem integration

The answers provided by the respondents for specific project review with the application of the Ti[l]es framework to the 3 study case targets *Dancing Trees Singing Birds*, *Pasona Urban Farm* and *Makino Museum of Plants and People* are described and illustrated, with a brief characterization of the respective respondents profile in relation to the main panel.

2. Specific Project Review | a. *Dancing Trees, Singing Birds*

The respondents that have chosen to analyze this project have a similar background with the main group (the majority have Architecture as field of study, Masters as academic level – though with more higher education diplomas and no lower graduate studies, average of 5 years of work experience – less two years than main group average). In this group less respondents knew the project beforehand (only 11,1%). Present occupation is primarily Architect (33,3%, followed by Researcher and Graduate Student (respectively with 22,2%). The provenience of the respondents is diversified, although primarily from central west Europe, including Brazil and Malaysia.

Regarding their perspective towards architecture quality areas, this group, although attributing the highest relevance to Comfort and Functionality and Building Construction likewise the main group, doesn't emphasize such a clear preference for intrinsic quality areas, attributing a priori more relevance to Macro-

Local Relations and Environmental Balance. Towards the potential connection with local ecosystem, this group follows the emphasis pattern on extrinsic quality areas, with an extremely high relevance attributed to Environmental Balance (3) and lowest to Concept & Perceptive Quality (1,56).

The relevance attributed to the promotion of local ecosystem services and functions within architecture projects is mostly high (55,6%) [with an average relevance attributed of 2,44], similarly to the main group of respondents, but slightly more positive regarding the relevance of the development of Design assistance resources for ecosystem integration (66,7%) [with an average relevance attributed of 2,67].

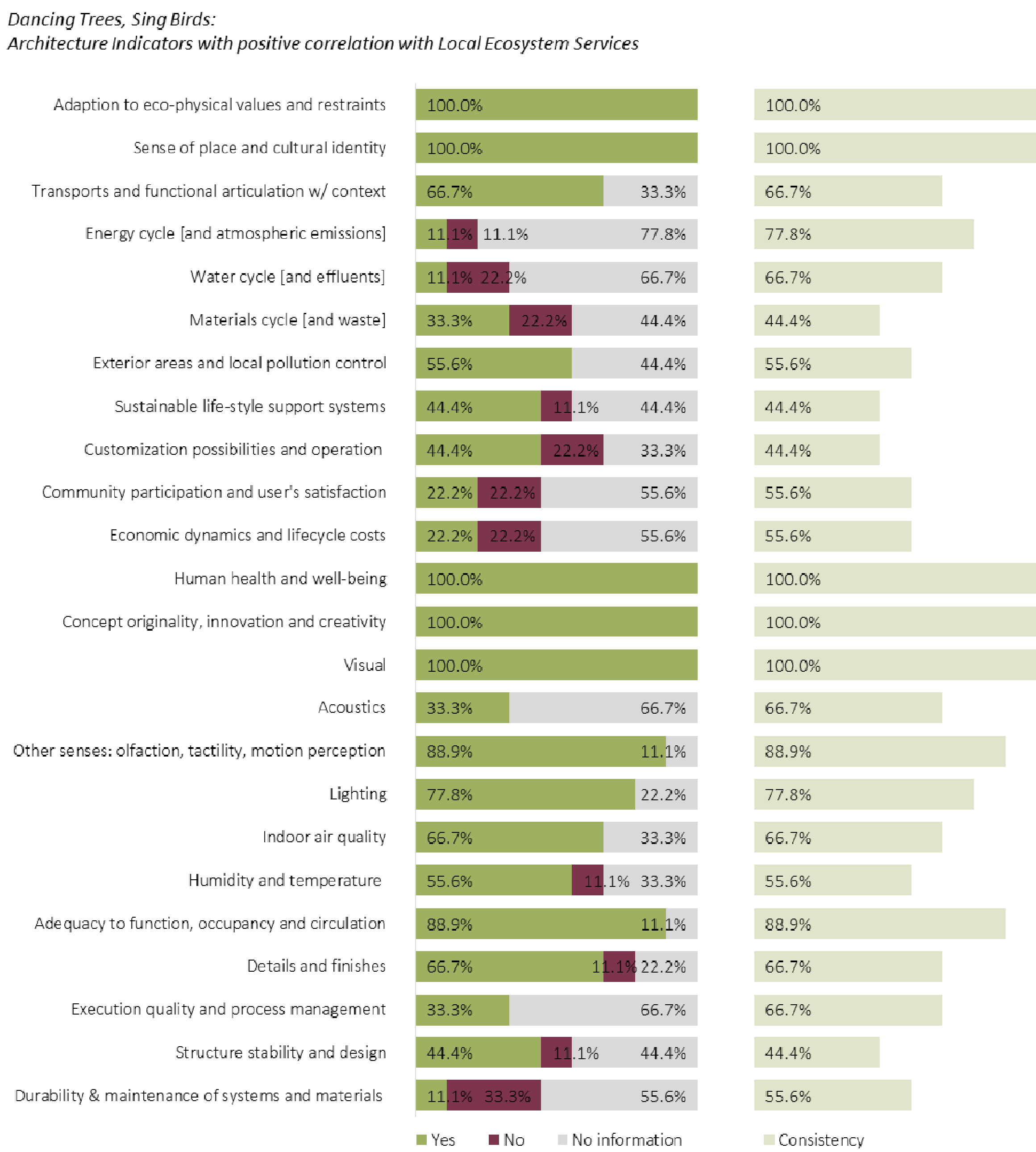


Figure 103. Architecture Indicators with positive correlations with Local Ecosystem Services in the project Dancing Trees, Singing Birds

Regarding the project review of the specific project within the Ti[l]es framework of analysis, the indicated architecture indicators that promote or benefit from local ecosystem services and functions are represented on Figure 103.

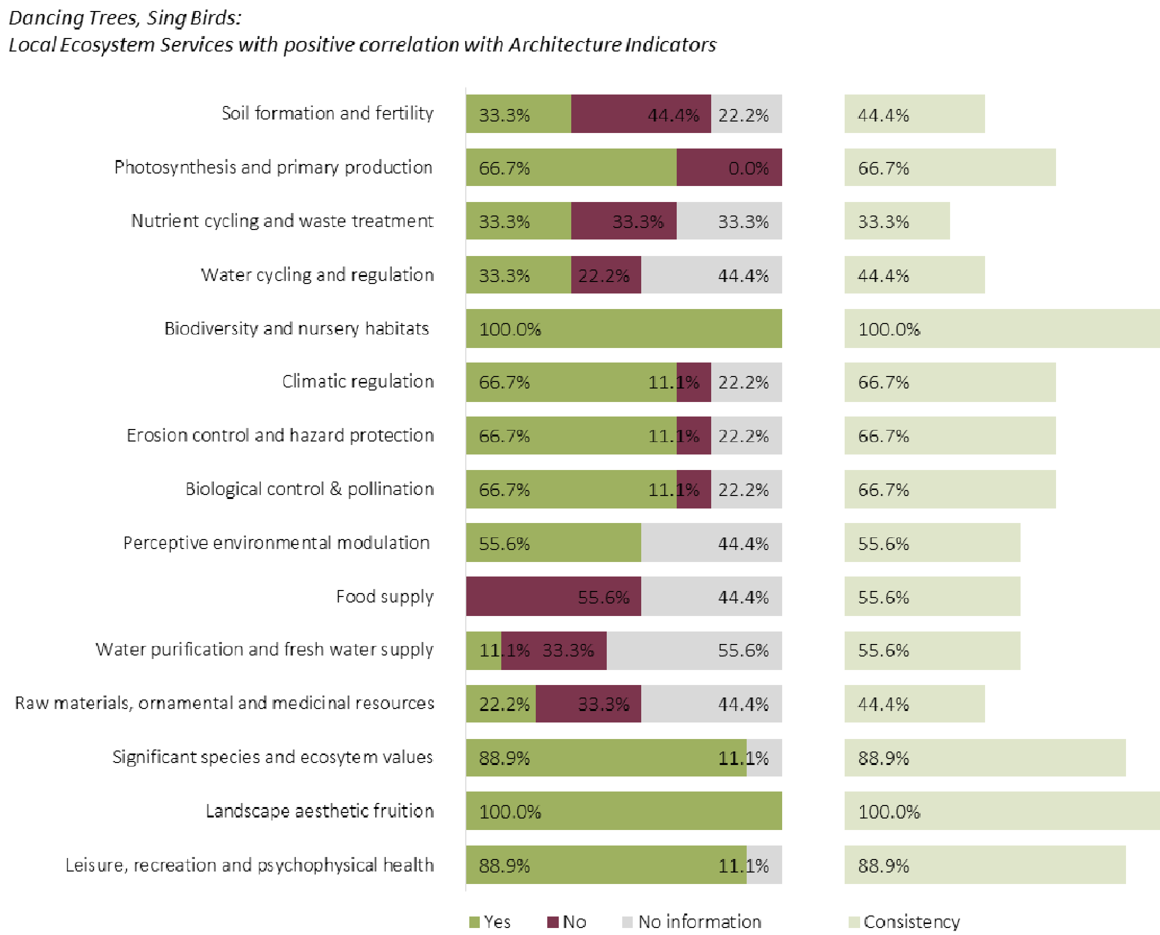


Figure 104. Local Ecosystem Services with positive correlation with Architecture Indicators in the project Dancing Trees, Singing Birds

The overall consistency (agreement) between respondent answers is, among architecture quality parameters, 70,4%, and for ecosystem services, 65,2%. The average for both, is 68,4%.

c. Final review

The respondents considered that in the *Dancing Trees, Singing Birds* project the promotion of local ecosystem services and functions is predominantly of higher relevance (66,7% of the answers), being the average relevance attributed of 2,56 (in a scale from 0 to 3). No respondent considered it *not relevant*, although some considered it of *low relevance* (4,2%).

Regarding the architecture design quality of the project, the respondents considered it predominantly of higher relevance (66,7% of the answers), being the average relevance attributed of 2,56. Likewise, no respondent considered it *not relevant*, although some considered it of *low relevance* (4,2%).

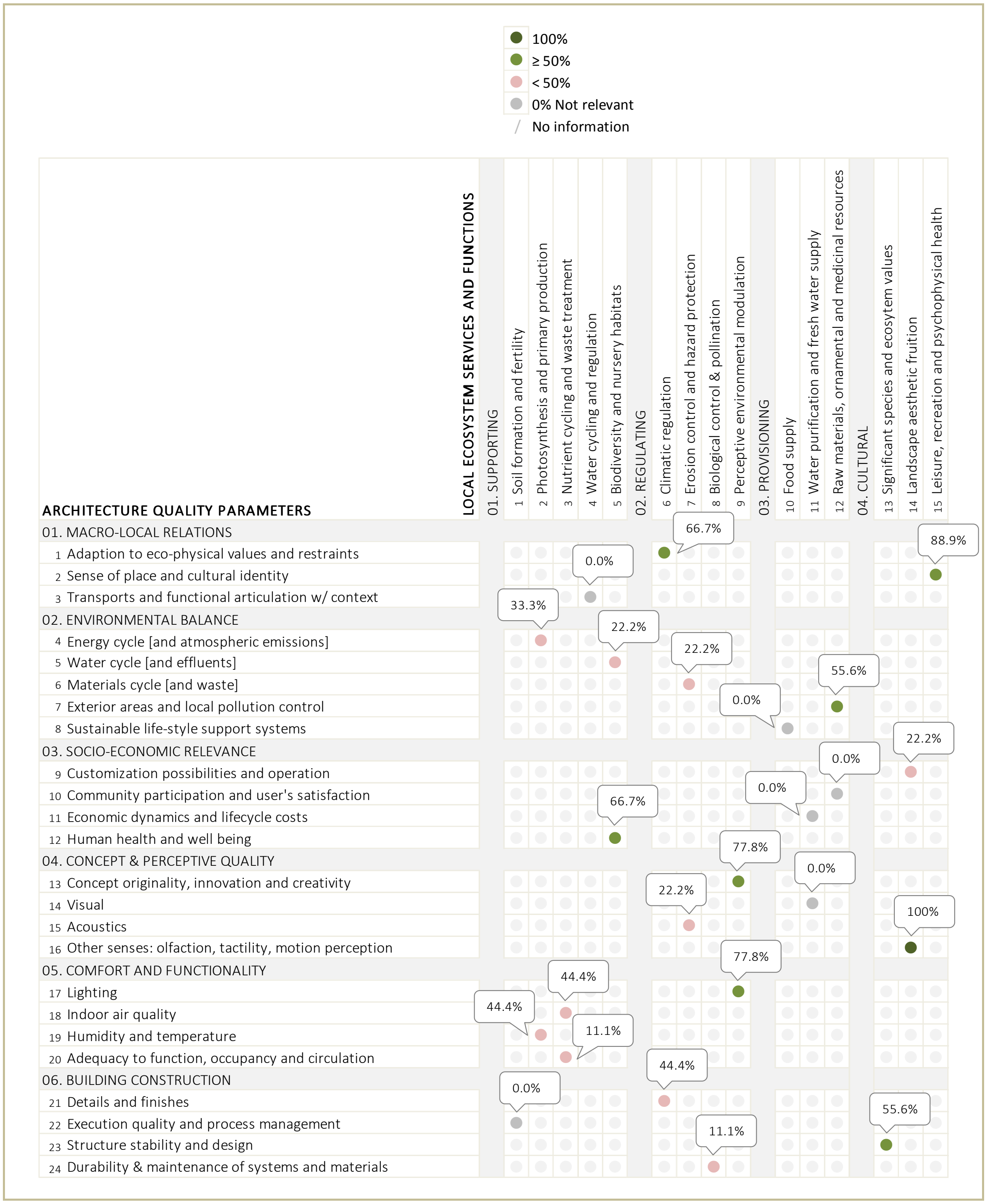


Figure 105. Identification of collaborative (positive) interactions in Dancing Trees, Singing Birds

2. Specific Project Review | b. Makino Museum of Plants and People

The respondents that have chosen to analyze this project have a similar background to the main group regarding field of study and academic level (the majority studied Architecture at Masters level) but with a higher average of work experience (10 years) – more three years than main group average). In this group also more respondents knew the project beforehand (37,5%). The present occupation of this group signals slightly less percentage of active Architects than main group average but more Consultants (25%). The provenience of the respondents is diversified, although primarily from west Europe, including Canada and Lebanon.

Regarding their perspective towards architecture quality areas, this group attributes a similar average relevance to all areas as the one of the main group, repeating the emphasis pattern on intrinsic areas. The exception is the slightly lower relevance attributed to Comfort and Functionality, and higher to Concept & Perceptive Quality, in the potential connection with local ecosystem [although maintaining the highest values to Macro-local relations and Environmental Balance]. Regarding the relevance attributed to the promotion of local ecosystem services and functions within architecture projects, in this group more respondents attribute it medium (62,5%), than high relevance (37,5%) [with an average relevance attributed of 2,38]. They are also less positive regarding the relevance of the development of Design assistance resources for ecosystem integration, where answers of medium relevance (62,5%) also surpasses high relevance (37,5%) [with an equal average relevance attributed of 2,38].

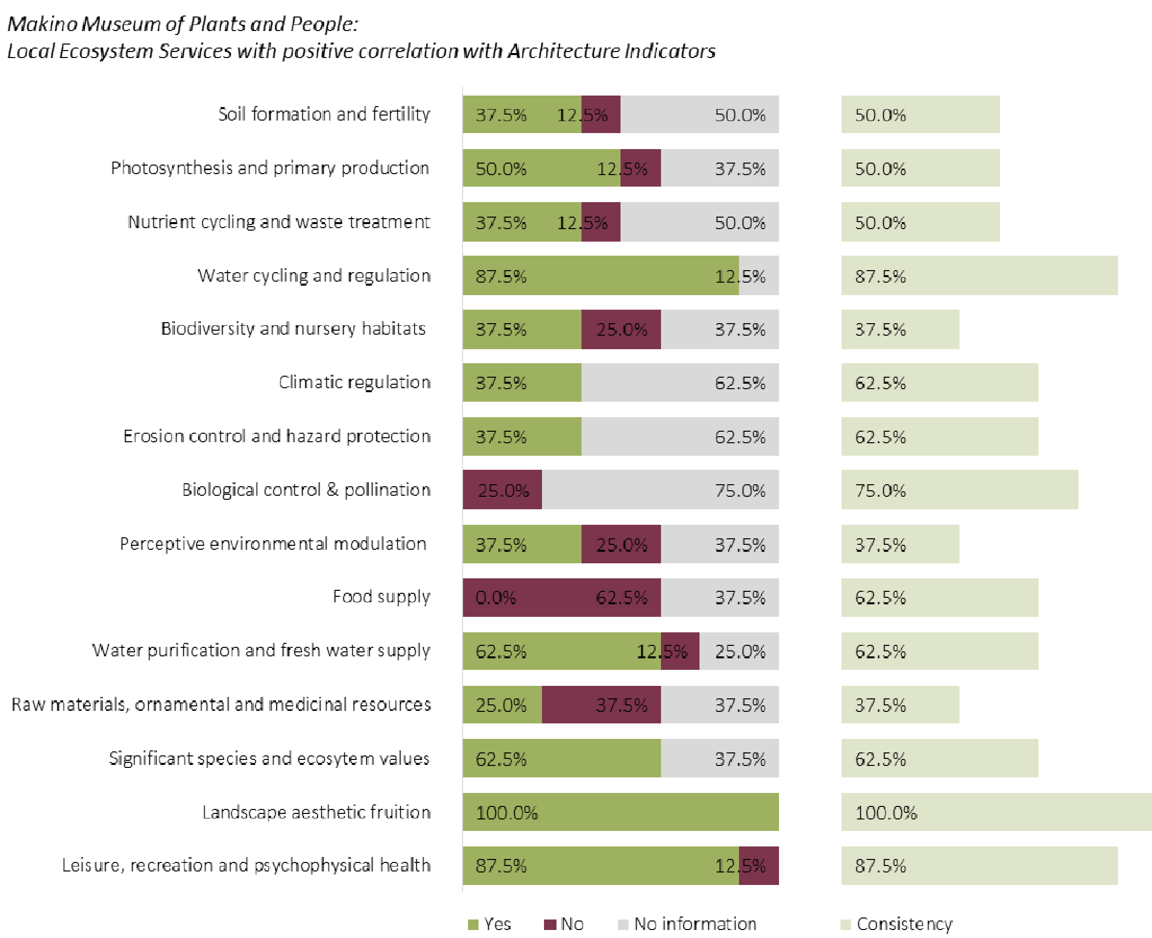


Figure 106. Local Ecosystem Services with positive correlation with Architecture Indicators in the project Makino Museum of Plants and People

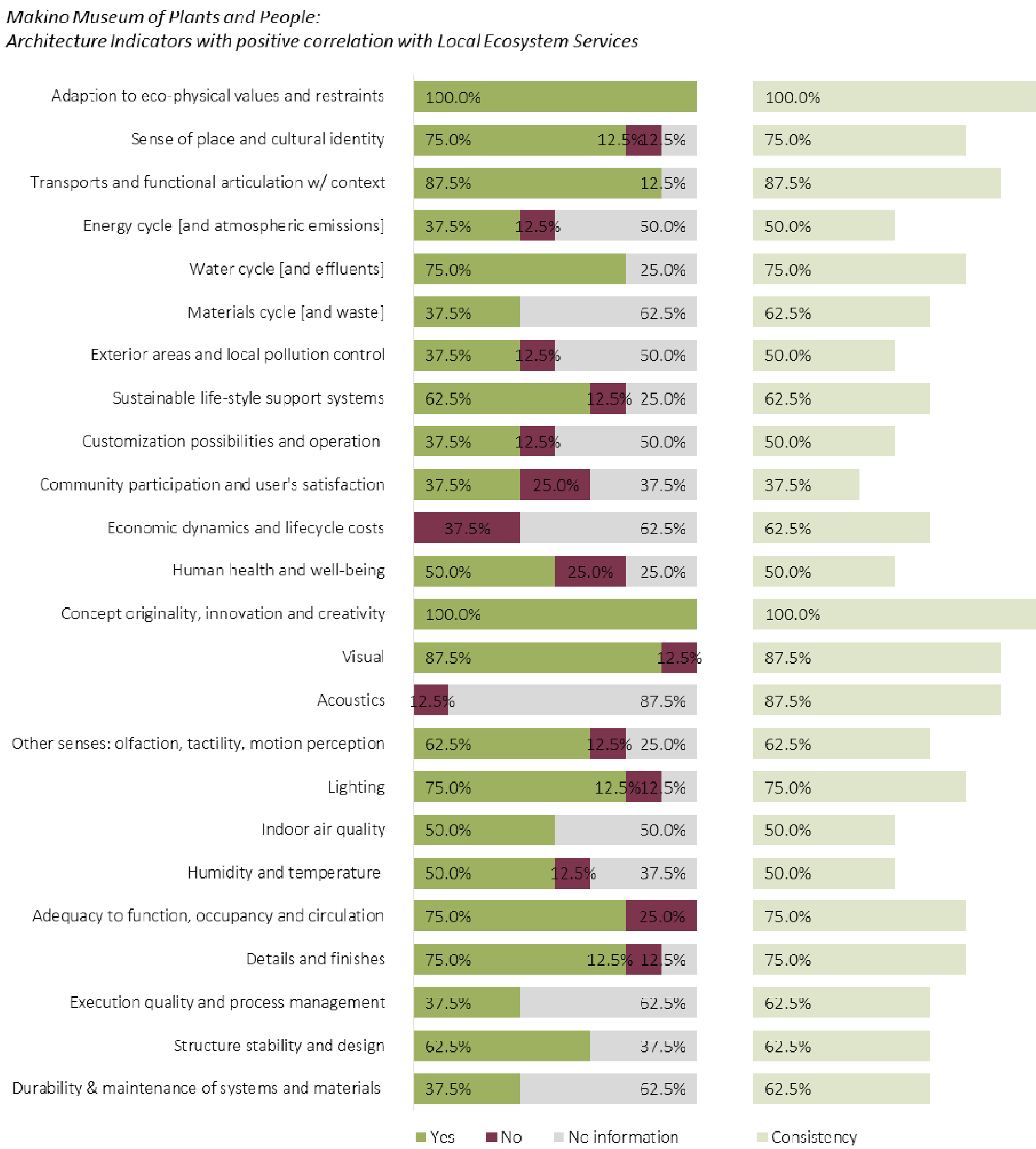


Figure 107. Architecture Indicators with positive correlations with Local Ecosystem Services in the project Makino Museum of Plants and People

The overall consistency (agreement) between respondent answers is 67,2% among architecture quality parameters and 61,7% among ecosystem services. The average for both, is 65,1%.

c. Final review

The respondents considered that in the *Makino Museum of Plants and People* project the promotion of local ecosystem services and functions is equally of medium and higher relevance (50,0% of the answers, respectively), being the average relevance attributed of 2,50 (in a scale from 0 to 3). No respondent considered it *not relevant*, nor of *low relevance*.

Regarding the architecture design quality of the project, the respondents considered it predominantly of higher relevance (75,0% of the answers), being the average relevance attributed of 2,75. Likewise, no respondent considered it *not relevant*, nor of *low relevance*.

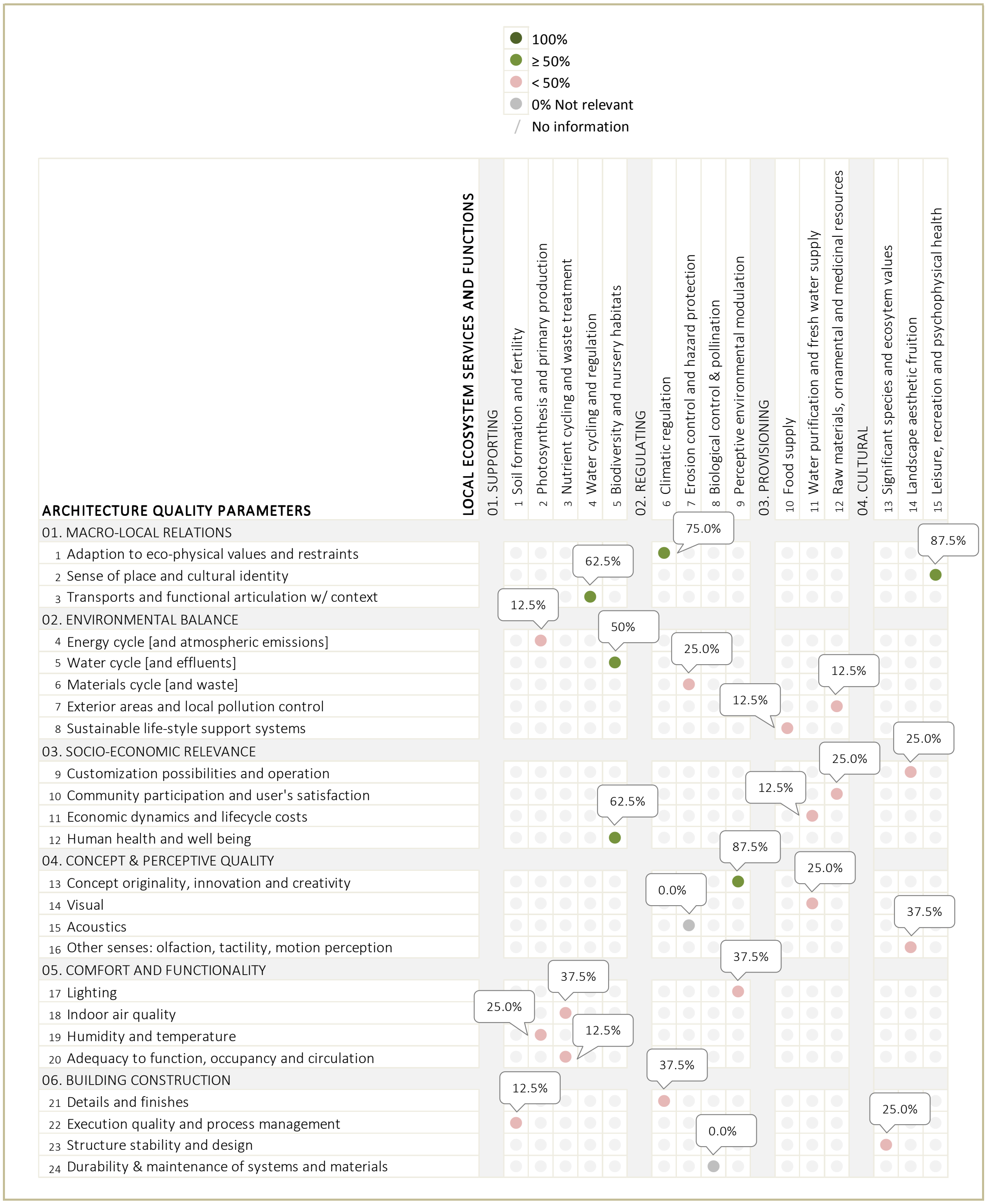


Figure 108. Identification of collaborative (positive) interactions in Makino Museum of Plants and People

2. Specific Project Review | c. Pasona Urban Farm

The respondents that have chosen to analyze this project have a similar background with the main group (the majority have Architecture as field of study, Masters as academic level – although no upper graduate studies, average of 6 years of work experience – slightly less one year than main group average, and similar percentage of respondents that knew the project beforehand). Present occupation is distributed through Architect, Researcher and Others (respectively with 28,6%). The provenience of the respondents is primarily from Europe (Iberian Peninsula and the Balkans), and Brazil.

Regarding their perspective towards architecture quality areas, this group attributes a higher relevance to Environmental Balance (paired with Comfort and Functionality) and Socio-Economic Relevance (paired with Building Construction), and a greater similarity between architecture quality relevant areas and the ones with greater connection with local ecosystem [but with the same pattern of macro-local relations rising in importance]. The relevance attributed to the promotion of local ecosystem services and functions within architecture projects is higher than in the main group (71,4%) of the respondents [with an average relevance attributed of 2,71]. They are also more positive regarding the relevance of the development of Design assistance resources for ecosystem integration (71,4%) [with an equal average relevance attributed of 2,71].

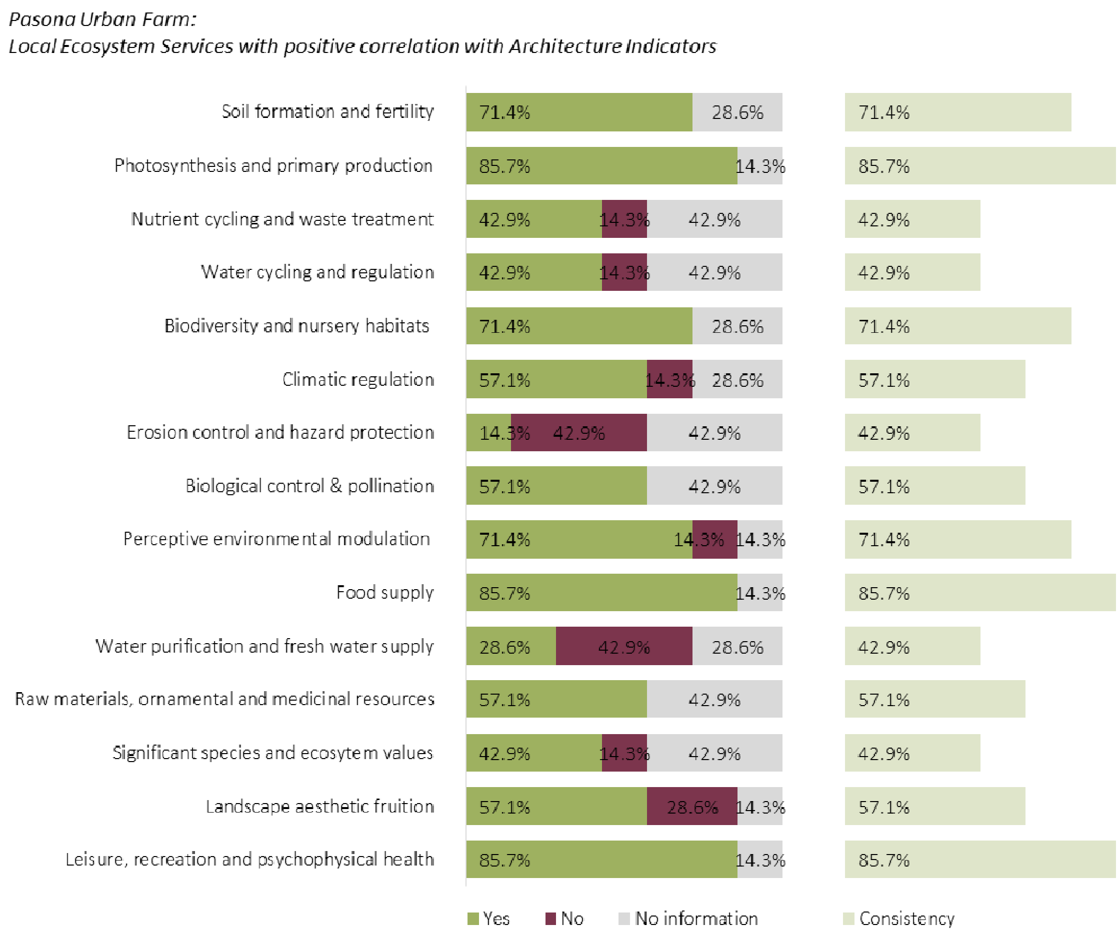


Figure 109. Local Ecosystem Services with positive correlation with Architecture Indicators in the project Pasona Urban Farm

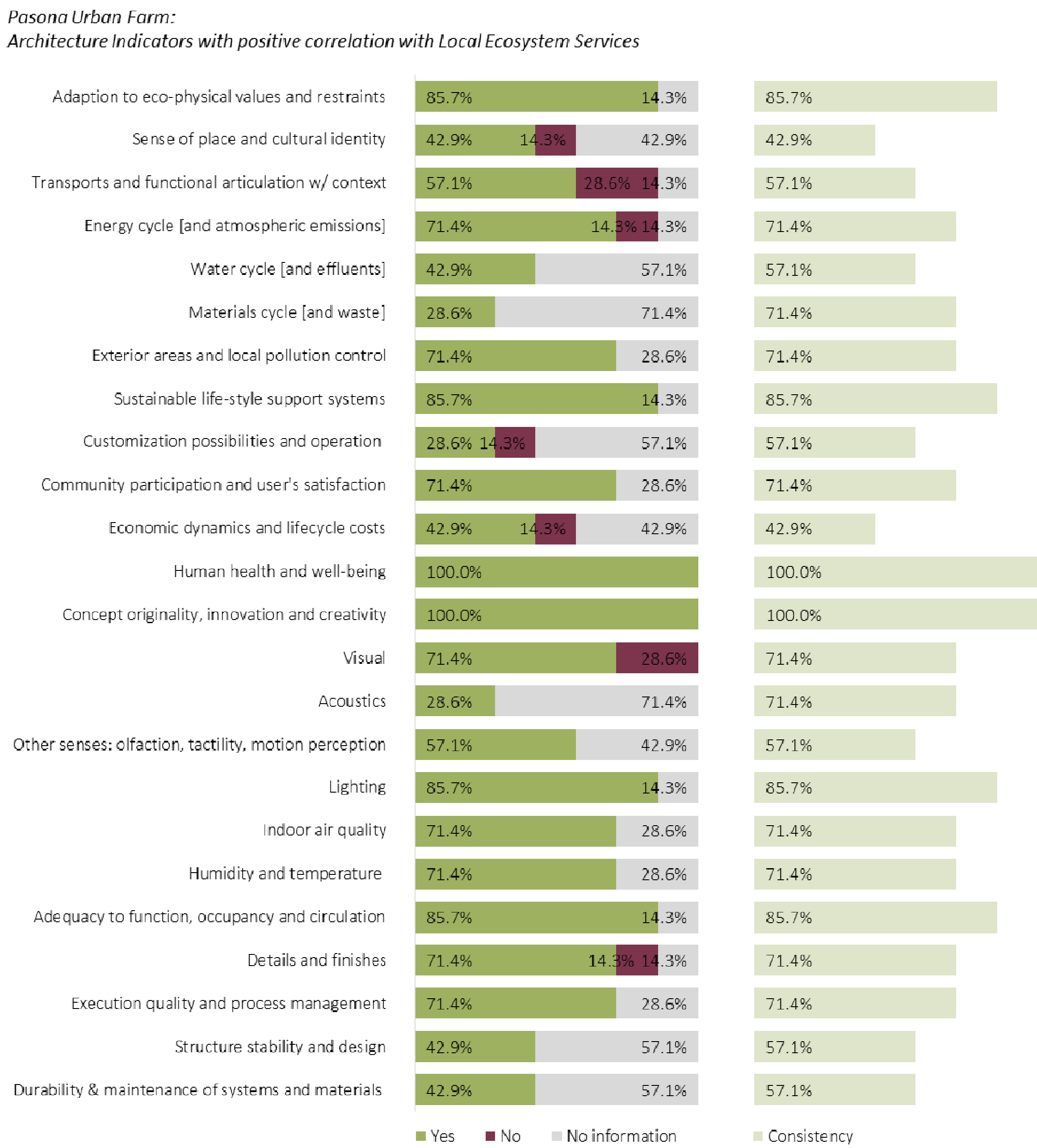


Figure 110. Architecture Indicators with positive correlations with Local Ecosystem Services in the project Pasona Urban Farm

The overall consistency (agreement) between respondent answers is, among architecture quality parameters, 70,2%, and for ecosystem services, 61,0%. The average for both, is 66,7%.

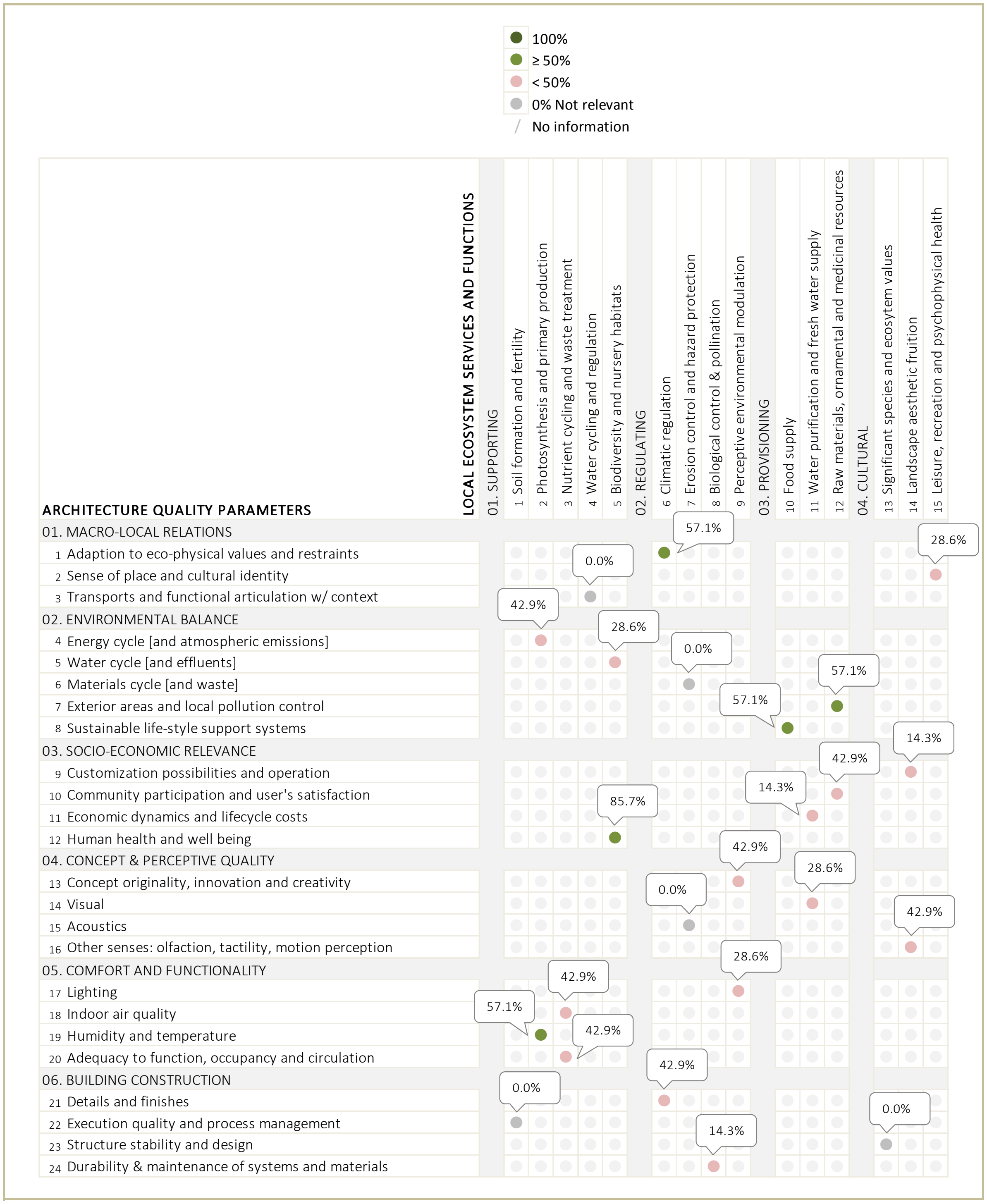


Figure 111. Identification of collaborative (positive) interactions in Pasona Urban Farm

c. Final review

The respondents considered that in the *Pasona Urban Farm* project the promotion of local ecosystem services and functions is predominantly of *high relevance* (71,4% of the answers), being the average relevance attributed of 2,57 (in a scale from 0 to 3). No respondent considered it *not relevant*, although some considered it of *low relevance* (14,3%).

Regarding the architecture design quality of the project, the respondents considered it predominantly of high relevance (57,1% of the answers), being the average relevance attributed of 2,43. Likewise, no respondent considered it *not relevant*, although some considered it of *low relevance* (14,3%).

3. Conclusions | Resources for Ecosystem Integration

a) *Relevance of the development of Design Assistance Resources for Ecosystem Integration:*

When inquired about the possible relevance of the development of Design Assistance resources for Ecosystem Integration, the respondents answered positively, with the majority attributing it high relevance (58,3%), or optionally, medium relevance (41,7%). No answers indicated low or no relevance.

b) *Uses and Qualities of the Proposed Assistance Method and Indicators for Ecosystem Integration:*

From the suggested purposes/finalities and benefits of the proposed framework the most selected by the respondents were Decision Making Tool (70,8%), to the Improvement of Local Ecology (83,3%) and the Improvement of Architecture Quality (70,8%).

Regarding the possible uses and qualities of the suggested method and indicators, the less relevant options considered were Checklist Management Tool and Consideration of Detail and Comprehensiveness, with less than half of the answers (41, 7%) respectively.

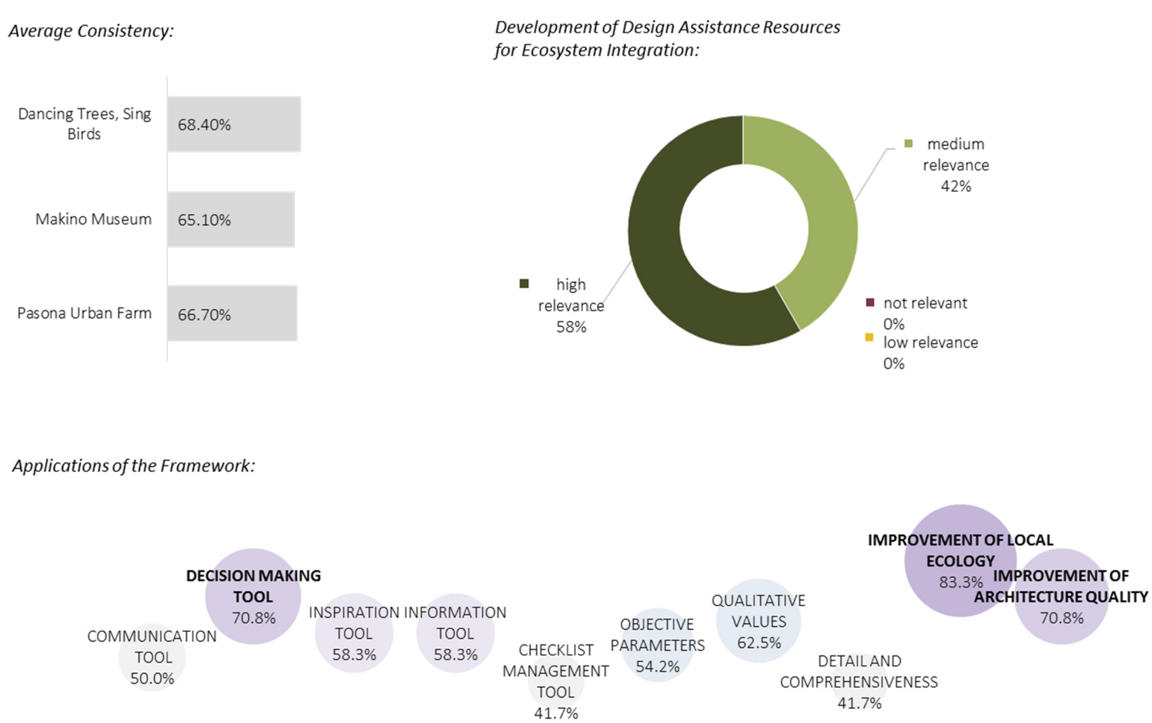


Figure 112. Overall Consistency and Receptivity of the Method

PART 4.

INTERPRETATION PATTERNS
[DISCUSSION and CONCLUSIONS]

09. COLLABORATIVE INTERACTIONS PRACTICE

9.1 Analysis and Discussion of the Results

The precedent chapters in Part 3 [Collaborative Interactions] have described the obtained results with the research methods employed in the thesis: 1) identification of collaborative interactions in multiple project reference database, 2) assessment of the design integration of local ecosystem services and functions in specific individual projects, and 3) observation of multiple user qualitative variations, in the use of the Ti[l]es Ecosystem Design Integration framework.

In the present chapter, are introduced the inferences obtained from the three complimentary methodology stages, and the overall combined assumptions resultant from them. Namely, it is attempted to provide a substantiated reply to the initial research questions, and to identify whether these are or not adequately answered. Expected and unexpected results from the initial assumptions are highlighted and pointed out, along with the identification and description of the possible causes and implications of these results. Interpretation of the results is provided, at the light of previously introduced topics and discussed literature review. Resulting from this analysis, it is finally attempted to provide some suggestions for criteria and guidelines to the design integration of local ecosystem services and functions.

9.2 The background of a contemporary trend?

In reply to the research questions *how collaborative interactions between local ecosystem services and architecture quality parameters are contemporarily perceived, interpreted, attempted?* and *what influence local ecosystem integration has at architectural design level?,* the present chapter discusses the results obtained with the compilation of the Reference Database, and the emergence of patterns within it.

One of the first premises that arises from the analysis of the reference case studies and the compiled collaborative interactions database is that: it is virtually possible to find correlations and design integration links between *all* architecture quality parameters and *all* ecosystem services. Even if individually each project is not perfect in its integration of local ecosystem services, there is reference to 85,6% Identified positive correlations, and only 14,4% Non identified positive correlations among the totality of the 240 catalogued projects.

The objectives of integration of local ecosystems and its functions and services in architectural projects includes, for one side, ecological restoration, and also the development of synergies established between ecological processes and design options in the built systems. Even though this analysis doesn't communicate what are the objective environmental benefits of the identified correlations, given the potentialities of built systems and ecosystem services to human well-being is natural that both systems would eventually share common reciprocal strategies.

Second, the construction of the reference database and the compilation of collaborative interactions within a wide range of projects, offers some clues about possible work typologies. These typologies emerge from the different approaches to address ecosystem services and functions, and include the following modes of design integration: Preservation, Regeneration, Support, Fruition, Reproduction and Emulation. With the urgency of preserving ecosystems health and balance, architecture has developed and utilized "traditional" forms of relationship between architecture and nature, such as fruition, support, Integration, Preservation, Reproduction and Mimesis, with emerging ones, as Emulation and Substitution and Remediation.

The analysis of ecosystem integration, within the reference case studies, highlight among the architectural quality parameters different modes of relation [homogeneous (almost one kind of relation), non homogeneous (very different patterns of relation with ecosystem services), and intermediate (more or less consistent variations observed according to supporting, regulating, provisioning or cultural services).
In parallel, the influence of local ecosystem integration in architecture quality parameters can be defined as reciprocal, active, passive. Patterns in reference database also identified that Active/Passive/Hybrid would be more operative ways of addressing architectural quality parameters in relation to ecosystem services in an alternative and perhaps more operative way than the division between Intrinsic and Extrinsic values.

The low number of collaborative interactions in certain architecture design parameters may be attributed to a diverse set of reasons: intrinsic lack of applicability, or reduced sources of information (as in the case of ergonomy, accessibility & universal design and of social responsible construction practices); preponderance of macro scale influence (safety and emergency systems); and uneven distribution of quality parameters, as in the duplication of acoustics indicators, double considered in comfort and perceptive quality areas.
More relevant or strong correlation criteria of ecosystem functions and services with architectural quality: sense of place and local identity: as mutual benefit extracted from either natural, cultural, socio-ecological systems.

The influence of Ecosystem Integration to mitigate urban ecological disturbance factors is also found to be relevant, although revealing different levels: higher, regarding Pressure on external ecosystems, and Biodiversity; medium, regarding Local pollution, Microclimate, and Water cycle: and lower, regarding Land and soil alteration.

The design strategies of building envelope surface and form, usage of materials, and community involvement assume relevance to provide and restore additional ecosystem functions, by water and greenery surfaces, habitat provision, and collaboration with provisioning and regulating processes. At the same time, the contemporary need and will to address ecosystem services and functions has, since early ecological architecture attempts, remarkable subjacent themes, such as those of the ark, or the tree of life. Regarding the involvement of building envelope and enclosure in ecosystem integration: is architecture becoming landscape?

The attempts and need for local ecosystem regeneration within architectural design, at micro urban scale, involves a fusion of the fields of landscape design and architecture, both as base knowledge and design solutions and research. The integration and collaboration with living materials within architectural design [regardless of its position to envelope integration, green walls, roof, site ground, etc.] implies many of the same challenges, techniques, and limitations developed within landscape architecture (including both the design of shapes, materials and colors, and the adequacy to local ecological aspects).

Envelope design may play, a major role on the local ecology integration in architectural projects, at micro urban scale. Envelope design, textures, surface, form and setting have a significant impact and potential to enhance biodiversity and assure other ecosystem functions and services, as well as to relate with diverse architectural quality parameters. Local ecology integration in architectural design is not an exclusive of environmental architecture. It has been incorporated in diverse architectural approaches, with and without sustainability and ecological concerns [or in different levels/degree]. It has however been done so, mostly in partial ways, and rarely pushed to its limits or addressed simultaneously in the different complementary ways that are illustrated in several diverse case studies. Still envelope design integration, doesn't exceed presently the collaboration with onsite landscape elements.

The analysis of the case studies included in the reference database also enlighten and clarify about which directions are presently explored towards ecosystem integration in these contemporary architecture projects. The number and diversity of approaches towards the integration of ecosystem services registered in the last decades indicate the possible rising of a trend, of a changing turn in architecture. The total different approaches in which they are expressed may be interpreted as attempts, or even experiments, as if architecture field is calibrating itself.

As it was demonstrated in the projects, the integration of ecosystem services and functions in architectural design can be, (and has been addressed) in multiple different ways. Cultural, Provisioning, Regulating and Supporting ecological functions and services are address differently and sometimes separately, as well as in different levels of either Local Ecology Promotion (Effectiveness) and Design Integration.

Regarding the application of the TI[L]ES framework, as also indicated regarding other assistance design methodologies, as SITES (2009), that focus on environmentally sustainability or more specifically on local ecology, and on ecosystem services benchmarks, as Millennium Ecosystem Assessment (2003, and 2005), it is many times experienced that in specific cases it is virtually impossible to obtain the total maximum of points. With the resource to additional data collection, the tentative outcomes of the correlation framework might be further assessed and rectified, reducing the degree of inaccuracy. The framework may then provide a backdrop comparison to enhance ecosystem integration during design process.

9.3 Individual Interpretations and Local Ecosystem Integration

The interpretation of design integration is eminently qualitative, grounded on a diversity of individual knowledge and perception. The answers provided for the TI[L]ES framework belong to this unquestionably qualitative realm. As such, as in any observation tool-experiment, the results reflect not only the observed object but as well the observer.

In the pilot questionnaire, there seems to be a correlation between the design areas that the respondent find more relevantly related with Local Ecology, and the answers provided for a specific case study. In particular, in the areas that the respondents consider less relevantly connected with local ecosystem, fewer collaborative interactions are identified. This might happen for diverse other reasons, as the particular specificities of the case study by coincidence correspond to the respondents' preconceptions, or depending according to data availability.

It is also interesting to note a similarity between the percentage of Identified Positive Correlations in the Reference Database with the general answers provided by the inquired individuals on the Final Research Questionnaire about Architecture Quality Areas with more relevant connection with Local Ecosystem.

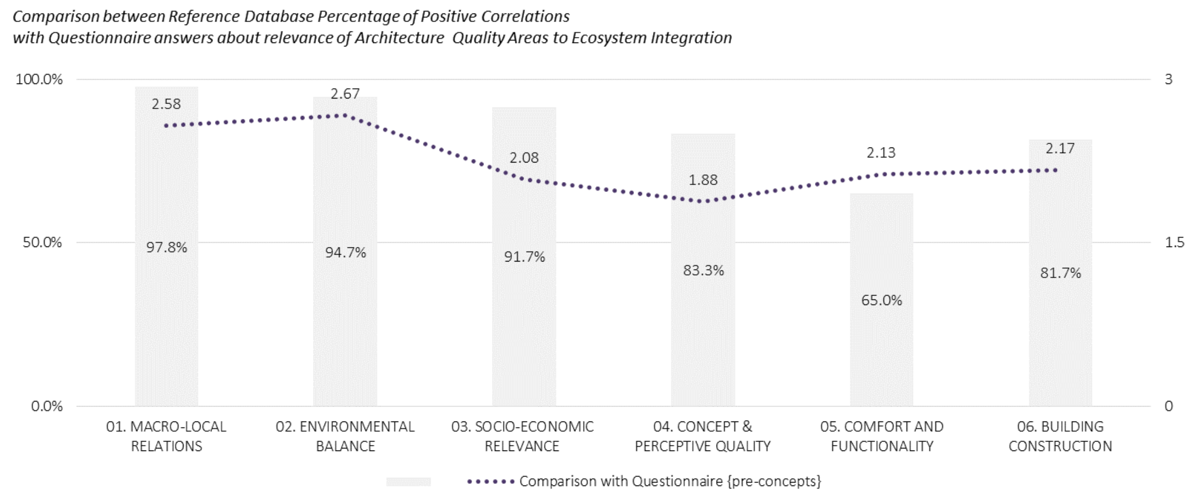


Figure 113. Comparison between Reference Database [Percentage of Positive Correlations] with Pre-concepts in Final Research Survey

Regarding personal perspectives and auto-assessment though the application of the proposed framework, there are questions about its possible use as a tool for thinking and decision making within design teams that emerge from the obtained results. As design integration assessment is mostly qualitative-subjective, it is possible that some designers tend to be more modest and see less connections than other observers. There is of course more optimistic and more skeptical individual profiles when it comes to judge qualitatively the design integration of local ecosystem services of their own design, but the collected sample is not ample enough to explore it.

The reasons for disparity in answers regarding the existence of correlations between factors may be due to:
1. Differences on information/knowledge between users [degree of eco-literacy, of sustainability assessment parameters, of technical information, or of known case studies, literature, etc.]
2. Differences in Design Priority or Relevance attributed to factors
3. Different Interpretation of indicators or even of the scope of mutual interaction between factors

From the results obtained with interviews, it has become clear that it is easier to enunciate decisive relevant factors taken in account in the project, within local ecosystem services and functions, or architecture quality parameters, rather than express where do these factors are connected or have specific positive correlations. It is also worth noting that there is seldom, a clear "no" in the answers of the questionnaire survey. However it is possible to examine the absence of certain correlations (or parameters) within the randomized set of indicators pairs.

The indication of the answer "Not enough information" may be due to several reasons: a. the information about a specific project was not sufficiently detailed, objective, clear or there was no information about that topic in the information materials relative to the specific project; b. the information about a specific indicator was not clear, or subject of misinterpretation in the information materials relative to indicators; c. the respondent didn't feel comfortable or confident towards that subject to reply; d. the respondent didn't use the information materials to reply, or e. result from the reluctance to assume a negative answer, and it might be related with questions of social desirability – the need of inquired respondents to look good at the eyes of the observer.

Since information about the project is readily available to design teams, one conclusion that can be derived from it is the necessity to reinforce the component of ecological literacy of the method, that is, to provide more detailed guidelines to interpret the integration of ecosystem services and functions in architectural design, embedded into the method, and thus strengthen the information function of the tool.

Another possible interpretation on the qualitative variations regarding identification of positive interactions between local ecology and architecture may also be due to knowledge projection. People tend to see or consider the collaborative interactions they already know and project them on the case studies. For instance, let's say the effects of climate regulation of local ecosystem in indoor temperature/and energy consumption are "well" established in passive design; as well as the influence of energy consumption performance into global climate, due to an intensive focus on energy in sustainable building metrics, teachings in school, etc., and therefore these connections, or the ones, the respondents feel more familiarized with, are more identified, regardless of the project. Other connections, less known and spread among architects and environmental specialists, are more difficult to grasp at first hand, and possibly more difficult to visualize into the presented case studies.

In the conducted questionnaire it is patent that *a priori*, for the majority of respondents, the architectural parameters areas that they value most are not coincident with the architecture parameter areas that they more easily associate with integration of local ecosystems. The results evidence that, within the inquired sample, Comfort & Functionality, and Building Construction are the two most valued areas for Architecture Quality, but Macro-local Relations and Environmental Balance are considered to be more relevantly connected with local ecosystem.

An interesting observation is that even if Concept & Perceptive Quality is not one of the architecture quality areas that the respondents (including pilot questionnaire, interviews and final research questionnaire) relate more with local ecology, when focusing on specific projects, they are able to recognize collaborative interactions with local ecosystem services more easily within it than with other areas [particularly the parameters Concept originality, innovation and creativity, and Visual]. While it can be argue that these two criteria could be more easily identified without direct observation onsite [due to availability of visual and descriptive materials on the provided information data], other non-visual Concept & Perceptive Quality parameters [as Other senses: olfaction, tactility and motion perception] also score higher values in the observed case studies. Acoustics is the only exception to this.

The qualitative subjectivity of the analysis contained in the Ti[l]es framework is sometimes questioned, among informal data collection and auscultation included in the pilot research survey and individual interviews. The need to specify more detailed parameters and delimit clearly the scope of answer for each indicator topic should be therefore included in future developments – which was attempted within the final research survey but could be object of improvement.

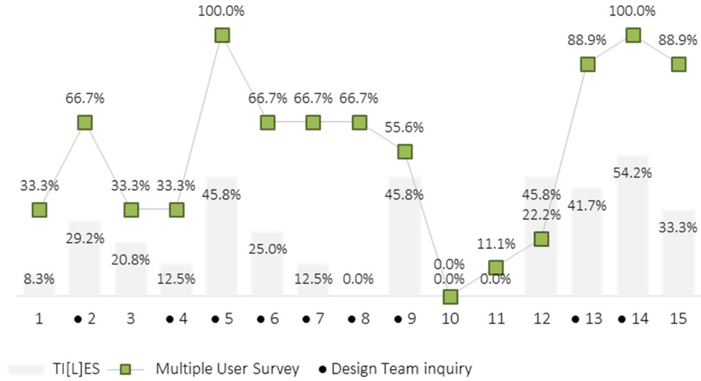
Even though, despite the wide range of possible framing of the questions regarding the relevance of each parameter into the design integration of ecosystem services, the evaluation of specific project targets within the final questionnaire survey demonstrate a consistency [agreement] between multiple users between around 60% to 70%. Individual parameter comparison in terms of consistency between different respondents in the TI[L]ES application is provided on the Figures 114-116.

From the possible uses and qualities of the proposed framework (indicators and methods of analysis) for ecosystem integration, the multiple user survey consider it a Decision Making Tool to the Improvement of Local Ecology and the Improvement of Architecture Quality, with emphasis on Consideration of Qualitative Values. An important part of the inquired respondents (58,3%) also considered the possibility of the proposed framework to act as an Inspiration Tool or an Information Tool. This might: 1) validate the use of ecosystem services as a comprehensive/intelligible interpretation of local ecological processes for non-specialists in the field; 2) point out the benefits of a tool that is simultaneously informative [contains descriptions of ecosystem services, an eco-literacy tool], and that is inspirational [doesn't imply prescriptive formulas but contains references or examples to trigger creative design processes].

Most of the inquired individuals replied very positively to the contextualization questions, as the relevance of integration of local ecology in architectural projects, regarding the use of the framework, and the relevance of the development of design assistance resources to design integration of local ecosystem services. However, this otherwise positive and encouraging results should be regarded with a certain caution, as they may probably result from social desirability and may not be directly related with a real practice motivation, being associated with value-action gap issues.

Dancing Trees, Singing Birds
Comparative Analysis

Local Ecosystem Services



Architecture Quality Parameters

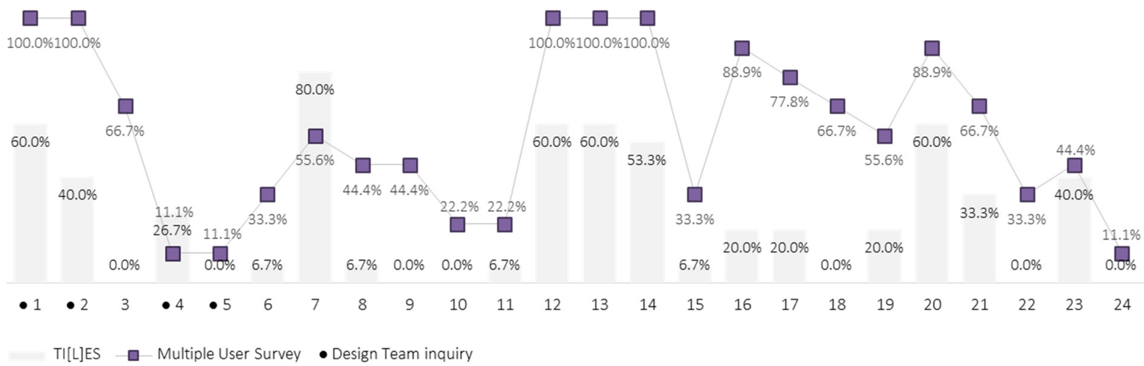
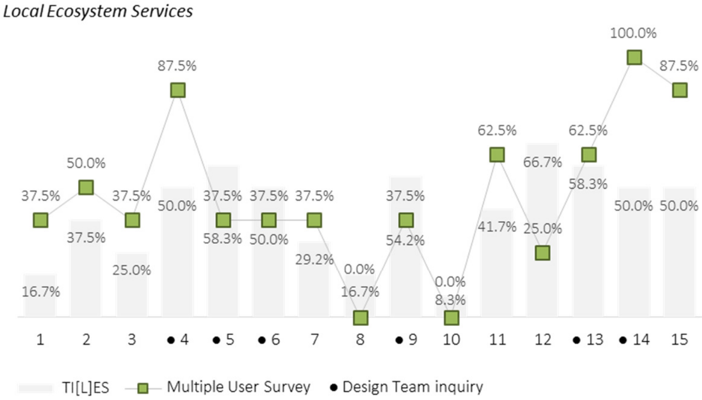


Figure 114. Comparative Analysis between different respondents in TI[L]ES application to Dancing Trees, Singing Birds

Makino Museum of Plants and People
Comparative Analysis

Local Ecosystem Services



Architecture Quality Parameters

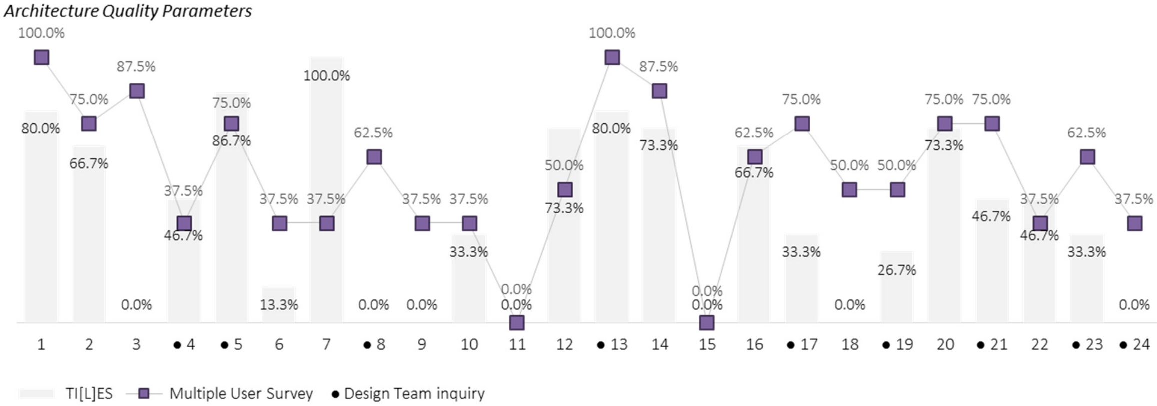
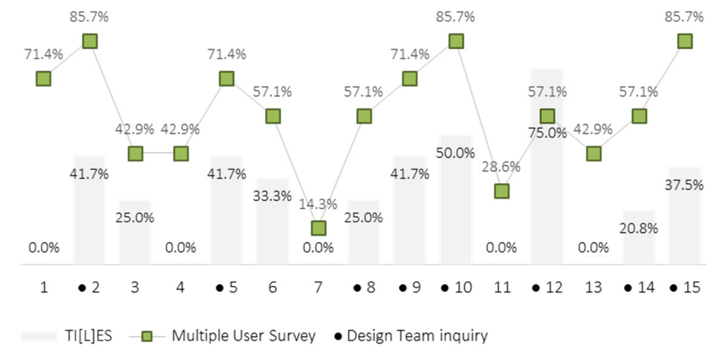


Figure 115. Comparative Analysis between different respondents in TI[L]ES application to Makino Museum of Plants and People

Pasona Urban Farm
Comparative Analysis

Local Ecosystem Services



Architecture Quality Parameters

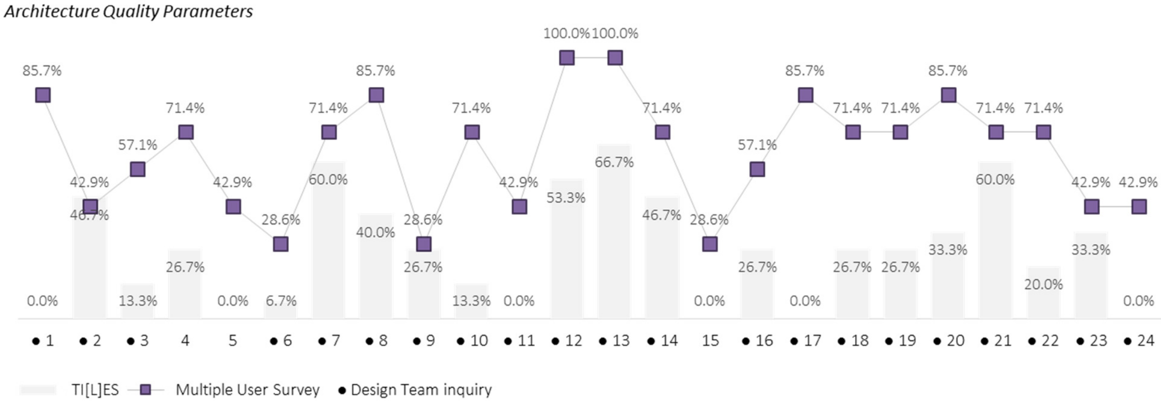


Figure 116. Comparative Analysis between different respondents in TI[L]ES application to Pasona Urban Farm

9.4 Local Ecosystem Integration Criteria and Guidelines

When co-working with natural processes and living materials in architecture, the concept of integration can be read as a three-fold: 1. the benefits reached to local ecology and local human community [that is, ecosystem health, functions and services]; 2. the benefits reached to architectural parameters; and 3. the degree of cohesion between the two systems [functionally, structurally, aesthetically]. It can also added the self-organization or self-maintenance of the systems, as a criteria: avoiding a constant demand of energy, water or other resources, greater than the site’s provision, to work, and the multi-functionality of the design solutions.

In Chapter 3, some of the criteria and methods used to assess site ecology and landscaping in architectural projects were discussed, along with generally accepted solutions. In the synthesis presented in the current chapter, we try to analyze the further connections found between local ecosystem functions and architectural projects, and reinterpret them in the perspective of design integration.

The first step for a successful design integration of ecosystem services and functions in architectural projects is, logically and first of all, to make them part of the design equation. This presupposes an active demand and information in pre-design stage [either in project brief or in earlier pre-research stages prior or parallel to concept development], by one of the following: client/commissioner, designer, consultants/advisors. The active role in the design development for ecosystem integration of these participants is visible in the case studies presented in chapter 7.

Some suggestions, guidelines and principles to ecosystem services and functions integration in architectural design are pointed as the need to apply design options for simultaneous multiple ecosystem services and multiple architectural design parameters, besides avoiding segregated solutions. Besides, local site diagnosis and research should include the following topics:

1) ecosystem integration traditions [vernacular, informal, etc.];
2) available on-site and local materials;
3) native and adapted plant species;
4) urban ecology problems or needs;
5) existing onsite and local resources or elements (including buildings, trees);
6) local animal species and their habitat needs;
7) engagement of the local human community [owners, users, etc.]

In addition, on pre-design and design stages, the following two questions should be incorporated: a) what are the site demands in ecosystem services and functions? [local ecological health and balance issues, as air pollution or water run-off; project needs, as climate regulation or environmental modulation demands, or food supply]; and b) what are the potentialities of the site in the provision ecosystem services and functions? [potential raw materials, existing habitats, views

One significant factor to have in account regarding the design integration of local ecosystem services in architectural projects relates with the position and spatial scheme of onsite biotic and abiotic elements. For instance, the ecosystem services provided by the integration of flora species [besides their inherent characteristics] vary according to their location, setting and surface integration. According to these factors, the integration of vegetation may or may not contribute to soil formation and fertility, erosion control, climate regulation, water filtering, among other ecological functions and services. Similarly, the implementation of spatial project options regarding the integration of these elements are also determinant to the degree to which ecosystem services may relate with architectural design parameters.

It is beyond the scope of the present dissertation to advise on particular design recommendations, as these would vary site by site, urban and cultural context and bioregional ecological characteristics, however the principle of multi-functionality, enunciated by diverse authors [including Lyle, Grant, and articulated both in permaculture and regenerative design guidelines, and as well as in resilience theory] seems to be of universal application. This is verified through the analysis of both reference and specific study case targets, and is a principle that is attempted to be integrated within the framework of Ti[l]es.

9.5 Synthesis: Interpretation Patterns on Local Ecosystem Integration

Integration of ecosystem services and functions has been subject of multiple architecture design expressions in the past years, that include projects that escape the scope of environmental assessment, including erudite architecture realistic built projects and futuristic projections of a new world. This happens in, and outside, Japanese context. The different approaches, however, carry with them, complementary methods and facets of local ecosystem integration, that is important to merge. The TI[L]ES framework offer a perspective on how this can be made, highlighting a complete panorama of possibilities.

One of the resulting suggestions from the compilation of reference database and case studies that it is virtually possible to find correlations and design integration links between *all* architecture quality parameters and *all* ecosystem services, is confirmed also by the auscultation of multiple different inquired individuals.

From the interviews and analysis of case studies, either in Japan or outside, it is possible to infer that *there is* an empirical knowledge towards ecosystem integration that is driven according to designers' interests and methodologies, but not a conscious movement or direction nor an organized approach towards it. That is, it is marginally intentional, and rarely a priority.

However, the quantitative analysis of different and individual ecosystem services in a given site can be objectively measured, the impact and relation of the same ecosystem services with architectural parameters is much more difficult to discern. Diverse ecosystem services are often associated, in reality. Perceptive environmental modulation, climate regulation and biodiversity and nursery habitats are ecosystem services that might be provided by the same tree canopy, for instance.

Although the integration of ecosystem services and functions, *per se*, doesn't necessarily produce overall environmentally sustainable or regenerative projects, the incorporation in architecture, urban planning and landscape design projects, of methods and concerns from ecosystem restoration and preservation, with different possible creative design solutions, the result of these methodologies result tendencially in a project *localness*, in a site specific responsiveness, and bioregional integration and restoration.

It is also observed that the TI[L]ES framework is a double translator of the interpretation patterns of ecosystem integration within Project and Observer.

In the present analysis, the TI[l]LES matrix has been used without a gradation of values. This way, there is no quantification of each positive correlation [and therefore the information of a very good correlation a slightly good correlation, in each project, and per comparison between projects, is missed].
Although it can be argued that a more specific approach focusing in one ecosystem function/or one design integration aspect, in case studies, would be an easier, objective research program; this method presents several limitations, as it totally elapses 1. The concept of design integration that is central to the research, 2. The fundamental associativity between ecosystem services that is a sounder ecosystem health assessment rather than the measurement of one.

As with the application by modules, the matrix diagram can be used in a quick, easy, broad way with a simplified version [just the main indicator areas: Supporting, Regulating, Provisioning and Cultural ecosystem services; with Macro-Local relations, Environmental Balance, Socio-Economic, Concept and Perceptive Quality, Comfort and Functionality, and Building Construction architecture quality criteria]. To decide, set objectives in pre-design, or communicate in an easy-grasp the global assessment in later stages, or project completion. A more detailed version, with selection of individual indicators, can be set for design stage and successive stages of assessment, and for detailed communication.

As suggested by some users (respondents) the possibility to integrate examples of collaborative interactions within the tool [for instance, linking the examples provided within the reference database], would reinforce it role as: 1. Tool for thinking, and 2. Eco-literacy tool. Due to its intended use as an assistance tool for architects, the visual communication of the tool plays an important factor. A suggestion for visualization output of the Ti[l]es table results is therefore proposed on the following Figures.

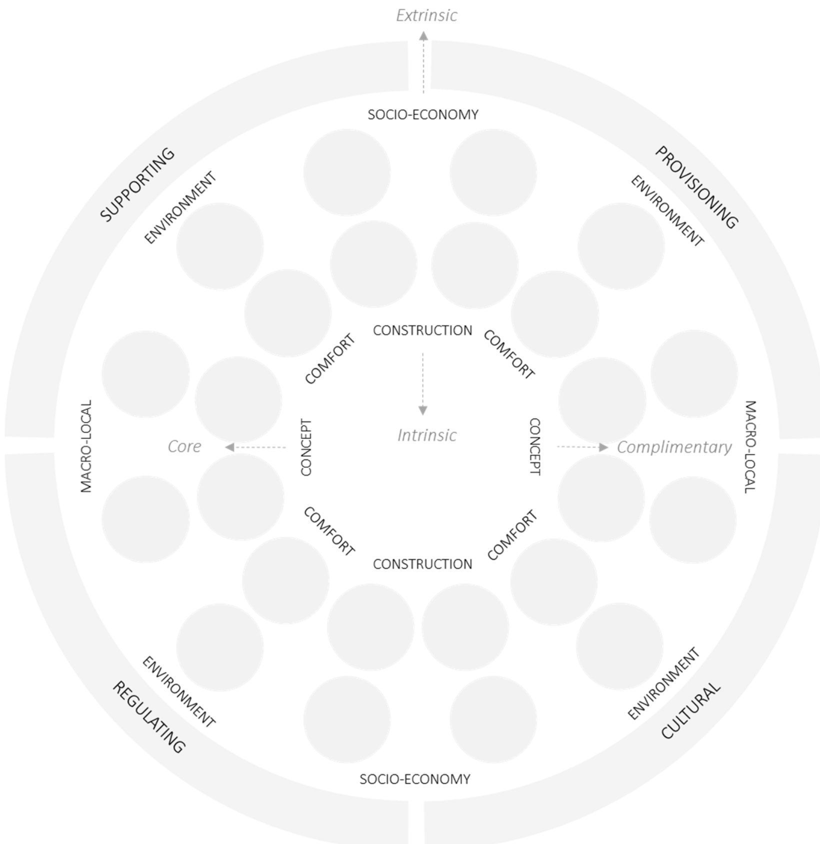


Figure 117. Collaborative Interactions Framework: Suggestion for Visualization Output.

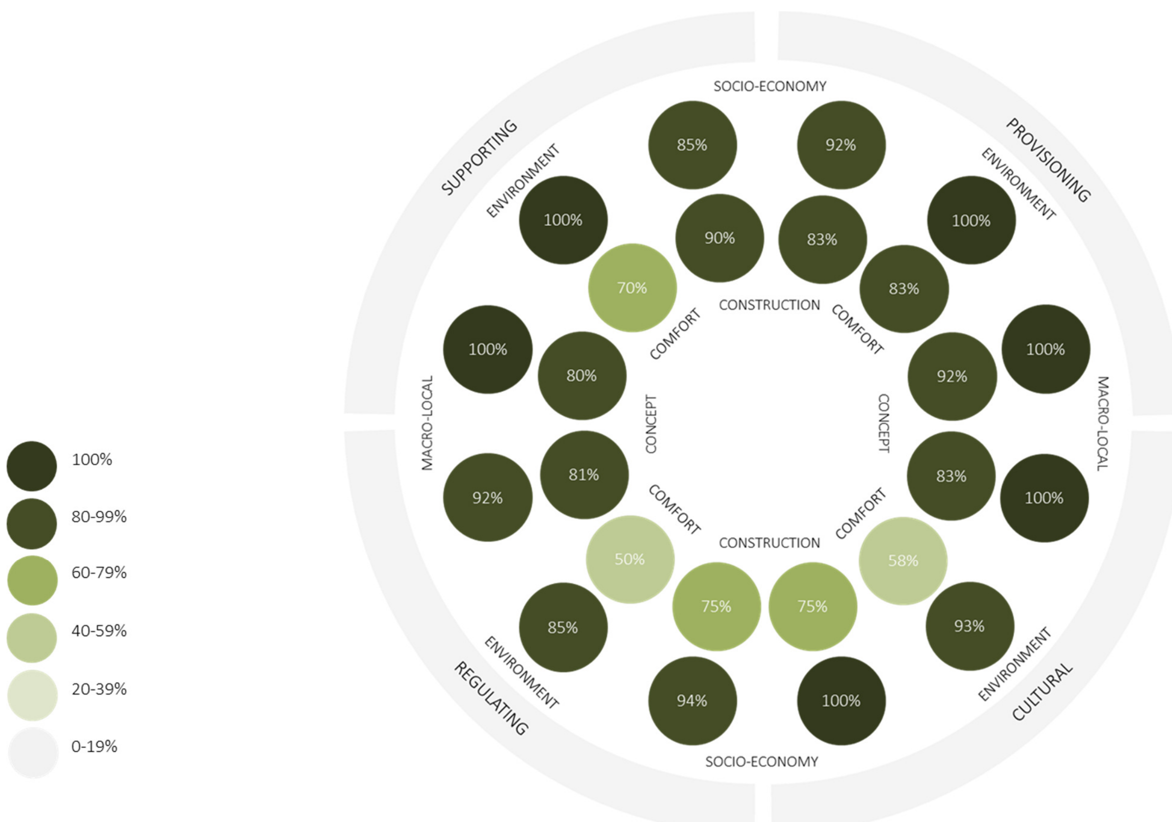
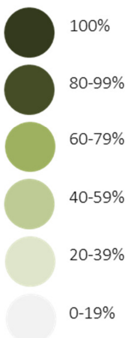


Figure 118. Visualization of TI[L]ES Results: Reference Database

Case 1. **DANCING TREES, SINGING BIRDS**



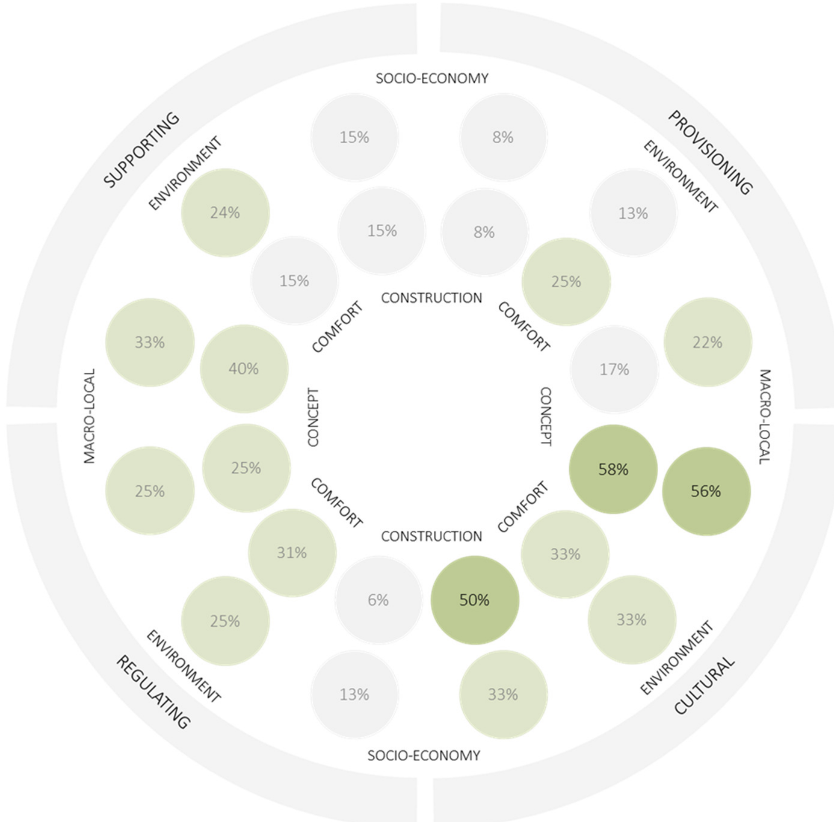
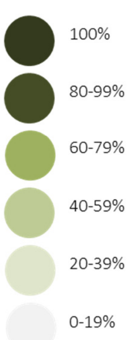


Figure 119. Visualization of TI[L]ES Results: Dancing Trees, Singing Birds

Case 2. **MAKINO MUSEUM OF PLANTS AND PEOPLE**



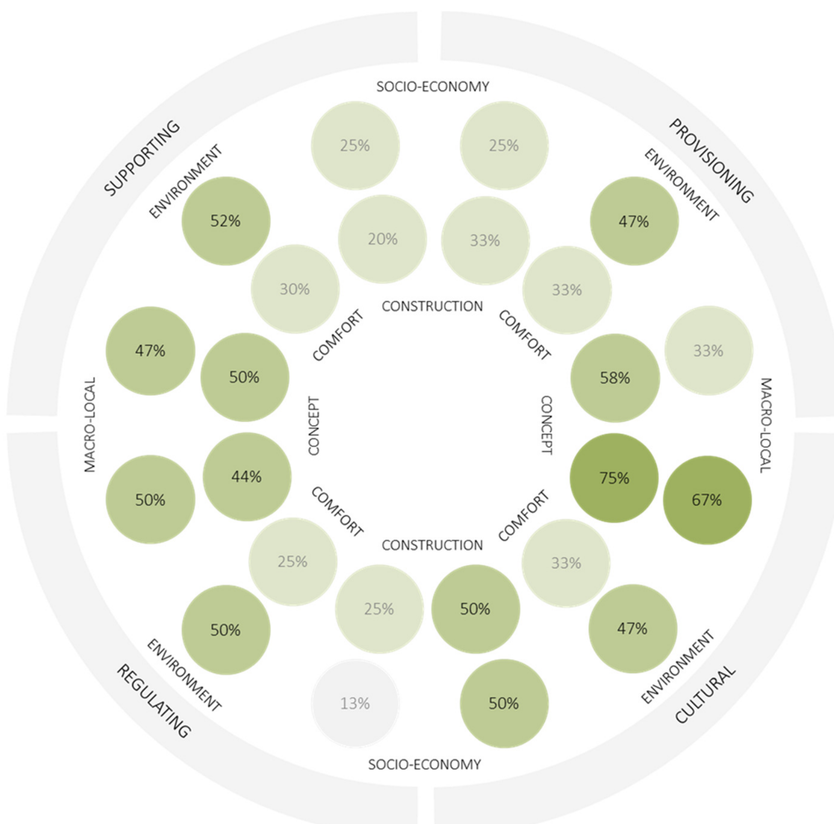
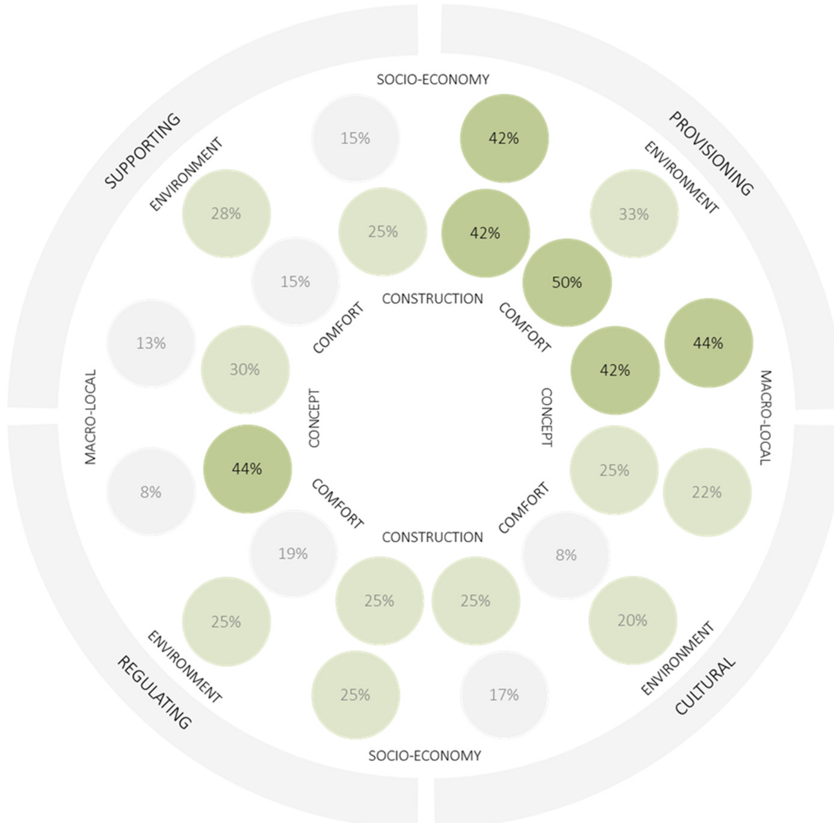


Figure 120. Visualization of TI[L]ES Results: Makino Museum of Plants and People

Case 3. **PASONA URBAN FARM**



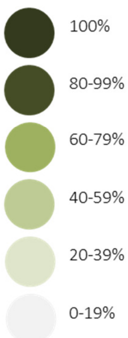


Figure 121. Visualization of TI[L]ES Results: Pasona Urban Farm

10. CONCLUSIONS

10.1 Local Ecosystem Integration in Contemporary Architecture

In reply to the central research question (*how to improve the integration of local ecosystem services at the scale of architecture?)*, this thesis elucidates on the meaning of Local Ecosystem Integration, and the diverse modes how it is been addressed and perceived in international architectural projects, with incidence on the contemporary time frame between 1990 and 2014. It discusses how the concept of Ecosystem Integration might be studied and assessed, through the proposition of a design assistance method, focusing on questions of Design Integration, whose application is attempted towards specific case study targets, within the context of Japan, and reflects on the validity of the qualitative results implied in its own method, by comparing outcomes from different individuals, and project objects. Finally, as a result of the cited analysis, it endeavors to identify key factors to potentiate the Design Integration of Local Ecosystem services and functions in contemporary and prospective projects.

The present research builds up on critical background review, of theoretical, historical and methodological sources, from where it derives the *Context* of this dissertation. On Chapter 1, the constellation of terms and knowledge fields that concur to form the concept of ecosystem integration operated within the thesis are clarified, entailing the interpretation of several associated notions in the fields of Ecology and Architecture, including: Ecosystem Services and Functions, Design Integration, and Environmental and Architecture Quality Indicators.

In Chapter 2, it is analyzed how diverse forms of ecological collaborative approaches have been addressed in the course of art, architecture and broader social contexts. Focusing on the convergence to the integration of local ecosystem services within architectural practice, it is observed through a thematic organization of authors, how it might follow a rise, consolidation and finally the transition signs of a shift of environmental architecture towards regenerative design during the 20th century. An insight to the context of Japan is also provided, though a brief discussion of local key environmental issues, approaches to architecture, culture and ecology, and procedures towards ecosystem services and biodiversity conservation. The period from 1990 to 2014, covered by the present research, is characterized by the launch and generalization of building environmental assessment methodologies, and an ongoing theoretical transition from environmental mitigation benchmarks to neutralization, and lastly, into regeneration, particularly noticeable within the U.S. and U.K.

An overview of existing design assistance methods and potential resources for the application of ecosystem integration in architectural design is provided on Chapter 3. The significance of the integration of local ecosystem services is emphasized within urban systems, where ecological disturbance factors may be interpreted as regeneration priority areas to orient the focus of collaborative design. Existing methodological processes employed by relevant ecological approaches towards site restoration and local ecology integration, both used in landscape and architecture design, are also examined. Finally, a discussion and comparative analysis on commonly and prospective tools and indicators for assistance and assessment of environmental architecture and design, unveils its non-uniform character in addressing factors related to local ecology, and the difficulty of embracing qualitative appreciation within them, although it is noted an increasing tendency among many of them to provide visualization outputs that highlight its role as interpretation and thinking support.

The development of the research design methodology employed within the present thesis is explained in *Methods*. Addressing the underlying objective to *potentiate a collaborative integration of local ecosystems in architectural design*, Chapter 4 explains the general adopted methodological approach of the dissertation and explains the development of the analysis framework designated by Ti[l]es (Tool for Integration of Local Ecosystem Services). The objective of the proposed methodological framework is to clarify, identify, and interpret the reciprocal relations between architectural design and local ecology aspects. The method is projected as a potential design assistance tool, providing project guidance, identifying opportunities and evaluating different possible solutions, being based on a multi-criteria matrix diagram, or correlation framework, that references ecosystem services and architecture design quality parameters.
In order to investigate the application of the Ti[l]es framework, the research design methodology, based on data triangulation, is unfolded in three methodological steps, unfolded in Chapter 5: 1) the constitution of a reference database [multiple project analysis], 2) the application of the framework to specific case study targets [single project analysis], and 3) a qualitative data validation through the application of the framework [by multiple user analysis].

On the third part of the thesis, are presented the obtained *Results* within these analysis. In Chapter 6, the identification of collaborative interactions in multiple project reference database provides criteria and background for subsequent analysis of single specific projects and application of the tool. Chapter 7 observes the Design Integration of local ecosystem services and functions in specific individual projects, comparing it with local ecology objective parameters and with surface and envelope design. Chapter 8 complements the precedent analysis, observing multiple user qualitative variations, and consistency verification in the use of Ecosystem Design Integration framework.

The possible causes and implications of the results are object of *Discussion* at the light of previously introduced topics. In Chapter 9, the inferences obtained from the 3 complimentary analysis stages, and the overall combined assumptions resultant from them, as well as the attempts to encapsulate suggestions for integration criteria and guidelines result in the following key findings:

One of the first premises that arises from the analysis of the reference case studies and the compiled collaborative interactions database is that: it is virtually possible to find correlations and design integration links between *all* architecture quality parameters and *all* ecosystem services. Even if individually each project is "imperfect" in its integration of local ecosystem services, there is reference to 85,6% Identified positive correlations, and only 14,4% Non identified positive correlations among the totality of the 240 catalogued projects. Collaborative interactions with local ecology are in fact an intrinsic part of architecture, which are not exclusive of contemporary efforts, nor are exclusive of environmental sustainability driven architecture. Passive design and creation of *genius loci* are ancient forms of collaborative interactions, as are green roofs, vineyard pergolas, water courtyards. Whether these architecture solutions contribute for the promotion of ecosystem functions and services - and to what level - or they just benefit from them, or neither of these, it is up to design *decisions*.

In contemporary architecture projects it is also possible to identify typologies that emerge from the different approaches to address ecosystem services and functions, and include the following modes of design integration: *Preservation*, *Regeneration*, *Support*, *Fruition*, *Reproduction* and *Emulation.* It is also possible to infer that *there is* an empirical knowledge towards ecosystem integration that is driven according to designers' interests and methodologies, but not a conscious movement or direction nor an organized approach towards it. The generality of the interpreted case studies within the context of Japan, confirm the diversity of approaches, towards different directions, in local ecosystem integration that is grasped in international context.

The present research unveils the existence of an unstructured, and sometimes subconscious and dispersed, multi-diverse relation of architecture with local ecosystem services that is perhaps important to acknowledge, recognize and value [to bridge present asymmetries]. The role of pre-knowledge, or prejudgment, may play an important part on the interpretation, and subsequently on the practice, of local ecosystem integration in architecture.

A priori considerations about the potential connections between architecture quality areas with local ecosystem services seem to emphasize the relations with Environmental Balance [particularly the connection between Energy cycle and Climate regulation might be referred in projects where it is not the most striking feature of design integration of local ecosystem services]. Alongside possible obvious collaborative connections with Water cycle, Exterior areas and Sustainable lifestyle support systems, attempted since the first ecological architecture experiments, this seems to reproduce the benchmarks and widespread focus of building environmental assessment (as response to key issues as Oil crisis and Climate Change).

However, when specific projects are analyzed in detail, other patterns emerge: namely, the recognition of the connection with parameters as Adaptation to eco-physical values and restraints, Sense of Place and Cultural identity, Human health and wellbeing, Concept originality, innovation and creativity, and Visual.

Regarding suggested guidelines, the first step for a successful design integration of ecosystem services and functions in architectural projects is, logically and first of all, to make them part of the design equation. This presupposes an active demand and information in pre-design stage [either in project brief or in earlier pre-research stages prior or parallel to concept development], by one of the following: client/commissioner, designer, consultants/advisors. The active role in the design development for ecosystem integration of these participants is visible in the examined specific case studies targets, as confirmed with interviews with design team members.

Another significant factor to have in account regarding the design integration of local ecosystem services in architectural projects relates with the position and spatial scheme of onsite biotic and abiotic elements. For instance, the ecosystem services provided by the integration of flora species [besides their inherent characteristics] vary according to their location, setting and surface integration. According to these factors, the integration of vegetation may or may not contribute to soil formation and fertility, erosion control, climate regulation, water filtering, among other ecological functions and services. Similarly, the implementation of spatial project options regarding the integration of these elements are also determinant to the degree to which ecosystem services may relate with architectural design parameters.

The principle of multi-functionality, enunciated before by diverse authors and articulated both in permaculture and regenerative design guidelines, and as well as in resilience theory is of fundamental importance. This is verified through the analysis of both reference and specific study case targets, and is a principle that is attempted to be integrated within the Ti[l]es framework.

The presented method suggests an assessment method that not only evaluates site's ecological performance, and architectural quality, but that offers a perception of the relations between both factors, which has been until now scarcely explored in what regards environmental design. It can be extrapolated and developed to cover not only site's ecological performance but other areas of environmental performance for architecture and planning. Finally, the results point out the possibility and interest of transforming the proposed TI[L]ES framework into a much needed ecological literacy tool, as the results towards possible uses as decision making tool and information tool seem to confirm.

10.2 Contributions and Implications of the Thesis

The proposed methodology in this study [Tool for Integration of Local Ecosystem Services, also referred under its acronym, TI[L]ES] is a design assistance instrument that can be implemented as self-assessment by design teams in an iterative heuristic process, identifying within proposed solutions, strengths, weaknesses and opportunities, leading to the formulation of an optimal acceptable solution. Based on the results of this study, the benefits of this method for the integration of local ecosystem services are suggested as decision support tool during design process (with general agreement within multiple user research survey and relevant consistency results between users), besides contributing to a better understanding of ecological literacy information derived from its analytical assessment of ecosystem services performance and design integration.

In addition, the present method complements conventional design composition and thinking methods [including spatial composition and component composition] generally employed by designers, and that are of limited relevance to the integration of ecosystem services. Architecture design teams tend to support their decisions in terms of physical or visible systems, therefore it is stressed the need for a method to visualize the expected anticipated functions and guarantee the adjustment between the provision of ecological services and architecture spatial and physical systems.

Another possible relevant contribution of this thesis is that it might help to support to bridge the still existent gap between environmental assessment driven construction and conceptual driven architecture, unveiling ecosystem integration as a common factor with different interpretations in both cases, and therefore stimulating the adoption of more complete forms of design integration of local ecosystem services. At the same time, the framework expressed by the Ti[l]es matrix and reference database constitute a potential instrument to increase the knowledge about the existence of possible solutions, and the benefits of incorporating ecosystem services in the design of micro-scale projects, besides providing a tool for thinking.

Unlike precedent researches on ecosystem services analysis into project design, the developed methodological tool focus on qualitative aspects. Traditionally and in the available literature review, the integration of local ecosystem services is almost always referred in connection with environmental balance parameters. This research demonstrates that although it is one of the most potential benefited areas, it is not the only.

It is also observed that to contribute to the improvement of the design integration of local ecosystem services in architectural projects, may be needed to reinforce the focus and development of research and practice on poorly developed or less referred areas - as Comfort and Functionality and Regulating Services.
Considering the overall importance attributed to Comfort and Functionality areas to define architecture quality – as indicated by the results obtained with the multiple respondents' panel -, the focus on these less referred connections could be very relevant not only to improve design integration but to strongly motivate design teams and stakeholders.

On the contrary, throughout the different stages of the research methodology, results strongly point out the relevance of aesthetic areas [particularly Concept and Visual] with significant association with, but not only, Cultural services. This contradicts the pre-concept belief that these design areas perform less connection with ecosystem services. Acknowledging this fact can also constitute an incentive to more actively integrate local ecosystem services in design projects.

Finally, the possible uses and benefits of the proposed Ti[l]es framework into design process assistance are identified primarily as a decision making tool, and following as information resource and inspiration instrument. Regarding the application of the proposed methodology, the analysis implied in the Design Integration Ti[l]es Matrix, reflects that the method can be applied to a wide range of different projects, with different site ecology approaches, and architectural design profiles; it can also be adopted during design process with readily available data by the design teams; suiting different design teams with different architectural priorities. The method permits as well the visualization of the project's design integration of onsite ecological services and functions, and although it doesn't measure quantitatively its impact, it might influence positively the decision making during design process in that direction. With resource to an integrated database, and maybe an interactive display, it can be used as an educational, informative tool, for instance, increasing the communication of eco-literacy and of design integration aspects among designers and other stakeholders.

With implications to other fields, the suggested method, although subject to improvements, can be expanded and adapted to other specific design integration issues or environmental areas of analysis [for instance, active solar systems, water cycle systems], to assess holistically how well they are integrated, and reinforcing the resilience and interconnection between factors.

In conclusion, to think about ecosystem integration in a way that is *connected* with architecture quality parameters as a whole, implies a *stronger bond with the place,* in the way buildings and cities are projected, reinforcing theoretically the site specific character of its design.

Although, there are limits to the benefits of design for ecosystem services in urban and built environments, - and strategies employed within architectural and urban planning projects need to be combined with other macro-local policies to address global environmental issues, as referred by Grant (2012)-, several contributions to *urban ecological factors and local key issues* are also derived, linking the increase of locally available ecosystem services to determinant human urban issues as the increase of local community resilience, through hazard mitigation, direct access to resources and economic benefits.

10.3 Limitations of the Study

While opening positive contributions and implications, the present research also entails inherent limitations. Regarding the application of the TI[L]ES framework to assess qualitative integration of ecosystem services in architectural projects, some barriers were also observed, particularly within qualitative data surveys. The use of the matrix framework proved to be time consuming, and from it, the following detrimental factors resulted: 1) the number of criteria had to be reduced; 2) results may suffer from the rush, or lack of commitment to the answer process; and 3) it was only possible to assess a small sample of multiple users for qualitative data validation, as not so many participants could be involved in the final research questionnaire and interviews process.

In the present research, the TI[L]ES framework only focus on positive interactions between local ecosystem services and functions and diverse parameters of architecture design quality. It does so, as its objective is to identify and highlight positive connections in existing architecture projects and its interpretation by design team members and stakeholders. It doesn't incorporate thus, the possible existing negative associations between the attempts of integration of ecosystem services and functions, in specific projects; and therefore it can't be used presently to analyze possible trade-offs in this integration.

Similarly, same reasoning can be applied to the fact that no gradation is provided for the identified positive interactions [except for the observation of beneficiary indicators: mutual, ecosystem or architecture indicators]. However, this can be later incorporated and an in-depth study of trade-offs in local ecosystem integration can be achieved in future research, without significant changes in the method.

The results or evaluation provided by the present method don't reflect the relation to the local ecosystem carrying capacity. It would be desirable to reinforce the connection with site capacity. An essential step to develop the current research would be to embed or relate quantitative or qualitative ecosystem integration analysis with the carrying capacity of the site, and its ecosystem services opportunities [including rainfall, native flora and fauna, for instance], adapting the assessment of specific projects to its contextual ecological constraints and potentialities.

As focused on a restricted expert panel, the final questionnaire was applied to a limited sample of 24 individuals. The results derived from this sample, however providing clues for individual interpretation on the TI[L]ES matrix and the selected case studies, shouldn't and are not intended to represent a group opinion. As such, the derived results of the limited sampling, cannot be extrapolated into any larger universe of architect designers and professionals in related fields.

To explore the qualitative perception of ecosystem integration, it would be recommended to expand the sample of inquired respondents to investigate and verify some of the interpretation lines suggested in the present thesis. The present study focused on the *perceived* qualitative integration of local ecosystem services within architectural quality parameters, focusing on interpretation patterns that emerged from project sources and individual auscultation. Another approach could be to try to assess through specific and more detailed benchmarks the qualitative integration of local ecosystem services in specific projects, exclusively based on descriptive *in situ* surveys, perhaps focusing on restricted architectural quality areas or specific groups of ecosystem services.

As considered as one of the limitations of the present study, the experimental application of the TI[L]ES framework is conducted on a restricted sample of 3 specific target projects. Although the selection of these project study cases intend to demonstrate the diversity of integration degrees and possibilities of local ecosystem services within architecture, it is recognized that the addition of other cases would benefit the reach of the research by adding broader ecosystem integration perception. It is also considered that this number of cases could be very limited to extrapolate the identification of result patterns, and thus, the enlargement of the examined projects universe is strongly recommended for future research.

Finally, attending to the end finality of the developed method – to be used as a design assistance and decision making resource among design teams -, it is observed the need to improve the suggested visualization interface and analysis output of the TI[L]ES application, in order to increase simultaneously its clarity and appeal.

10.4 Future Research and Recommendations

From the conducted investigation, further prospective developments to the study of the Design Integration of Local Ecosystem Services within Architectural Projects, were unwrapped and emerged during the course of the research. Some of these concur to the objective of overcoming stated limitations of the study, while others would intend to develop specific aspects or ramifications presented by the thesis. The following prospects and recommendations are suggested, for further progress within the topic, or extension of the present research:

1. *Development of the TI[L]ES framework as software or online tool*. One of the possible lines of investigation comprises the transformation of the proposed Ti[l]es framework into a software application. This would facilitate the process to receive and calculate inputs, and deliver visualization forms, increase the interactivity and include some of the suggestions discussed in the qualitative data surveys. Namely, one of these possibilities would be to increase its interactivity linking examples of the Reference Database with the collaborative interactions matrix, and reinforcement of the information purposes of the method. Another prospective benefit from this development would be to overcome some of the identified limitations of the application of the method in the present state, as to decrease answer time consumption and to enlarge the base of respondents of the study.

2. *Integration with design simulation*. Another possible exploration of the suggested framework, would be to find a way to link the results of design integration with local ecosystem services with computer aided design software, facilitating the interactivity with design simulations and visualization tools.

3. *Create an open project database*. The knowledge of current and past experiments of ecosystem integration in architectural projects could be further increased if, from the compiled reference database, a modifiable digital reference database would be created. An open digital reference database format would allow, at individual particular level [architecture offices, for instance], or publicly for multiple online users, the input of further projects (increasing its universality or personalizing it for specific research focus). It would also facilitate the search and selection by specific ecosystem services or architectural quality parameters, or by location or contextual references, reinforcing its role as eco-literacy information and inspiration instrument into design research.

4. *Examine other projects and contexts*. In the specific case analysis and application of the TI[L]ES framework, to examine the relations between the promotion of ecosystem services and its design integration within architectural projects, the study focused on a limited universe of contemporary projects, found in the context of Japan. While these projects demonstrate a certain degree of ecosystem integration, it would be necessary

to expand the range of examined projects, particularly trying to reach projects with purported higher degree of integration, to consolidate some of the achieved results. Similarly, it would be important to, as well as exploring other contexts, to examine other projects and inquire different design teams. By extending the number and geographical scope of the target projects, it could be possible to examine the existence and formation of possible regional patterns, which didn't pertain to the scope of the present research.

5. *Application of the TI[L]ES framework to an on-going project*. A strongly recommended research development possibility would imply the application of the TI[L]ES Interpretation framework through the full cycle of project development stages [in pre-design, design, construction and occupancy], with emphasis on design period, to verify the possibilities to support information, decision making and communication among project stakeholders, of the proposed tool. Considering that the final role of the proposed method is its application as decision support tool during design process, it is intended to determine and adjust its applicability through the implementation of its framework to the design development stages of an architecture project in a real case scenario, into regular design meetings and successive solutions iterative tests. Likewise applicable to other research recommendations (including a significant expansion of the project targets and respondent base, and possible developments into a digital application), these procedures would beneficiate to be preferably integrated within a larger institutional framework or research organization with more ample technical and human resources, and considerable larger reach and influence.

6. *Development of the visualization interface and output*. In future developments of the tool, and among further research recommendations, it is considered as experimental departing points for the improvement of the visualization interface and results output: a more creative and clearer resource to graphical elements and color, the integration with visual database references, the provision of an interactive digital display and application, and finally the possible connection of the proposed method with dedicated computer aided design software, facilitating design simulations and results preview.

10.5 Closing Statements

The unveiled Interpretation Patterns on the Design Integration of Local Ecosystem Services indicate that to reinforce and improve local ecology integration in architectural design projects, broadly and transversally, a true necessity lies on the provision of ecological literacy instruments and on the adjustment of the mental framework of the diverse agents comprised in the field of architecture. It is also emphasized that the design integration of local ecosystem services in architectural projects - for its focus and reinforcement on local resources - is a promising mean to strengthen community resilience and hazard protection, contributing to establish positive economic synergies, besides enriching the direct ties between human societies and accessible ecosystem services, particularly in urbanized areas.

As such, the scientific development of design assistance resources, as the proposed TI[L]ES framework, combining decision making and information functions, may contribute in the future to whole local ecosystem integration, which for now is observed as an open, yet unfulfilled, possibility at individual existing projects. As it is suggested in the present thesis, the principle of multi-functionality, enunciated in different knowledge contexts, and integrated within the Ti[l]es framework, is of fundamental importance, comprehending in this case the distributed inclusion of all classes of local ecological services and design quality areas, and preferably of all individual criteria, to assure reinforced integration between design quality and local ecology regeneration. Once these steps are accomplished, it will be therefore possible the emergence of a new conscious architecture less driven by formal constraints but by relations and flows, -- where the distinction between built and ecological systems would be no more than a distant abstraction, because they have become one, and integrated system.

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APPENDIX

Appendix I. Design Integration Reference Database

01. MACRO-LOCAL RELATIONS

1 Adaption to eco-physical values and restraints — Site selection and project adequacy to hydrography and topography

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample] Code	Designation	Life Cycle [introduction or application of design solutions] Pre-design	Design	Construction	Operation	End use	[Surface] Design Integration base envelope	lateral envelope	top envelope	enclosure	landscape
	01. SUPPORTING													
🟢	1 Soil formation and fertility	Avoid greenfields, farmland, rich ecological soil areas, 100 year flood zones and wetland features; regenerate used land [greyfield, brownfield, blackfiels]; preserve and restore existing native vegetation and soil coverage; building setting and location prefered for minimal earthworks and excavation [adaptation to topography, soils and drainage patterns], avoid steep slope areas, and fragile coastal areas	34	Rinker Hall	●	●	.	.	.	●	.	.	.	●
🟢	2 Photosynthesis and primary production	Preserve and restore existing native vegetation; avoid greenfields, farmland, rich ecological soil areas; regenerate used land [greyfield, brownfield, blackfiels]	215	Evergreen Brick Works	●	●	.	.	.	●	.	.	.	●
🟢	3 Nutrient cycling and waste treatment	Avoid greenfields, farmland, rich ecological soil areas, 100 year flood zones and wetland features; regenerate used land [greyfield, brownfield, blackfiels]; preserve and restore existing native vegetation and soil coverage	201	Scenic Hudson's Long Dock Park	●	●	.	.	.	●	.	.	.	●
🟢	4 Water cycling and regulation	Protect and restore riparian, wetland, and shoreline buffers, rehabilitate lost streams, wetlands, and shorelines; avoid greenfields, farmland, rich ecological soil areas, 100 year flood zones and wetland features; regenerate used land [greyfield, brownfield, blackfiels]; preserve existing vegetation and vegetation cover; respect topography and drainage patterns	237	El Coso municipal office building and Public Space	●	●	.	.	.	●	.	.	.	●
🟢	5 Biodiversity and nursery habitats	Avoid greenfields, farmland, rich ecological soil areas, 100 year flood zones and wetland features; regenerate used land [greyfield, brownfield, blackfiels], protect and restore biotopes, protect and rehabilitate lost streams, wetlands, and shorelines, respect ecological corridors, design for ecotones, guarantee disturbance-free areas	85	Pola Museum of Art	●	●	.	.	.	●	.	.	.	●
	02. REGULATING													
🟢	6 Climatic regulation	Impact of topography and land use on microclimate weather patterns, control of heat island effect by spatial arrangement of the built environment with interdispersed green spaces; avoid greenfields, farmland, rich ecological soil areas, forestry; regenerate used land [greyfield, brownfield, blackfiels],	144	Neepsend	●	●	.	.	.	●	.	.	.	●
🟠	7 Erosion control and hazard protection	Preserve natural vegetation areas and existing landscape elements, building setting and location prefered for minimal earthworks and excavation [adaptation to topography, soils and drainage patterns], avoid steep slope areas, and fragile/exposed coastal areas, preferred locations protected by ecosystems buffers [mangroves, tree wind barriers, water retention soils and vegetation] and avoid degraded soils and landscapes, steep slopes.	114	Palisade Bay	●	●	.	.	.	●	.	.	.	●
🟢	8 Biological control & pollination	Preserve and restore existing native vegetation; avoid greenfields, farmland, rich ecological soil areas, 100 year flood zones and wetland features; regenerate used land [greyfield, brownfield, blackfiels]	200	Phipps' Center for Sustainable Landscapes	●	●	.	.	.	●	.	.	.	●
🟢	9 Perceptive environmental modulation	Protect, preserve and restore features of the ecosystem environment, biotopes, existing vegetation, wetland features, and landscape fruition elements that provide environmental perceptive modulation	36	Dancing Trees, Singing Birds	●	●	.	.	.	●	.	.	.	●
	03. PROVISIONING													
🟢	10 Food supply	Avoid greenfields, farmland, rich ecological soil areas, 100 year flood zones and wetland features; regenerate used land [greyfield, brownfield, blackfields]; minimize construction footprint; project setting adapted to topography, soils and drainage patterns; relocation of building site adapted to land use [lot exchange], regenerate previous used land and structures	32	Center for Regenerative Studies	●	●	.	.	.	●	.	.	.	●
🟠	11 Water purification and fresh water supply	Protect and restore riparian, wetland, and shoreline buffers, rehabilitate lost streams, wetlands, and shorelines; use topography to create wetlands and rain gardens; avoid greenfields, farmland, rich ecological soil areas, 100 year flood zones and wetland features; preserve and restore existing native vegetation and soil coverage	180	Tyson Living Learning Center	●	●	.	.	.	●	.	.	.	●
🟠	12 Raw materials, ornamental and medicinal resources	Avoid greenfields, rich ecological soil areas, and wetland features; protect biotopes and sources of raw or ornamental materials; regenerate used land [greyfield, brownfield, blackfields]; minimize construction footprint; project setting adapted to topography, soils and drainage patterns; relocation of building site adapted to land use [lot exchange], regenerate previous used land and structures	53	Tree Mountain-a living time capsule	●	●	.	.	.	●	.	.	.	●
	04. CULTURAL													
🟠	13 Significant species and ecosytem values	Protect, preserve and restore features of the ecosystem environment, significant species, biotopes, existing vegetation, wetland features, and historical cultural landscapes; influence of cultural-natural-spiritual heritage areas and protections for site adequacy; building setting and location in adaptation to topography, soils and drainage patterns	72	Pocono Environmental Education Center	●	●	.	.	.	●	.	.	.	●
🟢	14 Landscape aesthetic fruition	Protect, preserve and restore features of the ecosystem environment, significant species, biotopes, existing vegetation, wetland features, historical cultural landscapes, viewpoints, and "focal" corridors; site selection and project setting and location adapted to existing toprography and hydrography providing landscape aesthetic fruition	1	Okinawa Institute of Science and Technology	●	●	.	.	.	●	.	.	.	●
🟠	15 Leisure, recreation and psychophysical health	Avoid greenfields, farmland, rich ecological soil areas, 100 year flood zones and wetland features; regenerate used land [greyfield, brownfield, blackfiels], protect, preserve and restore features of the ecosystem environment that provide leisure and health opportunities	175	Mill Creek Canyon Earthworks	●	●	.	.	.	●	.	.	.	●

2 Sense of place and cultural identity — Local context references, landscape integration, socio-cultural adequacy and relevance

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample] Code	Designation	Life Cycle [introduction or application of design solutions] Pre-design	Design	Construction	Operation	End use	[Surface] Design Integration base envelope	lateral envelope	top envelope	enclosure	landscape
	01. SUPPORTING													
🟠	1 Soil formation and fertility	Use of locally sourced onsite soil materials in a coeherent local practice and contribution of soil formation and fertility towards characteristic site specific landscape or identities	112	Iceland turf houses	.	●	●	.	.	.	●	●	.	●
🟠	2 Photosynthesis and primary production	Provision of vegetation as envelope and landscape materials and systems in coeherent local practices, and contribution of plant selection and distribution towards characteristic site specific landscapes or identities [microgreenery, trellises, pergolas and other local cultural relevant strategies]	107	Tokyo micro-greenery	.	●	.	●	.	.	●	●	○	●
🟠	3 Nutrient cycling and waste treatment	Adapted use of local common nutrient cycling strategies and systems integrated in architecture [on-site waste water treatment, air or soil remediation practices...]; recover of local identity elements and structures through nutrient cycling and local pollution remediation	215	Evergreen Brick Works	●	●	●	.		.	○	○	.	●
🟠	4 Water cycling and regulation	Adapted use of local common water regulation related strategies [exterior pavements, vegetation, harvest systems] and its contribution towards characteristic site specific landscape or identities; maintenance and provision of culturally relevant water surfaces [lakes, rivers, coastal areas, ponds, cisterns...] and its influence in sense of place; coeherent local architecture practices and characteristic site specific landscape or identities formed by flood prevention or tidal adpation in coastal and inland waters	147	World Birding Center Headquarters	●	●	.	.	.	○	.	●	○	●
🟠	5 Biodiversity and nursery habitats	Adapted use of local common construction techniques, materials, and traditions providing habitats for native species [built nests, shelters, water and food resources..], and contribution of biotopes and biodiversity support elements [sounds, colors, shade, landscape..] towards characteristic site specific landscape or identities, and sense of place; Provision of culturally relevant local plant species in envelope and landscaping	140	Edge Hill Halls of Residence	●	●	.	●	.	.	●	●	.	●
	02. REGULATING													
🟠	6 Climatic regulation	Adapted use of local common construction techniques, materials or systems towards climatic regulation; contribution of microclimate control [wind, temperature, humidity...] local common strategies [microgreenery, gardens, wind barriers...] influence on site perception and sense of place, site specific landscape or identities;	108	Real Alcázar of Seville	●	●	.	●	.	.	●	●	○	●
🟠	7 Erosion control and hazard protection	Adapted use of local common erosion and hazard protection strategies and its contribution towards characteristic site specific landscape or identity and sense of place [vegetation ground cover, integration with protection ecosystem buffers and natural structures, retention walls and terraces, low walls to control runoff, materials barriers from wind, water and waves [boulders in coastal areas, tree and cane alignments]....]	53	Tree Mountain-a living time capsule	●	●	●	.	.	○	○	○	.	●
🟠	8 Biological control & pollination	Adapted use of local common biological control and polllinator atraction strategies and its contribution towards characteristic site specific landscape or identities, and sense of place [landscape biodiversity and plant species selection and association, use of pest repellent species and other strategies in envelope or landscape (window frame color and geraniuns/lavender to drive off flies and other insects)]; Importance of pollination agents to the maintenance of landscape biodiversity and identity plants and trees; Local adapted use of biotic pollinator farming [bees, butterflies, birds]	194	Mediterranean window pots and gardens	●	●	.	●	.	.	●	●	○	●
🟠	9 Perceptive environmental modulation	Adapted use of local common environmental perceptive modulation strategies and its contribution towards characteristic site specific landscape or identity and sense of place [site-specific modulation of sunlight, and wind, barriers from noise and light, microgreenery, green envelope and landscaping]	104	Vine pergolas in South Europe	●	●	.	●	.	.	●	●	.	●
	03. PROVISIONING													
🟠	10 Food supply	Adapted use of local food supply systems and its contribution towards characteristic site specific landscape or identity and sense of place [construction techniques, materials and traditions towards food supply provision: trellises with edible species, kitchen gardens and urban farms, topography modification and other agricultural structures...]	222	Edible Terrace + Edible Terrace2	●	●	.	●	.	.	○	●	○	●
🟠	11 Water purification and fresh water supply	Contribution of natural water surfaces [lakes, rivers, ponds] and its maintenance and restoration for the creation of sense of place, site specific landscape or identities; Adapted use of local common systems to water capture, harvest and filter [dwells, cisterns, springs, constructed wetlands, filtering ponds] and revitalization of water surfaces	39	River remediation and development in Medina of Fez	●	●	.	●	.	.	○	●	○	●
🟠	12 Raw materials, ornamental and medicinal resources	Resource to locally used construction techniques, structures and design based on locally available raw materials and its contribution to the formation of characteristic site specific landscape or identities; Formation of biotopes and socio-ecological landscapes associated with raw material production and harvest; Provision of ornamental or medicinal resources as envelope and landscape materials and systems in coeherent local practices, and contribution of plant selection and distribution towards characteristic site specific landscapes or identities [cultural adequation of medicinal and ornamental plant species selection and structures]	110	Cliff dwellings of Anasazi	●	●	.	●	.	.	●	●	●	●
	04. CULTURAL													
🟠	13 Significant species and ecosytem values	Protection, valorization and inclusion of local identity relevant landscape and biodiversity features and its contribution to reinforce local identity and sense of place [behavioral or cultural uses and traditions that provide significant species habitat support in architectural and landscape structures]	103	Ise Shrine	●	●	.	●	.	.	●	●	.	●
🟠	14 Landscape aesthetic fruition	Adapted use of local common landscape valorization strategies and its contribution towards characteristic site specific landscape or identities, and sense of place [formation of viewpoints, scenic valuation, and relation with other contextual elements; Mutual influence of landscape and built features in the formation of local cultural identity [orientation and topography adaptation of local buildings, relations with paths and vegetation...]	113	Jean-Marie Tijbaou Cultural Center	●	●	.	●	.	○	○	○	.	●
🟠	15 Leisure, recreation and psychophysical health	Protection, valorization and provision of locally relevant leisure and recreation outdoor spaces and traditions [parks and gardens, rivers and lakes, private, public and mixed open air areas, street arrangement...]; Influence of recreation and leisure landscapes and its connection to local cultural identity and sense of place	88	Seto-chi Shinanodai Elementary school	●	●	.	●	.	.	.	○	.	●

3 Transports and functional articulation w/ context — Relation with infrastructures & volumes, access to daily functions, & low impact mobility

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample]	Life Cycle [introduction or application of design solutions] Pre-design	Design	Construction	Operation	End use	[Surface] Design Integration base envelope	lateral envelope	top envelope	enclosure	landscape
	01. SUPPORTING												
●	1 Soil formation and fertility	Design of circulation and access for minimal disturbance of soil formation; adequate selection of pavements type and perviousity; Impact of functions location in exposure to disturbance vectors, ground cover conditions and drainage patterns; influence of local transport modes in atmospheric emissions and soil depositions and balance of Carbon (C) and Nitrogen (N)	1 Okinawa Institute of Science and Technology	●	●	.	.	.	●	.	.	.	●
●	2 Photosynthesis and primary production	Design of circulation and access for photosynthesis and primary production [low-impact mobility circuits and eco-corridors...]; Impact of shades, location of functions, alteration of local climate, exposure to disturbance vectors and biotope conditions in plant growth	31 HighLine	●	●	.	.	.	●	.	.	.	●
●	3 Nutrient cycling and waste treatment	Design of circulation and access for nutrient cycling provision [low-impact mobility circuits and eco-corridors, urban functions proximity...]; reduction of disturbance vectors for local biota to perform nutrient cycling, and reduction of pollution components in air, water, soil; Impact of shades, location of functions, alteration of local climate, exposure to disturbance vectors and biotope conditions in the biota capacity of provision of clean air, water and fertile soils, and cycle of life-essential nutrients in the food chain; impact of topography and microclimate weather patterns and low emission transport direct local influence on local atmospheric pollution reduction	178 The perfumed jungle	●	●	.	.	.	●	.	.	.	●
●	4 Water cycling and regulation	Design of circulation and access for minimal disturbance of water cycle and water regulation support; adequate selection of pavements type and perviousity; relation of the project with existing water elements, infra-structures and drainage patterns; reduction of daily transport and infrastructure needs by direct access to water [through captation in springs, rivers and underground aquifers, rain water storage]	207 Urban Ecotones	●	●	.	.	.	●	.	.	.	●
●	5 Biodiversity and nursery habitats	Project adaptation and provision of ecological corridors; Impact of shades, location of functions, alteration of local climate, and exposure to disturbance vectors in biotope conditions and biodiversity; positive effect in disturbance reduction [atmospheric emissions and air pollution, traffic, noise] provided by low-impact transports in local biodiversity	72 Pocono Environmental Education Center	●	●	.	.	.	●	.	.	.	●
	02. REGULATING												
●	6 Climatic regulation	Design of circulation and access and preference for low-impact transports with positive impact in the minimization of local atmospheric emissions in the atmosphere and heat island effect reduction; mutual influence of urban, landscape forms and infrastructures on microclimate [shadows and solar exposure, wind patterns, heat island effect], and role of vegetation [selection of materials type and perviousity in circulation circuits] in heat island abatement and wind mitigation	47 Masthusen Bo01 District development	●	●	.	.	.	●	.	.	.	●
●	7 Erosion control and hazard protection	Volume relations and location of project towards existing hazard protection ecosystem buffers and natural structures, and accessibility through low emissions transport; Project adaptation to existing drainage patterns	109 Philipines mangrove coastal settlements	●	●	.	.	.	●	.	.	.	●
○	8 Biological control & pollination												
●	9 Perceptive environmental modulation	Low impact transport influence on noise reduction and other disturbance vectors; Protection of disturbance vectors derived from circulation corridors by perceptive environmental modulation strategies [vegetation fences, earth mounds, buffer zones...]	143 Shrubhill Works	●	●	.	.	.	●	.	.	.	●
	03. PROVISIONING												
●	10 Food supply	Reduction of daily transport needs by direct access to food supply sources; Impact of shades, alteration of local climate, biotope conditions, and functions location in the support for food supply sources	132 Dakakker Shieblock	●	●	.	●	.	●	○	●	●	●
●	11 Water purification and fresh water supply	Reduction of daily transport and infrastructure needs by direct access to water [through captation in springs, rivers and underground aquifers, rain water storage, and water recycle systems]; Influence of local transports and functions to water purification [adjacence and implications to water courses, drainage patterns, alteration in biota], overland and underground flows, and water storage areas; Minimization of local atmospheric emissions [from transport] in the atmosphere, with positive impact in water quality and purification	219 Pixel	●	●	.	●	.	●	○	●	●	●
●	12 Raw materials, ornamental and medicinal resources	Reduction of daily transport needs by direct access to raw materials, medicinal, aromatic, and ornamental supply sources, during construction, maintenance and operation; Impact of shades, location of functions, alteration of local climate, exposure to disturbance vectors and biotope conditions for production of raw materials, medicinal and ornamental species	155 Low Cost House	●	●	●	●	.	●	●	●	●	●
	04. CULTURAL												
●	13 Significant species and ecosytem values	Design of circulation, access and transport infrastructures for minimal disturbance of cultural significant species and ecosystem values; Influence of local identity ecosystem features in the the functional relation with the context; Volume design and infrastructure organization that permits the view, access, and fruition of existing protected places and species	202 National Renewable Energy Lab	●	●	.	.	.	●	.	.	.	●
●	14 Landscape aesthetic fruition	Functions location and organization with positive impact on transport modes and needs, and fruition of local landscape values; influence of volume and infrastructures to landscape fruition; low impact transport positive influence on the reduction of noise, air and visual pollution and other disturbance vectors to landscape fruition; influence of local parks, reserves, creeks, rivers, and other relevant landscape settings [including intrinsic urban man-made landscape] in volume and infrastructure organization	173 Charles David Keeling Apartments	●	●	.	.	.	●	.	.	.	●
●	15 Leisure, recreation and psychophysical health	Articulation of light mobility transport in leisure areas; Design of circulation, access, and proximity to leisure areas and recreation spaces; Impact of shades, location of functions, alteration of local climate, exposure to disturbance vectors and biotope conditions for leisure, recreation and psichophisical health conditions; Benefits of low impact transport [walking, cycling] to human health, and as leisure opportunities	141 Matripolis	●	●	.	.	.	●	.	.	.	●

02. ENVIRONMENTAL BALANCE

4 Energy cycle [and atmospheric emissions] — Energy consumption through life cycle, passive performance and renewable energy use

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample]	Life Cycle [introduction or application of design solutions] Pre-design	Design	Construction	Operation	End use	[Surface] Design Integration base envelope	lateral envelope	top envelope	enclosure	landscape
	01. SUPPORTING												
●	1 Soil formation and fertility	Role of soil surfaces or layers to provide insulation and passive design and contribute to reduction of energy consumptions [underground or half buried walls, green roofs...]; [macro influence of atmospheric emissions in soil composition and balance of Carbon (C) and Nitrogen (N) in soil]	164 California Academy of Sciences	●	●	.	.	.	●	●	●	.	●
●	2 Photosynthesis and primary production	Provision of vegetation features that contribute for bioclimatic/passive design and reduction on energy consumptions; [macro influence of local vegetation in absorbing and storing carbon and diminish concentration of atmospheric emissions]	16 Photo Stack	.	●	.	●	.	.	●	●	.	●
●	3 Nutrient cycling and waste treatment	Use of alternative energy sources derived from local nutrient cycling for heating and cooling; local atmospheric pollution mitigation by nutrient absorbtion and filtering provided by vegetation	185 LOTT Regional Services Center	.	●	.	●	.	.	○	○	●	●
●	4 Water cycling and regulation	Role of water horizontal plans, dispersion, evaporation, and plant evapotranspiration to provide insulation, air cooling and other passive design to reduce energy consumption; Contribution of cooling [energy saving] methods utilizing and regulating groundwater	154 Museum Brandhorst	.	●	.	.	.	.	○	●	○	●
●	5 Biodiversity and nursery habitats	Provision of habitat features that contribute for bioclimatic/passive design and reduction on energy consumptions [envelope insulation through green walls or roof; envelope or landscape design with deciduous , shading or wind blocking species; Impact of atmospheric emissions on local air quality and habitat conditions	70 Solaris	●	●	.	●	.	.	●	●	.	●
	02. REGULATING												
●	6 Climatic regulation	Spatial and design arrangement of the built environment, with interdispersed parks and green spaces, for climate and micro-climate control; Influence of climate regulation at local scale on heat island effect, wind speed, and amenities that reduce energy demand for heating and cooling; Positive impact of the minimization of local atmospheric emissions (carbon dioxide (CO2), methane (MH4) and nitrous oxide (NOx), from transports and other local sources, in the reduction of heat island effect	239 Putrajaya 2C5 Commercial Development	●	●	.	●	.	.	●	●	.	●
○	7 Erosion control and hazard protection												
○	8 Biological control & pollination												
●	9 Perceptive environmental modulation	Provision of perceptive environmental modulation features that contribute for bioclimatic/passive design and reduction on energy consumptions [green walls, trellis, and pergolas; envelope or landscape design with deciduous, shading species]; Positive influence of environmental perceptive modulation in lighting and energy demand	48 Centre for Interactive Research on Sustainability	.	●	.	●	.	.	●	●	.	●
	03. PROVISIONING												
●	10 Food supply	Passive design with deciduous trees, climbing plants, lattices, vertical landscaping and green roofs providing food supply resources	223 Agro Housing	.	●	.	●	.	.	●	●	○	●
●	11 Water purification and fresh water supply	Associated alternative technologies for water purification and renewable energy sources; use of locally available water resources for cooling strategies; mutual influence of the reduction of atmospheric pollution in water quality and of carbon dioxide in water cycle and the reverse	129 Bloom [Aquatic Farm]	.	●	.	.	.	○	○	○	●	○
●	12 Raw materials, ornamental and medicinal resources	Passive design with deciduous trees, climbing plants, lattices, vertical and roof landscaping with ornamental/medicinal/raw material sources; use of locally sourced materials for increased energy performance [insulation, thermal mass and inertia, etc.]; local reduction of atmospheric pollution by raw material and ornamental species biotopes [native forests (timber, orchards), wetlands and heathlands (reeds, cane and ti-trees), grasslands (straw)]	42 Suginami-ku assembly hall	.	●	.	●	.	.	●	●	.	●
	04. CULTURAL												
●	13 Significant species and ecosytem values	Participation of local significant species or biotopes in bioclimatic/passive design strategies	24 Reading room	●	●	.	.	.	.	○	○	.	●
●	14 Landscape aesthetic fruition	Use of renewable local energy sources with scenic valuation of the landscape or viewpoints; influence of local atmospheric emissions reduction in enhanced visibility	106 Wind mills landscapes	.	●	.	.	.	.	○	○	.	●
●	15 Leisure, recreation and psychophysical health	Provision of leisure and recreation areas that contribute for bioclimatic/passive design; influence of local emissions reduction in health and recreation conditions; contribution of carbon sequestration by leisure areas [forests, parks, lakes...] for project's carbon performance	167 Green Float	●	●	.	.	.	.	.	●	○	●

5 Water cycle [and effluents] — Consumption of water, rain water harvest, waste water management, treatment and reuse

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample]	Life Cycle [introduction or application of design solutions]					[Surface] Design Integration				
				Pre-design	Design	Construction	Operation	End use	base envelope	lateral envelope	top envelope	enclosure	landscape
	01. SUPPORTING												
●	1 Soil formation and fertility	Water [and rain water] management systems with positive impact on local soil productivity; landscape design with pervious surface materials and water saving efficient landscaping and vegetation; influence of soil structure in water retention capacity, and aquifer recharge	2 Sabo House	.	●	.	.	.	○	.	.	.	●
●	2 Photosynthesis and primary production	Role of vegetation as biological filter agent of water runoff and onsite waste water treatment [in landscape, wetlands, ponds, green roof and walls, constructed wetlands, living machines, filtering ponds, SUDs, raingardens..]; selection of apropriate vegetation species for efficient water landscaping; use of rainwater or recycled waste water for irrigation	198 House like a Tree	.	●	.	●	.	.	●	●	○	●
●	3 Nutrient cycling and waste treatment	Role of vegetation as biological filter agent to remove waste components in consumption water, stormwater runoff and rain water harvesting systems, and waste water recycling [living machines, constructed wetlands, bioretention ponds...]	220 Ausgrid Learning Centre	.	●	.	●	.	.	○	●	●	●
●	4 Water cycling and regulation	Role of land cover [materials and vegetation] influence on water cycling, control and purification of stormwater runoff, and rainwater harvesting capacity; on-site wastewater treatment and recycling for irrigation, cleaning and aquifer recharge, and stormwater retention and filtering [constructed wetlands, living machines, filtering ponds...] ; water saving landscape options with adequate native species selection	18 Sidwell Friends Middle School	.	●	.	●	.	.	○	●	○	●
●	5 Biodiversity and nursery habitats	Selection of apropriate native species and habitats support for water efficient landscaping; role of biodiversity in living water treatment systems; provision of habitat and nursery conditions for native species through on-site waste water and stormwater management [constructed wetlands, retention ponds, green roofs...]; Rain water harvesting, storage and filtering and provision of clean water collection points [water surfaces, ponds...]	40 Plaza Ecopolis	.	●	.	●	.	.	○	●	.	●
	02. REGULATING												
●	6 Climatic regulation	Role of water [harvest, recycle] surfaces to contribute to local climate regulation [water gardens, courtyards, ponds, blue roofs and waterfalls]; influence of microclimate in local precipitation patterns	76 Makino Museum of Plants and People	.	●	.	●	.	.	●	●	.	●
●	7 Erosion control and hazard protection	Storm water management (diversion, retention and filtering) influence on erosion control and flood prevention; vegetation ground cover to encourage infiltration, and minimize impervious areas and constitute wind barriers.	232 Water Re-Balance Skyscraper	.	●	.	●	.	○	○	●	.	●
●	8 Biological control & pollination	Revegetation of catchment areas and role of biological control in preventing contamination of water sources and outbreaks of enteric illness in water harvest systems; reduction of vectors of water borne disease in water cycle systems [avoid stagnated water surfaces where mosquitoes can breed in); influence of water management strategies as habitat for polinator species [bio-retention and filtering ponds, living machines, design of water drainage systems, bioswales...] and of the treatment of effluents in reduce the conditions for biological pests spread;	147 World Birding Center Headquarters	.	●	.	●	.	.	●	●	.	●
●	9 Perceptive environmental modulation	Provision of water harvesting/treatment structures as support for environmental modulation [constructed wetlands, retention ponds, water courses and cascades...]	186 Queens Botanical Garden Interpretation Center	.	●	.	●	.	.	●	●	●	●
	03. PROVISIONING												
●	10 Food supply	Use of local water management [harvest, recycle] for crop irrigation; selection of adequate water efficient food supply sources, as native species adapted to local water cycling patterns; provision of aquaculture ponds and living machines;	14 Hous.E+ Project	.	●	.	●	.	.	●	●	●	●
●	11 Water purification and fresh water supply	On-site wastewater and stormwater management, treatment and recycling, for irrigation of plant species, cleaning and aquifer recharge [through constructed wetlands, retention ponds...]; vegetation land cover for water cycling, control and purification of stormwater runoff; regeneration of existing water sources [bioretention filters for stormwater runoff]; water saving landscape options as native species selection adapted to local water cycling patterns and water saving equipment; local pollution control, detoxification and waste assimilation of overland and underground flows of water into receiving ecosystems (e.g. rivers, coastal and marine ecosystems) or water storage areas (e.g. soils, lakes, dams and wetlands), by restoring or improving ecosystem function); closed loop on-site water recycle systems	7 Living with Lakes Centre	.	●	.	●	.	.	○	●	●	●
●	12 Raw materials, ornamental and medicinal resources	On-site waste water and stormwater management systems that support raw materials biotopes (reeds, cane, t-trees) [through constructed wetlands, retention ponds...]; selection of raw material, medicinal or ornamental species adapted to local water cycling pattern, and low water footprint; water reuse, filter and purification systems with ornamental, medicinal or raw material species [constructed wetlands, ponds, living machines...]; local water management for ornamental, medicinal or raw material species irrigation	49 Perkins+Will New Atlanta Office	.	●	.	●	.	.	●	●	●	●
	04. CULTURAL												
●	13 Significant species and ecosytem values	Provision of water collection and treatment features that support or regenerate local significant species and other local ecosystem identity elements	187 Marine and Freshwater Resources Institute	.	●	.	●	.	.	○	●	.	●
●	14 Landscape aesthetic fruition	Resource to water cycle and performance strategies to enhance landscape valuation [ponds, water courses and pools, cascades, constructed wetlands...]	66 Gwinnett Environmental & Heritage Center	.	●	.	●	.	.	○	●	.	●
●	15 Leisure, recreation and psychophysical health	Provision of water harvesting/treatment structures as sources for leisure, or leisure ammenities [constructed wetlands, retention ponds, water courses...]	100 Water squares	.	●	.	●	.	.	.	●	○	●

6 Materials cycle [and waste] — Local, renewable and low impact materials, deconstruction, recycling and biodegradability

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample]	Life Cycle [introduction or application of design solutions]					[Surface] Design Integration				
				Pre-design	Design	Construction	Operation	End use	base envelope	lateral envelope	top envelope	enclosure	landscape
	01. SUPPORTING												
●	1 Soil formation and fertility	Selection and use of locally sourced onsite soil materials [clay, rammed earth, adobe...]; On-site treatment and recycling of biodegradable materials and waste, and production of compost to enrich topsoil	120 Tree Tenant + Humus Toilet	.	●	.	●	.	.	●	●	●	●
●	2 Photosynthesis and primary production	Provision of support systems for plant growth [green enveloping and landscaping] with low impact, locally sourced materials	37 House C	.	●	●	.	.	.	●	●	○	●
●	3 Nutrient cycling and waste treatment	Use and selection of locally sourced biodegradable materials, or that provide nutrient reassorbtion or balance into ecosystem; On-site treatment and recycling of biodegradable materials and waste, and production of compost to enrich topsoil	101 A different brick	.	●	.	●	.	.	●	●	○	●
●	4 Water cycling and regulation	Use and selection of low impact materials for water regulation solutions [as pervious surfaces for water infiltration and runoff control]; self-cleaning materials and water saving materials, water capturing and filtering materials	203 George 'Doc' Cavalliere Park	.	●	.	.	.	.	●	●	○	●
●	5 Biodiversity and nursery habitats	Use and selection of low impact materials [as wood, bamboo, rammed earth, thatch], that provide suitable habitat conditions for native species [either in on-site harvest place or in the built structure]; Comsumption of on-site invasive species as construction materials; reuse and recycle of existing available resources [as debris...] to provide biodiversity habitats	8 Crouch Hill Community Park	.	●	●	.	.	.	●	●	.	●
	02. REGULATING												
●	6 Climatic regulation	Use and selection of low impact materials that provide climate regulation functions; vegetation support materials [green walls and living materials] with climate regulation effects	204 Burbank Water and Power EcoCampus	.	●	.	.	.	.	●	●	.	●
●	7 Erosion control and hazard protection	Use and selection of low impact or locally sourced/salvaged materials for use in sedimentation and run-off control, and erosion prevention; Use of consolidated on-site materials derived from erosion control or hazard prevention strategies	238 Dune	●	●	.	.	.	○	.	●	.	●
●	8 Biological control & pollination	Use and selection of low impact or locally sourced/salvaged materials to provide habitat or atract pollinators [green walls and living materials, envelope and landscape structures...]	227 Marks & Spencer Cheshire Oaks	.	●	.	.	.	.	●	●	.	●
○	9 Perceptive environmental modulation												
	03. PROVISIONING												
●	10 Food supply	Use and selection of low impact or locally sourced/salvaged materials to provide food supply support systems; decomposition of organic waste into compost and natural fertilizer for local food supply vegetal species	115 New York City Steady State	.	●	.	●	.	.	●	●	●	●
●	11 Water purification and fresh water supply	Use and selection of low impact materials for water purification systems; Low water footprint materials, self-cleaning and water saving materials, water capturing and filtering materials; prevention of contaminations to water flows and water storage areas from material use	198 House like a Tree										
●	12 Raw materials, ornamental and medicinal resources	On-site provision, harvest and management of local renewable materials [timber and bamboo forests and trees, reeds, cane and other fibers] and ornamental sources for construction use; Use and selection of locally sourced biodegradable and recyclable raw material, and influence on construction materials low impact; Recycle and reuse of existing on-site materials into new local material resources	15 Minka farmhouses in Satoyama landscapes	.	●	.	●	.	.	●	●	●	●
	04. CULTURAL												
●	13 Significant species and ecosytem values	Use and selection of low impact materials that provide suitable habitat conditions for native cultural significant species [either in on-site harvest place or in the built structure]; Reuse and recycle of existing available resources [as debris...] to provide biodiversity habitats [shelter, shade, water]	62 Bay Education Center	.	●	.	.	.	.	●	●	.	●
●	14 Landscape aesthetic fruition	Use and selection of low impact materials that provide integration with the landscape	202 National Renewable Energy Lab	.	●	.	.	.	.	●	●	.	●
○	15 Leisure, recreation and psychophysical health												

7 Exterior areas and local pollution control

Landscape and amenities, control of light pollution, noise, heat island effect and glare

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample]		Life Cycle [introduction or application of design solutions]					[Surface] Design Integration				
	01. SUPPORTING				Pre-design	Design	Construction	Operation	End use	base envelope	lateral envelope	top envelope	enclosure	landscape
🟠	1 Soil formation and fertility	Vegetation cover of soil, maintenance and design of pervious areas, storm water capture and filtering, project sitting and landscape design adapted to topography and hidrography and drainage patterns, native species selection; influence of soil fertility in vegetation amenities and biodiversity support	73	Revival Fields I and II	.	●	.	●	.	●	.	.	.	●
🟠	2 Photosynthesis and primary production	Maintenance of temperature, moisture and other local conditions for vegetation development, with landscape, project setting design, and bioclimatic/passive design solutions; influence of vegetation on exterior amenities with resource to vegetation for temperature and humidity control, control glare, mitigate noise and filter atmospheric particles, diminish light pollution and heat island effect	167	Green Float	.	●	.	●	.	.	●	●	.	●
🟠	3 Nutrient cycling and waste treatment	Influence of exterior areas design and elements on local nutrient cycling capacity, and reduction of disturbance factors on local biodiversity and living organisms that provide nutrient cycling; Influence of nutrient cycling role to diminish atmospheric concentrations that enhance light pollution, heat island effect, and noise pollution	73	Revival Fields I and II	.	●	.	●	.	.	●	●	.	●
🟠	4 Water cycling and regulation	Project sitting and landscape design adapted to topography, hidrography and drainage patterns, maintenance and design of pervious areas and vegetation cover of soil, storm water capture and filtering, native species selection adapted to local pluviousity; resource of surface waters to create amenities, landscape and design features, control microclimate, and support biodiversity	130	Dormitories for ITRI Southern Taiwan Campus	.	●	.	.	.	●	.	○	.	●
🟠	5 Biodiversity and nursery habitats	Provision of habitat conditions and amenities, preserve and reintroduce native species, existing and prospective flora and fauna habitats; positive effect of the reduction of disturbance factors [light pollution, glare, changes in micro-climate, noise] for local biodiversity; additional species habitat provided through amenities startegies [vegetation barriers and buffer zones, water surfaces...]	38	Roku Museum	.	●	.	.	.	.	●	●	.	●
	02. REGULATING													
🟠	6 Climatic regulation	Role of landscape design, topography, land-use and vegetation cover on microclimate regulation, and reduction of thermic pollution; influence of local climate patterns in outdoor comfort and amenities;	239	Putrajaya 2C5 Commercial Development	.	●	.	●	.	.	●	●	.	●
🟠	7 Erosion control and hazard protection	Project adapted to topography, soils and drainage patterns, preservation of natural vegetation and role of vegetation on soil fixation, fertility, water infiltration, and minimization of impervious areas; storm water management landscape amenities (diversion, retention and filtering) influence on erosion control; reduction of sediment dispersion, and concentration of dust and particles in the atmosphere through erosion control; influence of ecosystem buffers and natural structures in local climate regulation and protection of extreme events [wind barriers, water run-off, etc], provision of shadow, and control of heat island effect	240	Grotão Community Center	.	●	.	.	.	●	.	○	.	●
🟠	8 Biological control & pollination	Landscape and envelope landscaping with resources to natural biologic control (native revegetation and species selection) and reduction of potential pest/disease vectors and invasive species; suitable habitats for biotic pollinators [shade and shelter, provision of food sources, climate and water regulation]; influence of local pollution prevention, as heat island effect, for suitable habitats for pollinating vectors and species; Role of pollination and pest control for biodiversity and amenity maintenance, as production of flowers, seeds and fruits	86	ZeroCO2 House	.	●	.	●	.	.	●	●	.	●
🟠	9 Perceptive environmental modulation	Role of landscape design, topography, land-use and vegetation cover on environmental modulation and its influence of local climate patterns, adequate noise-light environments, comfort and amenities, and local pollution control [provision of shadow, glare and light protection, noise abatement...]; Absorbtion and diffraction of background noise by thick vegetation patches (scattering and diffusing sound and reducing the reverberation time); and role of landscaping features, thermal insulation materials, street furniture, and planting materials to abate urban noise and other sources of local pollution	23	House on Pali Hill	.	●	.	.	.	.	●	●	.	●
	03. PROVISIONING													
🟠	10 Food supply	Mutual strategies for food supply and local pollution abatement [green roofs, vertical landscaping, pergolas and trellises, aquaculture, fruit trees...]; influence of urban agriculture to reduce local pollution [heat island, glare, light pollution], create interesting landscapes, control wind and provide shadows; impact of local exterior conditions in food supply sources	124	City Farm	.	●	.	●	.	●	●	●	.	●
🟠	11 Water purification and fresh water supply	Project sitting and landscape design influence in overland and underground flows of water or water storage areas, maintenance and design of pervious areas, storm water capture and filtering, improvement of catchment management (by restoring or improving ecosystem functions); role of fresh water supply in amenization of local pollution as heat island effect, and contribution for maintenance of amenities and landscape; influence of water purification on local pollution control, detoxification and water assimilation	40	Plaza Ecopolis	.	●	.	.	.	.	.	○	.	●
🟠	12 Raw materials, ornamental and medicinal resources	Provision of adequate conditions for ornamental, medicinal and raw materials resources habitat, with reduction of disturbance factors to their biotopes; resource to ornamental and medicinal vegetal species for landscaping and creation of amenities, use of local raw materials to provide pervious pavements, and structures, amenities and exterior equipment; role of medicinal, ornamental and raw material vegetation into air and water purification, environment modulation and local pollution control	25	Maison Séoul	.	●	.	.	.	.	●	●	.	●
	04. CULTURAL													
🟠	13 Significant species and ecosytem values	Exterior areas design to provide and preserve local cultural/identity landmarks, and biotopes/habitats for significant species [landscape species selection, association and distribution]; Positive influence of local pollution reduction [noise, light pollution and other stress/disturbance factors] for fruition/protection of culturally relevant landscapes [as night sky constellations...] and fruition/protection of totemic species [bats, owls, foxes, etc]	60	Laketown "Miwa no Mori"	.	●	.	.	.	●	●	●	.	●
🟠	14 Landscape aesthetic fruition	Design of exterior areas, amenities and comfort elements to provide landscape fruition; influence of local pollution control into the access and fruition of landscape;	50	Dockside Green	.	●	.	.	.	.	○	○	.	●
🟠	15 Leisure, recreation and psychophysical health	Provision of adequate environmental and design conditions for outdoor sports and leisure, and human health; influence of local pollution reduction [noise, light pollution, heat island effect...] for fruition of outside activities, and healthy environments	39	River remediation and development in Medina of Fez	●	●	.	.	.	.	.	○	.	●

8 Sustainable life-style support systems

Provision of kitchen gardens, compost, bicycle parking, laundry dry

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample]		Life Cycle [introduction or application of design solutions]					[Surface] Design Integration				
	01. SUPPORTING				Pre-design	Design	Construction	Operation	End use	base envelope	lateral envelope	top envelope	enclosure	landscape
🟠	1 Soil formation and fertility	Provision of agriculture areas within project landscape or envelope, with resource to permaculture strategies and organic waste composting to improve soil fertile conditions; on-site soil formation and fertility influence for urban agriculture and sustainable food production	63	Cheasapeake Bay Foundation	.	●	.	●	.	.	○	●	○	●
🟠	2 Photosynthesis and primary production	Provision of agriculture areas within project landscape, envelope or enclosure [exterior and interior kitchen gardens, fruit trees, planted balconys and windows, vertical and horizontal lattices...] and its contribution to photosysnthesis production; Photosysnthesis and primary production role to support plant growth and provide improved conditions and amenities for outdoor sustainable life-style support systems	142	Happy Habitats	.	●	.	●	.	.	●	●	●	●
🟠	3 Nutrient cycling and waste treatment	Nutrient cycle and biota role to the production of compost and soil fertilizer, and water cleaning to the use in agriculture areas within project site; Provisioning of agriculture areas within project landscape, envelope or enclosure [exterior and interior kitchen gardens, fruit trees, planted balconys and windows, vertical and horizontal lattices...] and its contribution to nutrient cycling	58	EcoVillage Matsudo	.	●	.	●	.	.	●	●	○	●
🟠	4 Water cycling and regulation	Provision of pervious surfaces for water infiltration through alocation of sustainable lifestyle support systems in the project, as agriculture areas [in landscape and envelope]; Utilization of rain water harvest and filtering, and on-site wastewater treatment for irrigation of kitchen gardens, exterior areas cleaning and other water saving strategies	143	Shrubhill Works	.	●	.	●	.	.	●	●	.	●
🟠	5 Biodiversity and nursery habitats	Provision of agriculture areas within project landscape or envelope, with resource to permaculture strategies with positive impact on biodiversity; Contribuition of biodiversity as pest control and pollination vector into urban agriculture systems and creation of amenities and favorable conditions for plant development, or food sources for aquaculture and livestock production	47	Masthusen Bo01 District development	.	●	.	●	.	.	●	●	○	●
	02. REGULATING													
🟠	6 Climatic regulation	Provision of agriculture areas within project landscape or envelope, providing land cover and vegetation with influence on microclimate; Influence of micro climate regulation on outdoor amenities for sustainable filestyle support systems [breeze for laundry dry, or conditions for plant development..]	32	Center for Regenerative Studies	.	●	.	●	.	.	●	●	.	●
🟠	7 Erosion control and hazard protection	Project adapted to topography, soils and drainage patterns, preservation of natural vegetation and role of vegetation on soil fixation and fertility, in kitchen gardens and other agriculture areas within site; reduction of sediment dispersion, dust and particles in the atmosphere through erosion control, and its contribution to the amenities and comfort of outdoor sustainable life style systems	44	Mountain Band-Aid	.	●	.	●	.	●	.	○	.	●
🟠	8 Biological control & pollination	Selection of biodiverse native species to increase biological control (in organic agriculture kitchen gardens), and reduction of habitat for pests; Role of biota control and pollination to maintain local urban agriculture [plant reproduction, production of seeds and fruits] and derived products; Provision of pollinators farming	125	Ginza Honeybee Project	.	●	.	●	.	.	○	●	.	●
🟠	9 Perceptive environmental modulation	Creation of amenities for outdoor sustainable activities [provision of shadow, wind protection, and breezes, noise and light filter...]; Provision of sustainable life support systems as source of environmental modulation [noise abatement and light filtering with vegetation fences, trellises, tree canopies...]	47	Masthusen Bo01 District development	.	●	.	●	.	.	●	●	.	●
	03. PROVISIONING													
🟠	10 Food supply	Provision of landscape and building areas for user's resource and maintenance of food supply [exterior and interior kitchen gardens, orchards, and ponds...] on immediate site or envelope [planted balconies and windows; vertical and horizontal lattices, green roofs, aquaculture...] and its contribution to other sustainable life style support systems [compost production and outdoor amenities...]	222	Edible Terrace + Edible Terrace2	.	●	.	●	.	.	●	●	●	●
🟣	11 Water purification and fresh water supply	Contribution of fresh water supply sources and harvest and on-site water purification strategies for irrigation in local gardening and agriculture	198	House like a Tree	.	●	.	●	.	.	.	●	○	●
🟠	12 Raw materials, ornamental and medicinal resources	Selection of apropriate local adapted species and plant association [permaculture] between onsite agriculture areas with raw materials, medicinal and ornamental resources in exterior and interior kitchen gardens on immediate site or envelope [planted balconies, vertical and horizontal lattices, green roofs, green landscaping...]; Utilization of on-site organic compost to feed raw materials, medicinal and ornamental resources; Contribution of raw materials, medicinal and ornamental resources on outdoor amenities for other sustainable lifestyle support systems	77	Satonokaze daytime workshop	.	●	.	●	.	.	●	●	○	●
	04. CULTURAL													
🟠	13 Significant species and ecosytem values	Protection, valorization and restoration of significant local species and its contribution for amenities for outdoor sustainable activities; Use of locally cultural relevant sustainable support systems, food supply species and crop systems with local identity traits	206	Urban Savannah, Alley Midlands, Understory Dwellings	.	●	.	●	.	.	○	●	.	●
🟠	14 Landscape aesthetic fruition	Integration of sustainable lifestyle suppport systems with landscape fruition opportunities and valorization, landscape fruition points [belvederes, terraces...], or enhanced landscape fruition conditions and amenities	141	Matripolis	.	●	.	●	.	.	○	●	.	●
🟠	15 Leisure, recreation and psychophysical health	Provision of support areas for sustainable life style systems [community gardens, local food production, organic compost, and recycling and reuse centers] that encourage and create amenities for outdoor activities, exercise and social interaction, and healthy life styles	224	Vertical Farm Arcology	.	●	.	●	.	.	○	●	.	●

03. SOCIO-ECONOMIC RELEVANCE

9 Customization possibilities and operation — Interior space, comfort and envelope control, possibilities of extension and modification

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample]	Life Cycle [introduction or application of design solutions]: Pre-design	Design	Construction	Operation	End use	[Surface] Design Integration: base envelope	lateral envelope	top envelope	enclosure	landscape
	01. SUPPORTING												
○	1 Soil formation and fertility												
● (green)	2 Photosynthesis and primary production	Envelope and landscape costumization by the addition of green leaf vegetation elements [micro and window greenery, trellis and pergolas...]	188 Vertical Garden Kit	.	●	.	●	.	.	●	○	○	●
● (orange)	3 Nutrient cycling and waste treatment	Envelope and landscape costumization by the addition of nutrient cycling support vegetation or other biota elements [partitions, micro and window greenery, trellis and pergolas...]	42 Suginami-ku assembly hall	.	●	.	●	.	.	●	○	○	●
● (green)	4 Water cycling and regulation	Costumizable envelope and landscape elements with support for water cycling and regulation [green roofs, water walls, bio-ponds, wetlands...]; Envelope and landscape modification with addition to pervious exterior pavements and soil vegetation coverage	209 Symbiotic Existence Through Transactional Awareness	.	●	.	●	.	.	●	●	.	●
● (orange)	5 Biodiversity and nursery habitats	Envelope and landscape costumization by the addition of local biodiversity support elements [partitions, micro and window greenery, trellis and pergolas, living walls and roofs, ponds, and intermediate spaces...]	209 Symbiotic Existence Through Transactional Awareness	.	●	.	●	.	.	●	●	.	●
	02. REGULATING												
● (orange)	6 Climatic regulation	Costumizable envelope and landscape elements with support for local climate regulation [green roofs and walls, micro and window greenery, ponds, and other passive design systems, land cover, colour and material options...]	97 Yakushima Symbiotic Housing	.	●	.	●	.	.	●	●	.	●
○	7 Erosion control and hazard protection												
● (green)	8 Biological control & pollination	Envelope and landscape costumization by the addition of biological control and pollination support elements [species selection and association in micro and window greenery, trellis and pergolas, to control pest and disease vectors, and attract pollinators...]	194 Mediterranean window pots and gardens	.	●	.	●	.	.	●	●	○	●
● (orange)	9 Perceptive environmental modulation	Customization of envelope and landscape to enhance environmental modulation [passive design features and other auto-regulatory modulation processes of natural elements, as living walls, pergolas and trellises with deciduous species, water surfaces and greenery partitions and canopies]	174 Special NO 9 House	.	●	.	●	.	.	●	●	○	●
	03. PROVISIONING												
● (orange)	10 Food supply	Envelope and landscape costumization by the addition of food supply support elements [partitions, micro and window greenery, trellis and pergolas, allowance of possible spaces for self cultivation and breeding...]; use of food supply species/materials as form of envelope control [balconies, gardens and roof gardens [private or shared], trellises with groundling food plants, window curtains with food sources...]	162 Cascading Gardens	.	●	.	●	.	.	●	●	●	●
○	11 Water purification and fresh water supply												
● (orange)	12 Raw materials, ornamental and medicinal resources	Envelope and landscape costumization by the addition of ornamental, medicinal or raw material sources [fences, partitions, micro and window greenery, trellis and pergolas, living walls and roofs, ponds, and intermediate spaces...]; use of local ornamental materials and living plants (shutters, blinders, courtains) for envelope control; use of local materials as reed and bamboo for envelope control (shutters, blinders, courtains);	107 Tokyo micro-greenery	.	●	.	●	.	.	●	●	●	●
	04. CULTURAL												
● (green)	13 Significant species and ecosytem values	Envelope, landscape costumization and space appropriation that protect or support identity features of local environment [significant species habitat, food, nests...]	145 Rehabilitation	.	●	.	○	.	.	●	●	.	●
● (green)	14 Landscape aesthetic fruition	Envelope or site costumization for landscape aesthetic fruition [construction of observation points, amenities...] or landscape fruition through interior views	126 Habitat 67	.	●	.	○	.	.	●	●	.	●
● (green)	15 Leisure, recreation and psychophysical health	Envelope, landscape costumization and space appropriation for leisure, recreation areas or psychophysical healing environments with immediate comfort controlable systems	87 Amami hospital	.	●	.	○	.	.	●	●	○	●

10 Community participation and user's satisfaction — Participatory processes, engagement with local communities & stakeholders and user targeting

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample]	Life Cycle [introduction or application of design solutions]: Pre-design	Design	Construction	Operation	End use	[Surface] Design Integration: base envelope	lateral envelope	top envelope	enclosure	landscape
	01. SUPPORTING												
● (green)	1 Soil formation and fertility	Engagement with local populations [tennants, neighborhood communities...] for the support of soil local ecological functions and organic fertilization [community initiative and self-organization, workshops and events, realization of design charretes for kitchen gardens and landscaping initiatives]	214 Le 56 – Ecointerstice	●	○	.	●	.	.	.	●	.	●
● (green)	2 Photosynthesis and primary production	Engagement with local populations [tennants, neighborhood communities...] and participation of stakeholders in the support of local greenery and photosynthesis production [community initiative and self-organization, workshops and events, realization of design charretes for green landscaping and enveloping initiatives]	235 Ekostaden Augustenborg	●	○	.	●	.	.	○	●	○	●
● (green)	3 Nutrient cycling and waste treatment	Engagement with local populations [tennants, neighborhood communities...] and participation of stakeholders in the support of local nutrient cycling [community initiative and self-organization, workshops and events, realization of design charretes for green landscaping and enveloping initiatives]	201 Scenic Hudson's Long Dock Park	●	.	.	●	.	.	.	○	○	●
● (orange)	4 Water cycling and regulation	Engagement with local populations [tennants, neighborhood communities...] and participation of stakeholders to implement water regulation practices [community initiative and self-organization, workshops and events, realization of design charretes for green landscaping and enveloping initiatives, guarantee pervious surfaces and vegetated soil in customizable areas, rain water management, creation of open air water courses, and self- protection against floods]	235 Ekostaden Augustenborg	●	○	.	●	.	.	○	●	.	●
● (orange)	5 Biodiversity and nursery habitats	Engagement with local populations [tennants, neighborhood communities...] participation of stakeholders for the protection of local habitat conditions and biodiversity [community initiative and self-organization, workshops and events, realization of design charretes for green landscaping and enveloping initiatives; specific comissioning and client requirements for biodiversity conservation and promotion	168 Phoenix Garden	●	○	.	●	.	.	●	●	.	●
	02. REGULATING												
● (orange)	6 Climatic regulation	Engagement with populations for climate regulation strategies [low emission transports and access, preservation of land-use and vegetation ground cover, bioclimatic design an exterior amenities], within private areas in the project; influence of local climate factors on user's satisfaction and specific comissioning and client requirements	150 Kurimoto Millennium City	●	●	.	●	.	.	●	●	.	●
● (orange)	7 Erosion control and hazard protection	Engagement with local populations [tennants, neighborhood communities...] and participation of stakeholders for erosion control and hazard protection practices [maintenance and restoration of drainage patterns and soil vegetation cover, through urban agriculture, private or public gardens and other self-sustained systems; wind or wave protection buffers]	240 Grotão Community Center	●	●	.	●	.	●	.	.	.	●
● (orange)	8 Biological control & pollination	Engagement with local populations [tennants, neighborhood communities...] and participation of stakeholders for biological control practices in urban agriculture and gardens, and support of pollination vectors	131 HK Farm / HK Honey	○	○	.	●	.	.	●	●	○	●
● (orange)	9 Perceptive environmental modulation	Engagement with local populations for creation and maintenance of environmental modulation comfort strategies [bioclimatic design and green landscaping, trellises and pergolas..]	42 Suginami-ku assembly hall	●	○	.	●	.	.	●	●	.	●
	03. PROVISIONING												
● (orange)	10 Food supply	Engagement with local populations [tennants, neighborhood communities...] and participation of stakeholders for local food production within project site; specific comissioning and client requirements for food supply sources and self-subsistency buildings	214 Le 56 – Ecointerstice	●	●	.	●	.	.	●	●	○	●
● (orange)	11 Water purification and fresh water supply	Engagement with local populations [tennants, neighborhood communities...] and participation of stakeholders for water resource purification, protection and managed use of local water resources; specific comissioning and client requirements for water purification, local pollution control, detoxification and waste water treatment, and self-subsistency buildings in water	39 River remediation and development in Medina of Fez	●	○	.	●	.	.	○	●	○	●
● (orange)	12 Raw materials, ornamental and medicinal resources	Engagement with local populations [tennants, neighborhood communities...] and participation of stakeholders for protection and management of local raw materials, ornamental and medicinal resources; specific comissioning and client requirements for on-site raw materials or ornamental resources use or production within project;	95 Tsubaki [Camelia] Castle	●	●	.	●	.	.	●	●	○	●
	04. CULTURAL												
● (orange)	13 Significant species and ecosytem values	Engagement with local populations and participation of stakeholders for the protection of local identity landscapes, elements and species [formation of local bounds with place-community through public participation methods, community initiative and self-organization, workshops and events, realization of design charretes..]; specific commissioning or client requirements for valorization and protection of local cultural identity features and species	53 Tree Mountain-a living time capsule	●	○	.	●	.	.	○	○	.	●
● (orange)	14 Landscape aesthetic fruition	Engagement with local populations [tennants, neighborhood communities...] and participation of stakeholders for protection and valorization of landscape and scenery features [community participation design methods or civic movements motivated by landscape fruition objectives]; specific commisioning for landscape aesthetic fruition	200 Phipps' Center for Sustainable Landscapes	●	●	.	●	.	○	○	○	.	●
● (orange)	15 Leisure, recreation and psychophysical health	Engagement with local populations [tennants, neighborhood communities...] and participation of stakeholders for protection and valorization of local recreation and leisure areas; formation of place-community local bounds through public participation in design and construction and; specific comissioning for leisure, recreation, and community health spaces	236 Ecobarrio Suerte 90	●	●	.	●	.	○	.	○	.	●

11 Economic dynamics and lifecycle costs

Economic impact and distribution, balance of initial investment, operation and end use costs

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample]		Life Cycle [introduction or application of design solutions]					[Surface] Design Integration				
						Pre-design	Design	Construction	Operation	End use	base envelope	lateral envelope	top envelope	enclosure	landscape
		01. SUPPORTING													
●	1	Soil formation and fertility	Role of soil as protective and insulating layer to envelope membranes and materials, and its influence in the reduction of operation costs [green roof, landscape...]	158	East Hills Center	.	●	.	●	.	.	○	●	.	●
○	2	Photosynthesis and primary production													
●	3	Nutrient cycling and waste treatment	On-site waste treatment systems as source of cost saving or additional tennant/developer income [compost and other nutrient products, filtered water...]	207	Urban Ecotones	.	●	●	●	.	.	○	●	.	●
●	4	Water cycling and regulation	Storm water management systems influence in the reduction of operation costs [green roof, blue roof, landscape SUD's...], through hazard prevention (flooding), envelope membrane materials durability, and reduction of energy operation costs	163	Bronx Blue-and-Green Roof	.	●	.	●	.	.	.	●	.	●
●	5	Biodiversity and nursery habitats	Influence of biodiversity supporting strategies on final real estate market value and reduction of operation costs [protection of envelope membranes, passive design...]; Economical investment and budget adequation to biodiversity supporting strategies	145	Rehabilitation	.	●	.	●	.	.	●	●	.	●
		02. REGULATING													
●	6	Climatic regulation	Role of local climate regulation features in the reduction of operation costs [passive design, and bioclimatic strategies...], through reduction of heating/cooling demand	152	Willow School	.	●	.	●	.	.	●	●	.	●
●	7	Erosion control and hazard protection	Hazard prevention landscape design and building setting solutions and its influence on longer construction and materials durability cycles, through the reduction of flooding, landslides, extreme wind or waves	89	Research Institute for Humanity and Nature	●	●	●	.	.	●	.	.	.	●
●	8	Biological control & pollination	Use of biological control strategies in landscape and green envelope design [as species selection, association and biodiversity] and its influence on landscape maintenance costs (with pesticides, fungicides or herbicides, and potencial crop losses); prevention of pests through biological control and its influence on materials and systems durability and maintenance	135	Lufa Farms	.	●	.	●	.	.	●	●	●	●
●	9	Perceptive environmental modulation	Influence of environmental modulation features on final real estate market value and reduction of operation costs [protection of envelope membranes, passive design...];	69	Stacking Green	.	●	.	●	.	.	●	●	.	●
		03. PROVISIONING													
●	10	Food supply	Contribution of local provision of food supply to tenants, users and owners economy (as self-subsistency and commercial income) purposes [in exterior and interior kitchen gardens, orchards, and ponds, immediate site, green roof, planted balconys and windows; vertical and horizontal lattices...]	188	Vertical Garden Kit	.	●	.	●	.	.	●	●	●	●
●	11	Water purification and fresh water supply	Contribution of local water supply sources to tenants, users and owners' economy and self-sustainance; influence of water purification systems in the reduction of operation costs in water for human consumption and cleaning;	152	Willow School	.	●	.	●	.	.	.	●	○	●
●	12	Raw materials, ornamental and medicinal resources	Local provision of raw materials sources for tenants, users and owners' economy and self-sustainance during operation, or as construction/furniture materials; local provision of medicinal and ornamental resources (teas, aromatic herbs, flowers and other products) for building users and owners economy, as self-subsistency or commercial income source [in exterior and interior kitchen gardens, orchards, and ponds, immediate site, green roof and walls, planted balconys and windows; vertical and horizontal lattices; Role of species selection, association and placement in the reduction of landscape maintenance and energy operation costs	181	Painters Hall Community Center	.	●	.	●	.	.	●	●	●	●
		04. CULTURAL													
●	13	Significant species and ecosytem values	Protection or rehabilitation of local significant species and ecosytem values and its influence on final real estate market value and reduction of operation costs [protection of envelope membranes, passive design...]; Economical investment and budget adequation for the support of cultural significant ecosystem values	159	Nitshill Integrated Green Infrastructure	.	●	.	●	.	.	○	●	.	●
●	14	Landscape aesthetic fruition	Influence of landscape and scenery valuation on final real estate market values; Economical investment and budget adequation to landscape valuation strategies	50	Dockside Green	.	●	.	●	.	.	○	●	.	●
●	15	Leisure, recreation and psychophysical health	Influence of leisure and recreation amenities on final real estate market values;	31	HighLine	.	●	.	●	.	.	○	●	.	●

12 Human health and well being

Human health and well-being and other psycho-sociological aspects

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample]		Life Cycle [introduction or application of design solutions]					[Surface] Design Integration				
						Pre-design	Design	Construction	Operation	End use	base envelope	lateral envelope	top envelope	enclosure	landscape
		01. SUPPORTING													
○	1	Soil formation and fertility													
●	2	Photosynthesis and primary production	Inclusion of vegetation in landscape, building envelope or building interior, and its influence on indoor air quality and indoor-outdoor visual psycho-social aspects	136	FSMA Tower	.	●	.	●	.	.	●	●	●	●
●	3	Nutrient cycling and waste treatment	Elimination and filtering of nocive compounds and nutrient regulation in water and air; Inclusion of vegetation in landscape, building envelope or building interior, and other nutrient cycling solutins [eco-machines, living machines, ponds and wetlands; purification materials...]	17	Treescraper Office Building of the Future	.	●	.	.	.	.	○	●	●	●
●	4	Water cycling and regulation	Provision of rain water management design solutions with positive effects on human wellbeing [on-site rainwater harvest and storage, stormwater retention and filtering [constructed wetlands, living machines, filtering ponds...; landscape options and ground cover with vegetation]	235	Ekostaden Augustenborg	.	●	.	.	.	.	.	○	○	●
●	5	Biodiversity and nursery habitats	Protection of existent biotopes or ecological corridors, provision of habitat support (shelter, food, water) for native local species, and positive impact of biodiversity into qualitative comfort [through interaction with animal and plant species...]	30	Setagaya-ku Fukasawa Symbiotic Housing Complex	.	●	.		.	.	●	●	.	●
		02. REGULATING													
●	6	Climatic regulation	Influence of micro climate regulation in the creation of positive amenities for human health and wellbeing [reduction of heat island effects and wind discomfort, confortable leisure areas...]	81	House of Outlook	.	●	.	●	.	●	○	●	○	●
●	7	Erosion control and hazard protection	Influence of hazard mitigation solutions at local level in human health and wellbeing [reduction of wind disconfort, protection from extreme tides, vegetation land cover for erosion prevention]	109	Philipines mangrove coastal settlements	.	●	.	.	.	●	.	●	.	●
●	8	Biological control & pollination	Resource to biological control strategies in the reduction of human pests and disease vectors [plant associations, provision of habitats for natural repellents and predators in landscape, green roofs, window greenery]	194	Mediterranean window pots and gardens	.	●	.	●	.	.	●	●	●	●
●	9	Perceptive environmental modulation	Influence of natural environmental modulation [light filter through vegetation, sounds of water and wind..] into human wellbeing, psychological comfort and qualitative apreciation of space	157	CH2 [Council House 2]	.	●	.	●	.	.	●	●	●	●
		03. PROVISIONING													
●	10	Food supply	Provision of food supply species and resources in landscape, building envelope or building interior [vertical partitions, planters and ceiling], courtyards or exterior areas [fruit trees, green walls and roofs, trellises...], with positive visual and/or physical contact, to human health and wellbeing	41	Pasona HQ Urban Farm	.	●	.	●	.	.	●	●	●	●
●	11	Water purification and fresh water supply	Provision of clean water supply and purification resources and its influence on human well being [water surfaces and running water courses, balance of moist and temperature in the environment, and visual/acoustic delight]; local water quality regulation impact in human health [control of contamination sources, disease and pest vectors]	210	Prince Edward Island Ark	.	●	.	●	.	.	○	●	●	●
●	12	Raw materials, ornamental and medicinal resources	Provision of raw material, ornamental or medicinal supply species and resources in landscape, building envelope or building interior [vertical partitions, planters and ceiling], courtyards or exterior areas [trees, green walls and roofs, trellises...], with positive visual and/or physical contact, to human health and wellbeing; Inclusion of medicinal plants [aromatic, ornamental, phytochemical] in landscape, building envelope or building interior	137	Symbiotic Office	.	●	.	●	.	.	●	●	●	●
		04. CULTURAL													
●	13	Significant species and ecosytem values	Protection and preservation of features of the local environment [significant species, biotopes, existing vegetation, wetland features, historical cultural landscapes] contributing to socio-psicological comfort	76	Makino Museum of Plants and People	.	●	.	●	.	●	●	●	○	●
●	14	Landscape aesthetic fruition	Provision of scenic valuation and landscape observation opportunities within project site or interior, with positive impact on human wellbeing and health	80	Nissan Advanced Technology Center	.	●	.	●	.	●	○	●	.	●
●	15	Leisure, recreation and psychophysical health	Provision of leisure and recreation areas within project site with positive influence in human physical and psychological balance	234	BedZED	.	●	.	●	.	.	○	●	.	●

13 Concept originality, innovation and creativity — Artistic and conceptual valuation, contemporaneity, innovation, logic and intention

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample]		Life Cycle [introduction or application of design solutions] Pre-design	Design	Construction	Operation	End use	[Surface] Design Integration base envelope	lateral envelope	top envelope	enclosure	landscape
	01. SUPPORTING													
●	1 Soil formation and fertility	Design innovation or concept statement in the provision, support or resource to local soil formation and fertility	51	Rice/Tree/Burial	●	●	.	.	.	●	○	○	.	●
●	2 Photosynthesis and primary production	Design innovation or concept statement in the provision, support or resource to additional vegetation and photosynthesis opportunities	121	House Hundertwasser	●	●	.	.	.	.	●	●	○	●
●	3 Nutrient cycling and waste treatment	Design innovation or concept statement in the provision, support or resource to nutrient cycling and treatment of pollutants and waste	74	Torre de Especialidades	●	●	.	.	.	.	●	●	○	●
●	4 Water cycling and regulation	Design innovation or concept statement in the provision, support or resource to water regulation and cycling; Provision of innovative and qualified water regulation and cycling design solutions	100	Water squares	●	●	.	.	.	○	.	●	○	●
●	5 Biodiversity and nursery habitats	Design innovation or concept statement in the provision, support or resource to local biodiversity habitats; influence of local biodiversity features on architecture concept originality and design decisions	76	Makino Museum of Plants and People	●	●	.	.	.	●	●	●	.	●
	02. REGULATING													
●	6 Climatic regulation	Design innovation or concept statement in the provision, support or resource to climate regulation; provision of innovative and qualified local climate regulation design solutions	238	Dune	●	●	.	.	.	○	●	●	.	●
●	7 Erosion control and hazard protection	Design innovation or concept statement in the provision, support or resource to erosion control and hazard protection; design for erosion prevention [minimum earthworks and topography alteration, revegetation of soil]	114	Palisade Bay	●	●	.	.	.	●	.	.	.	●
●	8 Biological control & pollination	Design innovation or concept statement in the provision, support or resource to pollination or pest control; provision of innovative and qualified pollination and pest control promotion solutions	172	The Magic Mountain	●	●	.	.	.	.	●	●	.	●
●	9 Perceptive environmental modulation	Design innovation or concept statement in the provision, support or resource to environmental perceptive modulation	38	Roku Museum	●	●	.	.	.	.	●	○	○	●
	03. PROVISIONING													
●	10 Food supply	Design innovation or concept statement in the provision, support or resource to food resources supply	165	The Allotment	●	●	.	.	.	.	●	●	●	●
●	11 Water purification and fresh water supply	Design innovation or concept statement in the provision, support or resource to clean water resources supply [protection/restoration of water courses, collection and filtering of rainwater and wastewater]	2	Sabo House	●	●	.	.	.	○	●	●	●	●
●	12 Raw materials, ornamental and medicinal resources	Design innovation or concept statement in the provision, support or resource to raw materials, ornamental or medicinal resources supply; Influence of existing local raw materials, ornamental or medicinal sources in project concept	69	Stacking Green	●	●	.	.	.	.	●	●	●	●
	04. CULTURAL													
●	13 Significant species and ecosytem values	Design innovation or concept statement in the provision, support or resource to local significant species or values;	94	Chashitsu	●	●	.	.	.	●	●	●	●	●
●	14 Landscape aesthetic fruition	Design innovation or concept statement in the provision, support or resource to lanscape fruition and valuation; influence of existing local landscape values in project concept	99	Loblolly House	●	●	.	.	.	●	●	●	●	●
●	15 Leisure, recreation and psychophysical health	Design innovation or concept statement in the provision, support or resource to leisure and outdoor recreation areas; provision of innovative and qualified leisure and outdoor recreation spaces and opportunities	61	ACROS Fukuoka International Hall	●	●	.	.	.	.	●	●	○	●

14 Visual — Scale, rhythm and volume, colours and texture, transparency-opaqueness, light-shadow, and view framing

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample]		Life Cycle [introduction or application of design solutions] Pre-design	Design	Construction	Operation	End use	[Surface] Design Integration base envelope	lateral envelope	top envelope	enclosure	landscape
	01. SUPPORTING													
●	1 Soil formation and fertility	Visual integration and design of soil surfaces within immediate site and envelope [green roofs, balconies...]; Contribution of soil formation and fertility to enhance, accentuate or provide visual qualities to the project [volume, texture, geometries...]	91	Kitakami Canal Museum	.	●	.	.	.	.	●	●	○	●
●	2 Photosynthesis and primary production	Visual integration of vegetation support structures within immediate site and envelope [green enveloping with trellises, green walls, microgreenery...]; Creation of interesting landscaping and views through vegetation development; Contribution of green leaf plants to enhance, accentuate or provide visual qualities to the project [colors, volume, texture, geometries...]	56	Regional Chamber of Commerce and Industry	.	●	.	.	.	.	●	●	○	●
●	3 Nutrient cycling and waste treatment	Visual integration of biotic nutrient cycling elements (plants) within immediate site and envelope [green enveloping with trellises, green walls, microgreenery...]; Visual integration of nutrient cycling and balance systems [air-purifying materials, living machines...]; Contribution of nutrient cycling mechanisms to enhance, accentuate or provide visual qualities to the project [volume, texture, colors, geometries...]	69	Stacking Green	.	●	.	.	.	.	●	●	○	●
●	4 Water cycling and regulation	Visual integration of water cycling support strategies [natural or cultural water features: rivers, channels, ponds, lakes, shores, waterfalls; SUDs, pervious soil surfaces...] within project landscape and envelope providing sources for visual quality [shape and volume of water surfaces, reflection on materials, design and selection of ground surface materials, patterns for water infiltration...]	186	Queens Botanical Garden Interpretation Center	.	●	.	.	.	.	○	●	○	●
●	5 Biodiversity and nursery habitats	Visual integration of biodiversity habitat support in landscape and building envelope [provision of shelter and nourishment for wildlife with apropriate vegetation and hideouts]; Contribution of habitat provision elements to enhance, accentuate or provide visual qualities to the project [textures, volume and geometries shapes, light/shadow filter through vegetation canopies and trellises]	59	Bird apartment	.	●	.	.	.	.	●	●	.	●
	02. REGULATING													
●	6 Climatic regulation	Visual integration of climate regulation elements within immediate site and envelope [water surfaces, canopies and trellises, green roofs, deciduous trees and plants...]; Influence of visual elements into local climate [disposition and arrangement of volumes, land cover and vegetation design, exterior finishes, colors and materials, and shading...]	28	Miami Perez Art Museum	.	●	.	.	.	.	●	●	.	●
●	7 Erosion control and hazard protection	Visual integration and design of erosion control and hazard protection strategies [topography adaptation, vegetation ground cover, retention walls, terraces and mounds, element barriers from wind, water or waves]	175	Mill Creek Canyon Earthworks	.	●	.	.	.	.	.	○	.	●
●	8 Biological control & pollination	Visual integration of support systems for pollination and biologic control [provision of habitat for polinators, adequate plant selection and association...] in landscape and envelope design; Contribution of pollination role to the provision of visual quality elements [colors of flowers, seeds and fruits...]	161	K-abeilles Hotel for Bees	.	●	.	.	.	.	●	●	.	●
●	9 Perceptive environmental modulation	Visual integration and design of perceptive environmental modulation features in landscape and envelope [light filter and shadows through vegetation, water reflections and movements...]; Contribution of environmental comfort modulation features to the creation of visual qualities	24	Reading room	.	●	.	.	.	.	●	●	○	●
	03. PROVISIONING													
●	10 Food supply	Visual integration and design of food supply resources in landscaping, envelope and interior; Contribution of food supply systems to enhance, accentuate or provide visual qualities to the project [colors, texture, and shape of plants species, planting and farming structures, trees, vertical and horizontal trellises...]	182	Edible Garden, Canopy Walk and Cascades Garden	.	●	.	.	.	.	●	●	●	●
●	11 Water purification and fresh water supply	Contribution of fresh water supply local resources to enhance, accentuate or provide visual qualities to the project [natural or cultural water surfaces and harvest systems (rivers, channels, ponds, lakes, waterfalls, wells, cisterns), and its shape, volume geometry, reflection qualities ...]; Design of water purifying strategies and regeneration of watercourses or storage areas	22	Tara House	.	●	.	.	.	.	○	●	●	●
●	12 Raw materials, ornamental and medicinal resources	Visual integration and design of raw materials, ornamental and medicinal resources in landscaping, envelope and interior; Use and selection of onsite raw materials in interior and exterior; Contribution of raw materials, ornamental and medicinal resources support systems to enhance, accentuate or provide visual qualities to the project [colors, texture, and shape of plants species, planting structures, trees, vertical and horizontal trellises...]	212	Europe in Bloom	.	●	.	.	.	.	●	●	●	●
	04. CULTURAL													
●	13 Significant species and ecosytem values	Contribution of significant species and ecosystem values to enhance, accentuate or provide visual qualities to the project [colors, volume, texture, geometries, shadows, light filter trough vegetation canopies, trellises or water surfaces...]; Provision and visual integration of habitat support for local significant species or valorization of ecosystem elements in project landscape and envelope; Protection and fruition of existing landscape features through volume, shape, contrast;	24	Reading room	.	●	.	.	.	.	●	●	.	●
●	14 Landscape aesthetic fruition	Influence of visual elements [volume, texture, geometries, colors, patterns, and framing...] into landscape fruition; Contribution of scenic landscape fruition to enhance, accentuate or provide visual qualities to the project [interior and exterior views...];	9	Ando Hiroshige Museum	.	●	.	.	.	○	●	●	○	●
●	15 Leisure, recreation and psychophysical health	Visual integration and design of leisure and recreation areas within project limits, with the creation of interesting landscaping and views, and support for human health and well being;	119	Row house	.	●	.	.	.	.	○	●	○	●

15 Acoustics — Sound reflection, insulation and absorption, sounds from uses and materials

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options		Reference Study Case [Sample]	Life Cycle [introduction or application of design solutions]					[Surface] Design Integration				
						Pre-design	Design	Construction	Operation	End use	base envelope	lateral envelope	top envelope	enclosure	landscape
		01. SUPPORTING													
●	1	Soil formation and fertility	Use of soil as acoustic insulation material [in underground or half buried constructions, structural walls, green roofs or walls with soil layers]	92	Tanpopo [Dandelion] House	.	●	.	.	.	●	●	●	○	.
○	2	Photosynthesis and primary production													
○	3	Nutrient cycling and waste treatment													
●	4	Water cycling and regulation	Use of water cycling and storage through the ecosystem providing sources for acoustic quality within project [room acoustics and insulation, water falling or running sounds, water wall or roof...]	191	Shishi-odoshi	.	●	.	.	.	.	○	●	○	●
●	5	Biodiversity and nursery habitats	Design with living materials/vegetation to form acoustic insulation and modulation barriers, with positive impact to support biodiversity and breeding habitats; incorporation of sounds from biodiversity habitats and species	227	Marks & Spencer Cheshire Oaks	.	●	.	.	.	.	○	○	.	●
		02. REGULATING													
○	6	Climatic regulation													
○	7	Erosion control and hazard protection													
○	8	Biological control & pollination													
●	9	Perceptive environmental modulation	Design of noise insulation and filter through vegetation barriers [landscape trees, vegetal fences; envelope landscaping with living walls or roofs, and interior design]; Contribution of environmental comfort modulation to the creation of interesting acoustic features [sound filtering through vegetation and other support structures; water and wind sounds filtered through design or natural structures];	199	901 Cherry Offices	.	●	.	.	.	.	○	●	○	●
		03. PROVISIONING													
○	10	Food supply													
●	11	Water purification and fresh water supply	Project design utilizing fresh water supply sources or purification resources to enhance acoustic quality [room acoustics, insulation, water falling or running sounds, water wall or roof...];	116	Mãe d'Água Reservatory	.	●	.	.	.	.	○	○	●	●
●	12	Raw materials, ornamental and medicinal resources	Resource to local natural raw materials in accoustic valorization of the project [insulation/reflection, flooring properties, cladding and envelope materials [cork, rammed earth, wool, etc]; Resource to ornamental or medicinal species as insulation, absorption or reflection barriers in envelope, interior or landscape	20	Bosco Verticale	.	●	.	.	.	.	○	●	○	●
		04. CULTURAL													
○	13	Significant species and ecosytem values													
○	14	Landscape aesthetic fruition													
●	15	Leisure, recreation and psychophysical health	Accoustic design of leisure and sport areas, with noise filter and modulation of sound through natural elements, and its influence to human health and well being; minimization of interior/exterior noise as support or result from sports/leisure activities spaces	61	ACROS Fukuoka International Hall	.	●	.	.	.	.	●	●	.	●

16 Other senses: olfaction, tactility, motion perception — Surfaces texture, pavement regularity and steepness and height levels, scents from materials & uses

*		LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options		Reference Study Case [Sample]	Life Cycle [introduction or application of design solutions]					[Surface] Design Integration				
						Pre-design	Design	Construction	Operation	End use	base envelope	lateral envelope	top envelope	enclosure	landscape
		01. SUPPORTING													
●	1	Soil formation and fertility	Use of soil materials as texture and topography; Landscape and green envelope [roof] design influence of ground and pavement steepness angle, water infiltration and runoff, and vegetation ground cover for soil formation and fertility	175	Mill Creek Canyon Earthworks	.	●	.	.	.	○	.	●	.	●
○	2	Photosynthesis and primary production													
○	3	Nutrient cycling and waste treatment													
●	4	Water cycling and regulation	Combined use of ground surface materials and texture, and water cycling surfaces in tactility and motion perception; Landscape and green envelope design influence of ground and pavement steepness angle, soil formation and vegetation ground cover for water infiltration and runoff	186	Queens Botanical Garden Interpretation Center	.	●	.	.	.	.	○	●	.	●
●	5	Biodiversity and nursery habitats	Provision of habitats with characteristic olfactory elements [green landscaping and enveloping with aromatic vegetal species as pine forest, ceddars, myrtle...]; Design of envelope and landscape surfaces textures to provide specific habitat conditions [shade, shelter, microclimate...], and habitat support envelope [green roofs and walls] or landscape design with texture and tactility qualities;	38	Roku Museum	.	●	.	.	.	.	●	●	.	●
		02. REGULATING													
●	6	Climatic regulation	Provision of climate regulation through green landscaping and enveloping with olfactory characteristic [trellises of aromatic vegetal species as vines, roses..., shading, green shading, green roofs...]	104	Vine pergolas in South Europe	.	●	.	●	.	.	●	●	.	●
●	7	Erosion control and hazard protection	Landscape and green roof design for erosion control [ground pavement [materials, porosity], textures and volume, adaption to topography, retaining walls and surfaces, exterior steps and ramps]; Use of living, flexible materials in landscape, materials and systems to minimize flow of runoff with influence on tactility and motion perception	175	Mill Creek Canyon Earthworks	.	●	.	.	.	○	.	●	.	●
●	8	Biological control & pollination	Landscape and envelope design with attractive surfaces and elements to support pollinators; Role of pollination in the production of olfactory elements [scents of flowers, seeds and fruits]	79	Frontier Center for Environmental Symbiosis Technology	.	●	.	●	.	.	●	●	.	●
●	9	Perceptive environmental modulation	Provision of perceptive modulation through green landscaping and enveloping with olfactory characteristic [trellises of aromatic vegetal species as vines, roses..., shading, green shading, green roofs...] or motion perception [use of water falls as noise barriers/refreshing spots...]; influence of materials textures into environmental perceptive modulation; acentuation and dissipation of smells and intrinsic scents through natural materials and elements [trees, plants, soil, water]	166	Green Screen Home						.	●	●	.	●
		03. PROVISIONING													
●	10	Food supply	Provision of tactile and olfactory qualities through the resource to food supply species and structures [in landscaping, envelope landscaping and interior surfaces, with fruit trees, aromatic shrubs, mushrooms...]	182	Edible Garden, Canopy Walk and Cascades Garden	.	●	.	.	.	.	●	●	○	●
●	11	Water purification and fresh water supply	Design influence of ground materality and pavement steepness angle in water infiltration, runoff and filtering processes; Combined use of ground surface materials and texture, and water cycling surfaces in tactility and motion perception qualities [water surfaces, falling and run-off]	76	Makino Museum of Plants and People	.	●	.	.	.	.	●	●	○	●
●	12	Raw materials, ornamental and medicinal resources	Provision of tactile and olfactory qualities through the resource of raw materials and ornamental species and structures [in landscaping, envelope landscaping...]; Use of onsite or locally sourced raw materials and ornamental resources in finishings and structures [stairs, pavements, ramps, pebbles, wood chips pavement...] with influence on motion perception; Design with olfactory qualities of raw materials [as interior cladding materials as wood, tatami and reed elements...], and as raw or ornamental materials biotopes [bamboo and aromatic tree plantations...medicinal and ornamental plants in landscape, building envelope or building interior]	67	Cassia Coop Training Center	.	●	.	.	.	.	●	●	●	●
		04. CULTURAL													
●	13	Significant species and ecosytem values	Provision of tactile and olfactory qualities through the resource to significant species and elements, and other ecosystem landmarks in the design of surfaces and tactility in landscape and envelope; Provision of habitats for significant species with characteristic olfactory elements [green landscaping and enveloping with aromatic vegetal species as pine forest, ceddars, myrtle, flower scents and fruit scents...]; Design of envelope and landscape surfaces textures to provide specific habitat conditions [shade, shelter, microclimate...], and habitat support envelope [green roofs and walls] or landscape design with texture and tactility qualities;	55	House in Travessa do Patrocínio	.	●	.	.	.	.	●	●	○	●
●	14	Landscape aesthetic fruition	Influence of ground steepness, height diferences, and pavement tactility qualities to frame and provide landscape aesthetic scenery; influence of materials texture, tactile and olfactory aspects to landscape aesthetic fruition	193	Commerce Square	.	●	.	.	.	○	○	●	○	●
●	15	Leisure, recreation and psychophysical health	Influence of height levels, steepness, and (ir)regularity of pavements to outdoor recreation and leisure [modification of walking speed, and resting areas...]; Influence of scents in environment and its influence on human health and wellbeing	175	Mill Creek Canyon Earthworks	.	●	.	.	.	.	○	●	○	●

17 Lighting — Optimization of natural light sources, and luminance adapted to function and comfort levels

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample]	Life Cycle [introduction or application of design solutions] Pre-design	Design	Construction	Operation	End use	[Surface] Design Integration base envelope	lateral envelope	top envelope	enclosure	landscape
	01. SUPPORTING												
○	1 Soil formation and fertility												
● (orange)	2 Photosynthesis and primary production	Natural light filter [for extreme lighting exposure and glare avoidance] with green plant materials [passive design with deciduos trees or vines, and other green enveloping]; Adaptation of indoor natural lighting levels to support vegetation growth [in soil, water or aerobic planters]	83 BIQ	.	●	.	●	.	.	●	○	●	●
● (green)	3 Nutrient cycling and waste treatment	Adaptation of indoor natural lighting levels to support vegetation role in nutrient cycling [in soil, water and indoor air]; purification of wastewater in solar aquatics biofiltration systems	48 Centre for Interactive Research on Sustainability	.	●	.	●	.	.	○	○	●	.
○	4 Water cycling and regulation												
● (orange)	5 Biodiversity and nursery habitats	Natural light filter [for extreme lighting exposure and glare avoidance] with biodiversity support designs [living materials and vegetation modulation barriers, bioclimatic design, and habitat support enveloping and landscaping	48 Centre for Interactive Research on Sustainability	.	●	.	●	.	.	●	●	.	●
	02. REGULATING												
● (orange)	6 Climatic regulation	Natural light filter [for extreme lighting exposure and glare avoidance] with climate regulation support functions [passive design with deciduos trees or vines, and other green enveloping];	166 Green Screen Home	.	●	.	●	.	.	●	●	.	●
○	7 Erosion control and hazard protection												
○	8 Biological control & pollination												
● (purple)	9 Perceptive environmental modulation	Natural light filter [for extreme lighting exposure and glare avoidance] with perceptive environmental solutions [passive design with deciduos trees or vines, and other green enveloping and landscaping]	166 Green Screen Home	.	●	.	●	.	.	●	●	.	●
	03. PROVISIONING												
● (orange)	10 Food supply	Adaptation of indoor natural lighting levels to support food supply sources [in soil, water or aerobic planters]; Natural light filter [for extreme lighting exposure and glare avoidance] with passive design food supply deciduous trees, climbing plants, lattices, vertical landscaping	119 Row house	.	●	.	●	.	.	●	○	●	●
○	11 Water purification and fresh water supply												
● (orange)	12 Raw materials, ornamental and medicinal resources	Adaptation of indoor natural lighting levels to support raw materials, ornamental or medicinal supply sources [in soil, water or aerobic planters]; Natural light filter [for extreme lighting exposure and glare avoidance] with passive design ornamental, medicinal or raw materials deciduous trees, annual species, climbing plants, lattices, and vertical landscaping	117 Kanagawa Institute of Technology KAIT workshop	.	●	.	●	.	.	●	○	●	●
	04. CULTURAL												
● (purple)	13 Significant species and ecosytem values	Natural light filter [for extreme lighting exposure and glare avoidance] with local significant species or habitat provision support for significant species [cultural important deciduous trees, annual species, climbing plants, lattices, and vertical landscaping]	76 Makino Museum of Plants and People	.	●	.	●	.	.	●	○	.	●
● (purple)	14 Landscape aesthetic fruition	Adaptation of indoor natural lighting levels through the selection, location and design of landscape fruition spaces or openings within the project	80 Nissan Advanced Technology Center	.	●	.	●	.	○	●	○	●	○
○	15 Leisure, recreation and psychophysical health												

18 Indoor air quality — Air renovation, elimination of VOCs (volatile organic compounds), dust particles and humidity condensations

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample]	Life Cycle [introduction or application of design solutions] Pre-design	Design	Construction	Operation	End use	[Surface] Design Integration base envelope	lateral envelope	top envelope	enclosure	landscape
	01. SUPPORTING												
○	1 Soil formation and fertility												
● (purple)	2 Photosynthesis and primary production	Integration of apropriate indoor vegetation areas or surfaces [walls, ceilings, planters, partitions, greehouses, intermediate spaces and courtyards], and hybrid air circulation or purification systems with or without outdoor intake	41 Pasona HQ Urban Farm	.	●	.	●	.	.	○	○	●	○
● (purple)	3 Nutrient cycling and waste treatment	Integration of apropriate indoor vegetation areas or surfaces [walls, ceilings, planters, partitions, greehouses, intermediate spaces and courtyards], and hybrid air circulation or purification systems with or without outdoor intake; natural role of vegetation for breakdown of nocive compunds, particle filtering and bio-chemical balance;	118 APS - Active Phytoremediation System	.	●	.	●	.	.	○	○	●	○
○	4 Water cycling and regulation												
● (purple)	5 Biodiversity and nursery habitats	Integration of vegetation areas or surfaces [envelope green walls or roofs, intermediate spaces, courtyards and landscape] to support local biodiversity habitats and provide air circulation or purification systems with outdoor intake	71 DiGi Technical Office	.	●	.	.	.	.	●	●	○	●
	02. REGULATING												
● (purple)	6 Climatic regulation	Integration of vegetation areas or surfaces [envelope green walls or roofs, intermediate spaces, courtyards and landscape] to support local or micro climate regulation and provide air circulation or purification systems with outdoor intake, in association with natural ventilation strategies	113 Jean-Marie Tijbaou Cultural Center	.	●	.	.	.	.	●	●	○	●
○	7 Erosion control and hazard protection												
○	8 Biological control & pollination												
○	9 Perceptive environmental modulation												
	03. PROVISIONING												
● (purple)	10 Food supply	Integration of apropriate indoor vegetation areas or surfaces [walls, ceilings, planters, partitions, greehouses, intermediate spaces and courtyards], with provision of local food supply; Integration of food supply sources [envelope green walls or roofs, and landscape] to provide air circulation or purification systems with outdoor intake, in association with natural ventilation strategies	41 Pasona HQ Urban Farm	.	●	.	●	.	.	○	○	●	○
○	11 Water purification and fresh water supply												
● (purple)	12 Raw materials, ornamental and medicinal resources	Integration of apropriate indoor vegetation areas or surfaces [walls, ceilings, planters, partitions, greehouses, intermediate spaces and courtyards], with medicinal or ornamental value; hybrid air circulation or purification systems with or without outdoor intake from raw materials, medicinal or ornamentak vegetation sources; selection of local raw materials with low emission of indoor air polluting substances, as voc's	218 Umow Lai's Melbourne Office	.	●	.	●	.	.	○	○	●	○
	04. CULTURAL												
○	13 Significant species and ecosytem values												
○	14 Landscape aesthetic fruition												
○	15 Leisure, recreation and psychophysical health												

19 Humidity and temperature — Hygrothermal comfort through daily and annual cycles

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample]	Life Cycle [introduction or application of design solutions] Pre-design	Design	Construction	Operation	End use	[Surface] Design Integration base envelope	lateral envelope	top envelope	enclosure	landscape
	01. SUPPORTING												
●	1 Soil formation and fertility	Role of soil surfaces or layers to provide insulation and passive design and contribute to humidity and temperature indoor comfort [underground or half buried building walls, green roofs...]	112 Iceland turf houses	●	●	.	.	.	●	●	●	.	●
●	2 Photosynthesis and primary production	Passive design and bioclimatic solutions with resource to vegetation for temperature/humidity control; maintenance of temperature and moisture levels for vegetation development indoors and its influence to balance air humidity in air-conditioned environments.	118 APS - Active Phytoremediation System	.	●	.	●	.	.	●	●	●	●
●	3 Nutrient cycling and waste treatment	Use of alternative energy sources derived from local nutrient cycling for temperature comfort [compost as source of heat through microbial fermentation...]	196 A Recipe To Live	.	●	.	●	.	.	○	○	●	.
●	4 Water cycling and regulation	Role of water horizontal plans, dispersion, evaporation, and plant evapotranspiration to provide air cooling, insulation and other passive design solutions for temperature and humidity comfort;	108 Real Alcázar of Seville	.	●	.	●	.	.	○	●	○	●
●	5 Biodiversity and nursery habitats	Use of living materials, vegetation and other habitat and biodiversity support solutions, in bioclimatic and passive design;	70 Solaris	●	●	.	●	.	.	●	●		●
	02. REGULATING												
●	6 Climatic regulation	Influence of climate regulation functions in passive and bioclimatic design solutions that contribute to air humidity and temperature comfort [water and vegetation ground covers, canopies, trellises...];	65 Institute for Forestry and Nature Research	.	●	.	●	.	.	●	●	.	●
○	7 Erosion control and hazard protection												
○	8 Biological control & pollination												
●	9 Perceptive environmental modulation	Provision of perceptive environmental modulation features that contribute to bioclimatic/passive design and indoor humidity and/or temperature comfort [green walls, trellis, and pergolas; envelope or landscape design with deciduous, shading species];	21 Palmyra House	.	●	.	●	.	.	●	●	.	●
	03. PROVISIONING												
●	10 Food supply	Passive design with deciduous trees, climbing plants, lattices, vertical landscaping and green roofs providing food supply resources; mutual influence of indoor crops in hygrothermal comfort and indoor air humidity, and adequate temperature for plant growth	210 Prince Edward Island Ark	.	●	.	●	.	.	●	●	●	●
●	11 Water purification and fresh water supply	Use of local fresh water supply sources (collection, storage, filtering) in the amenization of heat island effect and/or thermic insulation on building envelope [water roofs and wall..], and balanced indoor air humidity levels	211 Meandering Greenway	.	●	.	●	.	.	○	○	●	●
●	12 Raw materials, ornamental and medicinal resources	Passive design with deciduous trees, climbing plants, lattices, vertical landscaping and green roofs providing raw materials, medicinal and ornamental sources; envelope insulation and thermal mass with local harvest raw materials; balance of indoor humidity with rammed earth; mutual influence of indoor crops in hygrothermal comfort and indoor air humidity, and adequate temperature for plant growth	42 Suginami-ku assembly hall	.	●	.	●	.	.	●	●	●	●
	04. CULTURAL												
●	13 Significant species and ecosytem values	Maintenance, protection or restoration of local significant species habitats, specimens and ecosystem values with influence on passive design solutions, and indoor hygrothermal comfort	24 Reading room	.	●	.	.	.	.	●	●	.	●
○	14 Landscape aesthetic fruition												
●	15 Leisure, recreation and psychophysical health	Provision of leisure and recreation areas that contribute for bioclimatic/passive design; Hygro-thermal confort conditions for indoor or intermediate sports and leisure areas	65 Institute for Forestry and Nature Research	.	●	.	.	.	.	○	●	○	●

20 Adequacy to function, occupancy and circulation — Functional and program organization, and circulation flows

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample]	Life Cycle [introduction or application of design solutions] Pre-design	Design	Construction	Operation	End use	[Surface] Design Integration base envelope	lateral envelope	top envelope	enclosure	landscape
	01. SUPPORTING												
●	1 Soil formation and fertility	Adaptation of project dimension, orientation, volume, circulation and program organization to building setting and location within the site avoiding earthworks [adaptation to topography, soils and drainage patterns], rich ecological soil areas, and preserving and restoring existing native vegetation and soil coverage;	64 Forestech	.	●	.	.	.	●	.	.	.	●
○	2 Photosynthesis and primary production												
○	3 Nutrient cycling and waste treatment												
●	4 Water cycling and regulation	Adaptation of project dimension, orientation, volume, circulation and program organization to building setting and location within the site allowing maximum perviousity, adaptation to drainage patterns, preserving and restoring existing native vegetation and soil coverage, and manage storm water runoff;	233 Infill Aquifer	.	●	.	.	.	●	○	●	○	●
●	5 Biodiversity and nursery habitats	Adaptation of project dimension, orientation, volume, circulation, and building setting to local existing or prospective habitat features; program of biodiversity support areas within the building or envelope [vertical landscaping, green roofs, courtyards...]	36 Dancing Trees, Singing Birds	.	●	.	.	.	●	●	●	○	●
	02. REGULATING												
●	6 Climatic regulation	Adaptation of project dimension, orientation, volume, circulation, and setting in order to provide support for micro climate regulation features [courtyards, water surfaces, vegetation on envelope or landscape...]	130 Dormitories for ITRI Southern Taiwan Campu	.	●	.	.	.	●	●	●	○	●
●	7 Erosion control and hazard protection	Adaptation of project dimension, orientation, volume, circulation, and setting in order to beneficiate and provide erosion control or hazard protection [avoid steep slopes, rich ecological soil areas; adapt to topography, soils and drainage patterns; preserve and restore existing native vegetation and soil coverage]	89 Research Institute for Humanity and Nature	.	●	.	.	.	●	.	.	.	●
○	8 Biological control & pollination												
●	9 Perceptive environmental modulation	Adaptation of project dimension, orientation, volume, circulation, and setting in order to provide beneficiate and support environmental modulation features [courtyards, water surfaces, vegetation on envelope or landscape...]	38 Roku Museum	.	●	.	.	.	●	○	○	○	●
	03. PROVISIONING												
●	10 Food supply	Adaptation of project dimension, orientation, and volume for integration of food supply areas within the building [greenhouses, courtyards, vertical landscaping, and green roofs] or landscape, and its coordenation with circulation and access	229 Living Tower	.	●	.	.	.	○	○	●	●	●
●	11 Water purification and fresh water supply	Adaptation of project dimension, orientation, and volume for integration of water supply, filter or storage and its coordenation with circulation and access	91 Kitakami Canal Museum	.	●	.	.	.	○	.	●	●	●
●	12 Raw materials, ornamental and medicinal resources	Adaptation of project dimension, orientation, and volume for integration of raw materials, medicinal or ornamental sources supply areas within the building [greenhouses, courtyards, vertical landscaping, and green roofs] or landscape and its coordenation with circulation and access	90 House & Garden	.	●	.	.	.	○	●	●	○	●
	04. CULTURAL												
●	13 Significant species and ecosytem values	Adaptation of project dimension, orientation, volume, circulation, and building setting to existing or prospective local significant species or landscapes values;	68 Pedras Salgadas Eco-Resort	.	●	.	.	.	●	○	○	.	●
●	14 Landscape aesthetic fruition	Adaptation of project dimension, orientation, volume, circulation, and setting in order to protect, preserve and restore viewpoints and "focal" corridors; and provide access and conditions to landscape aesthetic fruition	146 Sharp Centre for Design	.	●	.	.	.	●	●	●	○	●
●	15 Leisure, recreation and psychophysical health	Adaptation of project dimension, orientation, volume, circulation, setting and program organization in order to provide leisure and recreation areas within the building [greenhouses, courtyards, vertical landscaping, green roofs...] or landscape	19 Interactive Museum of History	.	●	.	.	.	●	●	●	.	●

21 Details and finishes — Coherence, quality and attributes of details and finishing materials

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample]	Life Cycle [introduction or application of design solutions] Pre-design	Design	Construction	Operation	End use	[Surface] Design Integration base envelope	lateral envelope	top envelope	enclosure	landscape
	01. SUPPORTING												
● (orange)	1 Soil formation and fertility	Selection of envelope materials and finishes that support soil ecological functions [green roofs, landscape ground cover...]; Detailing with on-site soil formation derived materials and finishes [clay, ramned earth...]	37 House C	.	●	●	●	.	.	●	●	○	●
● (green)	2 Photosynthesis and primary production	Cladding and detailing for vegetation photosynthesis [green enveloping, landscape ground cover...]	13 Green Cast	.	●	●	●	.	.	●	●	○	●
● (green)	3 Nutrient cycling and waste treatment	Cladding and detailing for local nutrient cycling [green enveloping, landscape ground cover, nano-materials...]	74 Torre de Especialidades	.	●	○	●	.	.	●	●	○	●
● (orange)	4 Water cycling and regulation	Selection of envelope materials and finishes that support local water regulation cycle or benefitiate from it [water retention and filtering on green roof or landscape, landscape pervious materials for water infiltration in soil; self-cleaning and water saving materials, water capturing materials]	169 Patio de los Naranjos	.	●	○	●	.	.	●	●	○	●
● (orange)	5 Biodiversity and nursery habitats	Selection of envelope materials, finishes, and detail design for the support of local biodiversity [provision of nests and shelters in walls, roofs, and landscape elements; green landscaping and enveloping...]	5 World Wide Fund Offices	.	●	○	●	.	.	●	●	○	●
	02. REGULATING												
● (green)	6 Climatic regulation	Selection of envelope materials and finishes that support local climate regulation functions [addition of water and vegetation elements, shades, cladding color options and material selection influence on micro-climate...]	29 Sony's Osaki Building	.	●	○	●	.	.	●	●	○	●
○	7 Erosion control and hazard protection			.	●	○	●	.					
● (green)	8 Biological control & pollination	Selection of envelope materials and finishes that support biological control and pollination [apropriate species selection in green enveloping and exterior design solutions, reduction of artificial habitat for vectors of water borne diseases, pests and sick building syndrome vectors]	71 DiGi Technical Office	.	●	○	●	.	.	●	●	○	●
● (orange)	9 Perceptive environmental modulation	Selection of envelope materials and finishes that support perceptive modulation [pergolas, trellises, water surfaces]; Influence of finishing materials in light and noise reflection and propagation	102 Shimane Arts Center	.	●	○	●	.	.	●	●	○	●
	03. PROVISIONING												
● (orange)	10 Food supply	Cladding and detailing for food supply provision [green enveloping, landscape ground cover...]	93 Nira House	.	●	●	●	.	.	●	●	○	●
● (green)	11 Water purification and fresh water supply	Cladding and detailing for water purification and fresh water supply [storm water and atmospheric pollution filtering materials; self-cleaning materials; water capturing or purification materials; water saving materials]	179 Physalia	.	●	○	●	.	○	●	●	○	●
● (orange)	12 Raw materials, ornamental and medicinal resources	Cladding and detailing for raw materials, medicinal or ornamental sources [green enveloping, landscape ground cover...]; Use of locally sourced raw materials and ornamnetal resources in details and finishes	92 Tanpopo [Dandelion] House	.	●	○	●	.	.	●	●	○	●
	04. CULTURAL												
● (green)	13 Significant species and ecosytem values	Cladding and detailing for support of local significant species [provision of significant species habitat support through cladding/details; regional identity features through material usage, systems and details...]	189 Nests in tile roof eaves	.	●	○	●	.	.	●	●	.	●
● (green)	14 Landscape aesthetic fruition	Influence of cladding, finishes and material detailing to provide landscape integration	183 San Telmo Museum Extension	.	●	○	●	.	.	●	●	.	●
● (green)	15 Leisure, recreation and psychophysical health	Apropriate selection of envelope materials and finishes for leisure and healing environments [color and texture options for psico-physical adequacy, addition of water and vegetation amenity elements, non-toxic emitting or disease vectors materials and systems...]	36 Dancing Trees, Singing Birds		●	○	●	.	.	●	●	○	●

22 Execution quality and process management — Rigor of construction methods, on-site management during life cycle and quality control

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample]	Life Cycle [introduction or application of design solutions] Pre-design	Design	Construction	Operation	End use	[Surface] Design Integration base envelope	lateral envelope	top envelope	enclosure	landscape
	01. SUPPORTING												
● (green)	1 Soil formation and fertility	Implementation of soil regeneration during construction; Regular analysis of soil quality and performance, monitoring and maintenance through life cycle	204 Burbank Water and Power EcoCampus	.	●	●	●	.	.	.	●	.	●
● (green)	2 Photosynthesis and primary production	Regular monitoring and maintenance of vegetation systems, and plant care through life-cycle	27 Caixa Forum	.	●	●	●	.	.	●	●	●	●
● (orange)	3 Nutrient cycling and waste treatment	Implementation of waste management strategies through life cycle [construction, operation, and end-use]; reduction of waste production and on-site waste water treatment [constructed wetlands, bioswales, living machines...] with regular monitoring and maintenance	18 Sidwell Friends Middle School	.	●	●	●	.	.	○	●	○	●
● (green)	4 Water cycling and regulation	Regular monitoring and maintenance of water systems and structures through life cycle [verification and correction of soil infiltration levels and drainage cleaning, stormwater retention...]; execution quality of sustainable drainage systems	163 Bronx Blue-and-Green Roof	.	○	●	●	.	.	○	●	.	●
● (green)	5 Biodiversity and nursery habitats	On-site management through life cycle, particularly during construction [to reduce disturbance of soil and vegetation..] and monitoring/maintenance of living systems and biodiversity	226 Welsh Assembly Government Offices	.	○	●	●	.	.	●	●	.	●
	02. REGULATING												
● (green)	6 Climatic regulation	Implementation and regular maintenance of details and finishes, structures and systems for local climate regulation through life-cycle [materials, envelope landscaping, vegetation and water structures...]	152 Willow School	.	○	●	●	.	.	●	●	.	●
● (green)	7 Erosion control and hazard protection	Implementation of construction control methods to avoid erosion [minimize bare area exposure and time during construction, schedule construction to dry season, divert run-on and run-off to exposed areas...]; Minimize destruction of ecosystem buffers zones and natural structures for protection of wind, water and waves, during construction, design and use; Regular monitoring and maintenance of erosion and hazard control elements	127 Tassafaronga Village	.	○	●	●	.	.	.	.	.	●
● (green)	8 Biological control & pollination	Regular monitoring of pollinators and species control mechanisms, and maintenance of biodiversity balance through life cycle; Reduction of artificial habitat for vectors of water borne diseases, building and landscape pests through maintenance and management	82 The Shimizu Institute of Technology	.	○	●	●	.	.	●	●	.	●
○	9 Perceptive environmental modulation												
	03. PROVISIONING												
● (green)	10 Food supply	Regular analysis, monitoring and maintenance of building's food production systems through life-cycle; Execution quality during construction and implementation of planters	41 Pasona HQ Urban Farm	.	●	○	●	.	.	●	●	●	●
● (green)	11 Water purification and fresh water supply	Regular monitoring and maintenance of details and finishes for water purification through life-cycle [building's fresh water harvest and cleaning systems: tanks, pipe network, water treatment systems...]; Prevention of contamination and waste deposit to overland and underground flows or water storage areas, local pollution control, detoxification and waste assimilation, during construction, operation and end-life;	18 Sidwell Friends Middle School	.	○	●	●	.	.	●	●	○	●
● (green)	12 Raw materials, ornamental and medicinal resources	Regular analysis, monitoring and maintenance of building's raw materials medicinal and ornamental resources support systems through life-cycle [maintenance of landscape design ornamental trees and other garden elements]	205 National Exhibition Centre	.	●	○	●	.	.	●	●	●	●
	04. CULTURAL												
● (green)	13 Significant species and ecosytem values	Implementation of rehabilitation and preservation strategies during construction; On-site management through life cycle, particularly during construction [to reduce disturbance of soil and vegetation..] and monitoring/maintenance of significant species and its habitat conditions within site	201 Scenic Hudson's Long Dock Park	.	○	●	●	.	.	●	●	.	●
● (green)	14 Landscape aesthetic fruition	On-site management through life cycle, particularly during construction [to reduce disturbance of soil and vegetation..]; maintenance and control of landscape fruition conditions within site	85 Pola Museum of Art	.	●	●	●	.	○	.	.	.	●
● (green)	15 Leisure, recreation and psychophysical health	Regular monitoring and maintenance, and implementation quality of amenity elements [vegetation, water surfaces, pavements...] in leisure and recreation areas through life cycle	61 ACROS Fukuoka International Hall	.	●	●	●	.	.	○	●	.	●

23 Structure stability and design

Resistance to use and regular loads and structure design quality

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample]	Life Cycle [introduction or application of design solutions] Pre-design	Design	Construction	Operation	End use	[Surface] Design Integration base envelope	lateral envelope	top envelope	enclosure	landscape
	01. SUPPORTING												
●	1 Soil formation and fertility	Structure design and adaptation to withstand extra loads derived from soil formation support on building envelope; selection of construction methods and structure type to avoid disturbance on soil formation and fertility during construction and operation	6 VanDusen Botanical Garden Visitor Centre	.	●	●	.	.	●	.	●	.	●
●	2 Photosynthesis and primary production	Structure design and adaptation to withstand extra loads derived from vegetation support on building envelope; selection of construction methods and structure type to avoid disturbance on local existing and prospective vegetation during construction and operation	121 House Hundertwasser	.	●	●	.	.	●	●	●	.	●
●	3 Nutrient cycling and waste treatment	Structural design and methods to incorporate nutrient cycling materials and systems	231 Propagate Skyscraper	.	●	●	.	.	.	○	○	○	.
●	4 Water cycling and regulation	Structure design and adaptation to withstand extra loads derived from rain water retention and runoff control on building envelope; selection of construction methods and structure type to avoid disturbance on water regulation and cycle patterns during construction and operation	62 Bay Education Center	.	●	●	.	.	●	.	●	.	●
●	5 Biodiversity and nursery habitats	Structure design and adaptation to withstand extra loads derived from habitat support on building envelope; selection of construction methods and structure type to avoid disturbance on local existing and prospective species during construction and operation	61 ACROS Fukuoka International Hall	.	●	●	.	.	●	●	●	.	●
	02. REGULATING												
●	6 Climatic regulation	Influence of structure design on micro climate, and structure adaptation to withstand extra loads and provide support elements for climatic regulation [trellises, pergolas, green roofs...]	98 Kagoshima Museum of Environment	.	●	●	.	.	.	●	●	.	.
●	7 Erosion control and hazard protection	Structure design and adaptation to withstand extra loads and provide support elements for hazard mitigation; selection of construction methods and structure type to avoid disturbance on natural erosion and hazard control elements during construction and operation; contribution and combination of natural erosion and hazard control [bunds, vegetation cover and setting..] elements for structure stability and design	76 Makino Museum of Plants and People	.	●	●	.	.	.	●	●	.	●
○	8 Biological control & pollination												
●	9 Perceptive environmental modulation	Structure design and adaptation to withstand extra loads derived from environmental modulation vegetation support on building envelope; selection of construction methods and structure type to avoid disturbance on local existing and prospective vegetation during construction and operation	126 Habitat 67	.	●	●	.	.	.	●	●	.	●
	03. PROVISIONING												
●	10 Food supply	Structure design and adaptation to withstand extra loads derived from local food supply support on building envelope or enclosure, and provide structural support elements for food supply [trellises, pergolas, green roofs and walls...]	221 60 Richmond Housing Cooperative	.	●	●	.	.	.	●	●	●	.
○	11 Water purification and fresh water supply												
●	12 Raw materials, ornamental and medicinal resources	Structure design and adaptation to withstand extra loads, and provide structural support elements for raw, medicinal or ornamental resources [trellises, pergolas, green roofs and walls, balconies...]; provision of local onsite raw materials for building or landscape structure	139 Trees Building for ABBANK	.	●	●	.	.	●	●	●	●	.
	04. CULTURAL												
●	13 Significant species and ecosytem values	Structure design and adaptation to withstand extra loads derived from the support of cultural significant species or local natural elements on building envelope or enclosure; selection of construction methods and structure design to avoid disturbance on existing cultural significant ecological values during construction and operation	35 Crystal Palace	.	●	●	.	.	●	●	●	●	●
●	14 Landscape aesthetic fruition	Structure design and adaptation to provide landscape aesthetic fruition on building envelope, enclosure or on-site landscape; selection of construction methods and structure design to avoid disruption on existing landscape values or view points	187 Marine and Freshwater Resources Institute										
●	15 Leisure, recreation and psychophysical health	Structure design and adaptation to withstand extra loads, and provide structural support elements for leisure, recreation and psychophysical health areas [green roofs, balconies...]	122 Thermal Village Blumau Rolling Hills	.	●	●	.	.	●	●	●	●	●

24 Durability & maintenance of systems and materials

Long life cycles of systems and materials, ease of substitution or repair, and local maintenance

*	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	Design Solution Options	Reference Study Case [Sample]	Life Cycle [introduction or application of design solutions] Pre-design	Design	Construction	Operation	End use	[Surface] Design Integration base envelope	lateral envelope	top envelope	enclosure	landscape
	01. SUPPORTING												
●	1 Soil formation and fertility	Integration of soil surfaces for protection of envelope membranes and materials and its contribution for longer maintenance cycles [green roofs, underground and semi-buried structures]	170 Moos Water filtration plant	.	●	●	.	.	.	●	●	.	●
●	2 Photosynthesis and primary production	Provision and selection of local adapted vegetation within project site, without maintenance requirements in water, fertilizer and plant care [xeriscaping and native grasses in green roofs and landscape...]	164 California Academy of Sciences	.	●	.	.	.	.	○	●	.	●
○	3 Nutrient cycling and waste treatment												
○	4 Water cycling and regulation												
●	5 Biodiversity and nursery habitats	Provision of biodiversity habitats support, with selection of native and local adapted vegetation species within project site, without maintenance requirements in water, fertilizer and plant care; Implementation of biodiversity support systems [vegetal structures in trellises, green roofs and walls, landscaping...] that contribute to longer cycles of maintenance of materials and structures	164 California Academy of Sciences	.	●	.	.	.	.	●	●	.	●
	02. REGULATING												
○	6 Climatic regulation												
●	7 Erosion control and hazard protection	Implementation of erosion mitigation methods within site [preserve and promote vegetation ground cover, minimize destruction of ecosystem buffers zones and natural structures for protection of wind, water and waves] during construction, design and use, and its contribution to longer maintenance cycles of structures, systems and materials [thorugh prevention of landslides, floods, minimization of regular loads and extreme events, and degradation of materials]	89 Research Institute for Humanity and Nature	●	●	●	○	.	.	●	●	○	●
●	8 Biological control & pollination	Selection and use of low-maintenance materials with pest control characteristics, and contribution of biological control to prevent the degradation of building materials and systems by pests	113 Jean-Marie Tijbaou Cultural Center	.	●	.	●	.	.	●	●	○	●
●	9 Perceptive environmental modulation	Implementation of perceptive environmental modulation systems [vegetal structures in trellises, green roofs, landscaping] to dampen light and noise, that contribute to longer cycles of maintenance of materials and structures	199 901 Cherry Offices	●	●	.	●	.	.	●	●	.	●
	03. PROVISIONING												
●	10 Food supply	Provision of food supply resources, with selection of native and local adapted vegetation species within project site, without maintenance requirements in water, fertilizer and plant care; Integration of food supply structures that provide protection from exterior agents to envelope membranes and materials [[vegetal structures in trellises, green roofs and walls, landscaping...]	115 New York City Steady State	.	●	.	●	.	.	●	●	.	●
○	11 Water purification and fresh water supply												
●	12 Raw materials, ornamental and medicinal resources	Selection and use of local available raw and ornamental materials, with longer life cycles [stone, wood, rammed earth..] with local repair available technologies and know-how; Use of ornamental vegetation elements to protect materials from direct sunlight and other climateric agents [vegetal structures in trellises, green roofs, landscaping] that contribute to longer cycles of maintenance of materials and structures	64 Forestech	.	●	●	●	.	.	●	●	○	●
	04. CULTURAL												
○	13 Significant species and ecosytem values												
○	14 Landscape aesthetic fruition												
○	15 Leisure, recreation and psychophysical health												

Appendix II. Catalogue of Reference Study Cases

CODE	Project Name	Author	Year	Periodization	Ti[L]es Matrix {relevant reference correlations}					Ecosystem Integration | Description
1	Okinawa Institute of Science and Technology [OIST]	**Nikken Sekkei + Kornberg Associates**	2010	1. Contemporary	Adaption to eco-physical values and restraints Transports and functional articulation w/ context	A1 A3	▶ ▶	E14 E2 E1	Landscape aesthetic fruition Photosynthesis and primary production Soil formation and fertility	site planning [location of buildings along forested hillside ridges, provision of views, and immersion of building into tree landscape], landscape design; minimization of acess paths through common subterranean acess, and pedestrian bridges that "(...) span the steep ravines, minimizing the impact of foot traffic on the native terrain and protecting the biologically rich and sensitive areas that serve as diurnal migration routes between ocean and mountains for the native fauna." use of regional stone.
2	Sabo House	**Nikken Sekkei**	2010	1. Contemporary	Concept originality, innovation and creativity Details and finishes Water cycle [and effluents]	A13 A21 A5	◆ ▶ ▶	E11 E1	Water purification and fresh water supply Soil formation and fertility	ecosystem regeneration. Water, Soil and Nutrients [as Envelope Strategies], water capture from air humidity
3	Omega Center for Sustainable Living	**BNIM Architects + John Todd Ecological Design**	2007	1. Contemporary	Water cycle [and effluents]	A5	◀	E12	Raw materials, ornamental and medicinal resources	eco machines to address water cycle, greenhouse interior vegetation and tanks sustainable site
4	Hawaii Preparatory Academy Energy Lab	**Flansburgh Architects**	2008	1. Contemporary	Adaption to eco-physical values and restraints	A1	▶	E14	Landscape aesthetic fruition	sustainable site, water collection and closed water cycle, passive design, volumes that step down with the landscape and open to views to the south.
5	World Wide Fund Offices	**RAU** [part of cradle to cradle architecture group] with ARUP	2006	1. Contemporary	Details and finishes	A21	▶	E5	Biodiversity and nursery habitats	CO2 neutral. Positive contribution to the environment, Bats and birds habitat support in wall elements, sustainable landscape
6	VanDusen Botanical Garden Visitor Centre	**Perkins + Will Architects**	2010	1. Contemporary	Structure stability and design	A23	◆	E1	Soil formation and fertility	undulating green roof 'petals' that float above curved rammed earth and concrete walls. designed to exceed LEED Platinum, and achieve Living Building Challenge. on-site, renewable sources to achieve net-zero energy on annual basis; sequesters enough carbon to achieve carbon neutrality; uses filtered rainwater for the building's greywater requirements; and treats 100% of blackwater in an on-site bioreactor. colaboration with an ecologist. biodiversity interaction and ecosystem services
7	Living with Lakes Centre for freshwater restoration and research	**Perkins + Will Architects**	2008	1. Contemporary	Water cycle [and effluents]	A5	◆	E11	Water purification and fresh water supply	regenerative design approach. water rain and greywater reuse, use of regional limestone to pH balance of site water, increased biodiversity.
8	Crouch Hill Community Park	**Penoyre & Prasad LLP**	2012	1. Contemporary	Materials cycle [and waste]	A6	▶	E5	Biodiversity and nursery habitats	biodiversity strategies, and habitat support for bats and birds. Landscape Design. Brown roofs. Land reclamation. passive design, carbon zero goals, demolition materials from existing buildings will be reused to create a biodiverse habitat on the school roof.
9	Ando Hiroshige Museum	**Kengo Kuma & Associates**	2000	1. Contemporary	Visual	A14	◆	E14	Landscape aesthetic fruition	locally sourced materials [cedar wood, and other local crafts]. Landscape fruition and framing
10	Sea/ Filter	**Kengo Kuma & Associates**	2001	1. Contemporary	Visual	A14	◆	E14	Landscape aesthetic fruition	locally sourced materials [clay bricks] on vertical and horizontal planes. landscape views
11	Z58	**Kengo Kuma & Associates**	2006	1. Contemporary	Visual	A14	◆	E2	Photosynthesis and primary production	water features, integration of vegetation in the facade, building refurbishment
12	Community Market Yusuhara	**Kengo Kuma & Associates**	2010	1. Contemporary	Sense of place and cultural identity	A2	◀	E12	Raw materials, ornamental and medicinal resources	locally [and culture] sourced materials [thatch]. local materials and traditional crafts, and system of maintenance, incentive for local economy
13	Green Cast	**Kengo Kuma & Associates**	2011	1. Contemporary	Details and finishes	A21	▶	E2	Photosynthesis and primary production	[original concept] green wall
14	Hous.E+ Project	**Polifactory**	2012	1. Contemporary	Water cycle [and effluents]	A5	◆	E10	Food supply	locally sourced materials [ramned earth]. aquaponics farm of organic fish, shellfish and vegetables. water cycle mixed with energy performance.
15	Traditional *minka* farmhouses in Satoyama landscapes	[vernacular architecture]	[...] 15-17th cent [until 19th cent.]	3. Pre-Modern	Materials cycle [and waste]	A6	◆	E12	Raw materials, ornamental and medicinal resources	locally sourced materials and ecosystem stewardship. living materials - production of forage.
16	Photo stack - "a house that ends the paradigm of consumption and begins the paradigm of giving"	**Seattle Architects** [Matthew Coates and Tim Meldrum]	2004	1. Contemporary	Energy cycle [and atmospheric emissions] Concept originality, innovation and creativity	A4 A13	◀	E2	Photosynthesis and primary production	passive design, with thermal mass; integrated PV in façade, and living skin photosynthetic and phototropic, based on extracted spinach protein [research]; vegetated roof, collects and filters storm water; living garden to treat effluents; production of vegetables; soy-foam wall pannels; operable louvers for ventilation; common/pro community features and sharing
17	Treescraper Office Building of the Future	**William McDonough + Partners**	2006	1. Contemporary	Human health and well being	A12	◀	E3	Nutrient cycling and waste treatment	biomimicry, water and air purification, production of energy, explore of full potential of existing technologies, tree-filled terraces that recycle water, structure, envelope, and mechanical systems of the building merge into super-thin, smart skins that automatically adjust to the sun and wind like a living, breathing organism.
18	Sidwell Friends Middle School	**KieranTimberlake Associates**	2006	1. Contemporary	Water cycle [and effluents] Execution quality and process management	A5 A22	◆ ◆ ▶	E4 E3 E11	Water cycling and regulation Nutrient cycling and waste treatment Water purification and fresh water supply	constructed wetland, stormwater management, on-site wastewater treatment, green roofs, salvaged materials, reintroduction of native species
19	Interactive Museum of History	**Nieto Sobejano Arquitectos**	2011	1. Contemporary	Adequacy to function, occupancy and circulation	A20	◆	E15	Leisure, recreation and psychophysical health	green roofs [underground architecture] and courtyards, integration with landscape, reclamation of industrial site
20	Bosco Verticale	**Boeri Studio** [with ARUP consulting]	2014	1. Contemporary	Acoustics	A15	◀	E12	Raw materials, ornamental and medicinal resources	green "walls", vertical vegetation, urban forestation, microclimate, filtering the dust particles, diversity of plants, absorb CO2 producing oxygen and protect from radiation and acoustic pollution, improving the quality of living spaces and saving energy. plant irrigation to great extent through the filtering and reuse of the grey waters produced by the building. Additionally aeolian and photovoltaic energy systems

Concretization	Environmental Assessment	Method	Rating	Country	Location	Geographic Cluster	Use | Function	Scale	Context	Sources
1. Built | Realized	2. Non-certified	[…]		Japan	Okinawa, Naha	3. S and E Asia-Oceania	2. Educational	4. Ensemble	3. Non-urban	http://www.archdaily.com/238664/okinawa-institute-of-science-technology-nikken-sekkei-kornberg-associates-kuniken/
2. Unbuilt | Plan	2. Non-certified	[…]		[…]	[2050's Earth deserted areas]	2. Europe-Africa-Middle East	1. Residential	2. Building	3. Non-urban	2050 AIJ exhibition poster
1. Built | Realized	1. Certified	Living Building Challenge	Living	US	Rhinebeck, New York	1. America-Pacific	2. Educational	2. Building	3. Non-urban	https://ilbi.org/lbc/casestudies/omega/water http://www.american-architects.com/projects/project-review-detail/25155_omega_center_for_sustainable_living
1. Built | Realized	1. Certified	Living Building Challenge LEED	Living Platinum	US	Kamuela, Hawaii	1. America-Pacific	2. Educational	2. Building	3. Non-urban	http://greensource.construction.com/green_building_projects/2011/1105_Preparatory_Academy.asp
1. Built | Realized	2. Non-certified	[…]		Netherlands	Driebergseweg, Zeist	2. Europe-Africa-Middle East	6. Offices	2. Building	2. Sub-urban	http://greensource.construction.com/projects/2009/05_world-wildlife-fund.asp
1. Built | Realized	1. Certified	Living Building Challenge LEED	Living Platinum	Canada	Vancouver	1. America-Pacific	3. Cultural	2. Building	2. Sub-urban	http://www.archdaily.com/215855/vandusen-botanical-garden-visitor-centre-perkinswill/
1. Built | Realized	1. Certified	LEED	Platinum	Canada	Sadbury	1. America-Pacific	2. Educational	2. Building	2. Sub-urban	http://www.archdaily.com/79470/awards-competitions-lift-profile-of-sustainability-projects/
1. Built | Realized	1. Certified	BREEAM	Outstanding	UK	London	2. Europe-Africa-Middle East	2. Educational	2. Building	2. Sub-urban	http://www.breeam.org/page.jsp?id=470 http://www.architecture.com/RIBA/Aboutus/SustainabilityHub/Casestudies/9a-CrouchHill,London.aspx
1. Built | Realized	2. Non-certified	[…]		Japan	Bato, Nakagawa-machi, Nasu	3. S and E Asia-Oceania	3. Cultural	2. Building	2. Sub-urban	KKAA http://kkaa.co.jp/works/nakagawa-machi-bato-hiroshige-museum-of-art/ http://www.hiroshige.bato.tochigi.jp/batou/hp/index_e.html
1. Built | Realized	2. Non-certified	[…]		Japan	Onoda-shi, Yamaguchi	3. S and E Asia-Oceania	5. Commercial	2. Building	2. Sub-urban	http://kkaa.co.jp/works/architecture/sea-filtert/
1. Built | Realized	2. Non-certified	[…]		China	Shanghai	3. S and E Asia-Oceania	4. Mixed Use	2. Building	1. Urban	http://kkaa.co.jp/works/architecture/z58/
1. Built | Realized	2. Non-certified	[…]		Japan	Takaoka, Yusuhara	3. S and E Asia-Oceania	4. Mixed Use	2. Building	3. Non-urban	http://www.archdaily.com/199790/yusuhara-marche-kengo-kuma-associates/
1. Built | Realized	2. Non-certified	[…]		Japan	Kanagawa, Odawara	3. S and E Asia-Oceania	4. Mixed Use	2. Building	2. Sub-urban	KKAA http://kkaa.co.jp/ http://www.dezeen.com/2012/06/18/green-cast-by-kengo-kuma-associates/ http://typekast.com/green-cast-odawara-building-by-japanese-studio-kengo-kuma-and-associates/f-green-cast-small-building-odawara-japan-27/
2. Unbuilt | Plan	2. Non-certified	[…]		Canada	Vancouver	1. America-Pacific	1. Residential	2. Building	3. Non-urban	http://www.dezeen.com/2012/07/24/hous-e-by-polifactory/ http://www.polifactory.com/architecture.html
1. Built | Realized	2. Non-certified	[…]		Japan	Diverse locations	3. S and E Asia-Oceania	1. Residential	4. Ensemble	3. Non-urban	TAKEUCHI: 2000 [other references in bibliography]] http://en.wikipedia.org/wiki/Minka Everyday Things in Premodern Japan: The Hidden Legacy of Material Culture, By Susan B. Hanley
2. Unbuilt | Plan	2. Non-certified	[…]		U. S. A.	Roanoke, Virginia	1. America-Pacific	1. Residential	2. Building	2. Sub-urban	http://www.architectureink.com/2005-11/c2c.htm
2. Unbuilt | Plan	2. Non-certified	[…]		[…]	Temperate Climate	1. America-Pacific	6. Offices	2. Building	1. Urban	http://mcdonoughpartners.com/project/office-building-of-the-future/
1. Built | Realized	1. Certified	LEED	Platinum	U.S.A.	Washington	1. America-Pacific	2. Educational	2. Building	1. Urban	http://greensource.construction.com/projects/0707_sidwell.asp http://www.aiatopten.org/node/140
1. Built | Realized	2. Non-certified	[…]		Spain	Lugo	2. Europe-Africa-Middle East	3. Cultural	2. Building	2. Sub-urban	http://www.dezeen.com/2011/08/08/interactive-museum-of-the-history-of-lugo-by-nieto-sobejano-arquitectos/ http://openbuildings.com/buildings/interactive-museum-of-history-of-lugo-profile-41426
1. Built | Realized	2. Non-certified	[LEED application]	[Gold]	Italy	Milan	2. Europe-Africa-Middle East	1. Residential	2. Building	1. Urban	http://www.dezeen.com/2014/05/15/stefano-boeri-bosco-verticale-vertical-forest-milan-skyscrapers/ http://www.stefanoboeriarchitetti.net/en/portfolios/bosco-verticale/

CODE	Project Name	Author	Year	Periodization	Ti[L]es Matrix {relevant reference correlations}					Ecosystem Integration | Description
21	Palmyra House	Studio Mumbai	2007	1. Contemporary	Humidity and temperature	A19	◄	E9	Perceptive environmental modulation	water features, local materials/crafts, landscape [palm tree] integration in coconut plantation, water collection
22	Tara House	Studio Mumbai	2005	1. Contemporary	Visual Acoustics Adequacy to function, occupancy and circulation	A14 A15 A20	◄ ◄ ◄	E11 E6	Water purification and fresh water supply Climatic regulation	aquifer use/reserve [water collection], local materials/crafts, vegetation courtyard
23	House on Pali Hill	Studio Mumbai	2008	1. Contemporary	Exterior areas and local pollution control	A7	◆	E9	Perceptive environmental modulation	urban greenery, planted trellises, preservation of existing trees and renovation of existing structure
24	Reading room	Studio Mumbai	2003	1. Contemporary	Visual Energy cycle [and atmospheric emissions] Humidity and temperature	A14 A4 A19	◄ ◆ ◄	E9 E13	Perceptive environmental modulation Significant species and ecosytem values	local crafts, under banyan, aesthetic valuation
25	Maison Séoul	Patrick Blanc	2003	1. Contemporary	Exterior areas and local pollution control	A7	◆	E12	Raw materials, ornamental and medicinal resources	green walls at house entrance
26	Costume National Aoyama Complexe Wall	Patrick Blanc	2011	1. Contemporary	Indoor air quality Visual	A18 A14	◄	E12	Raw materials, ornamental and medicinal resources	interior green walls
27	Caixa Forum	Patrick Blanc + Herzog & de Meuron	2007	1. Contemporary	Details and finishes Execution quality and process management	A21 A22	► ►	E6 E22	Climatic regulation Photosynthesis and primary production	exterior green walls on existing structure, refurbishment
28	Miami Perez Art Museum	Patrick Blanc + Herzog & de Meuron	2013	1. Contemporary	Visual	A14	◆	E6	Climatic regulation	hanging green canopy/columns, selection of low maintenance resilient local plants, creation of microclimate in intermediate outside/interior spaces
29	Sony's Osaki Building	Nikken Sekkei	2011	1. Contemporary	Details and finishes	A21	►	E6	Climatic regulation	rain water harvesting contributing to passive cooling and reduction of heat island effect, creation of microclimate [bioskin ceramic pipes, and shape-setting adjusted to prevailing winds], volume to fit wind patterns, inspiration from traditional "sudare" and "uchimizu"
30	Setagaya-ku Fukasawa Symbiotic Housing Complex	Iwamura Atelier	1997	1. Contemporary	Human health and well being	A12	◄	E5	Biodiversity and nursery habitats	regeneration of used urban lot, biotope restoration [historical elements of the place], community participation, kitchen farms, green roofs
31	HighLine	James Corner Field Operations (Project Lead) + Diller Scofidio + Renfro, + Piet Oudolf	2009 2011 2014	1. Contemporary	Economic dynamics and lifecycle costs Transports and functional articulation w/ context	A11 A4	◄ ►	E15 E2	Leisure, recreation and psychophysical health Photosynthesis and primary production	landscape project in deactivated railroad, use of greyfield, spur of real estate development, biodiversity
32	Center for Regenerative Studies	John Lyle + Dougherty + Dougherty Architects LLP [submiting architects]	1994	1. Contemporary	Adaption to eco-physical values and restraints Materials cycle [and waste] Sustainable life-style support systems	A1 A6 A8	► ►	E10 E6	Food supply Climatic regulation	on-site wastewater treatment system with landscape design, passive design with vegetation, kitchen farms, educational use, landscape with plants that provide wildlife habitat/forage, natural topography closely intact
33	Vancouver City Library	Moshe Safdie & Associates + American Hydrotech	1995	1. Contemporary	Water cycle [and effluents] Durability & maintenance of systems and materials	A5 A24	◄ ◄	E5 E12	Biodiversity and nursery habitats Raw materials, ornamental and medicinal resources	green roof [intensive and extensive], low-intensity irrigation system, not requiring fertilization or cutting for the grass like coverage
34	Rinker Hall [University of Florida]	Croxton Collaborative Architects, P.C. + Gould Evans Associates	2003	1. Contemporary	Adaption to eco-physical values and restraints Adequacy to function, occupancy and circulation	A1 A20	► ►	E1	Soil formation and fertility	relocation of project to suitable land use (reconversion of a parking lot), interactive-charette process, passive design, site planning and transport, outside amenities and community fruition, rain water collection, enhancement of existing landscape features, Integration of on-site wastewater treatment system with landscape design, Landscape with indigenous vegetation
35	Crystal Palace [great exhibition of 1851]	Joseph Paxton	1851	3. Pre-Modern	Structure stability and design	A23	◆	E13	Significant species and ecosytem values	preservation and inclusion of the existing old elm trees within the greenhouse transept
36	Dancing Trees, Singing Birds	Hiroshi Nakamura	2007	1. Contemporary	Adequacy to function, occupancy and circulation Acoustics Adaption to eco-physical values and restraints Details and finishes	A20 A1 A21	◆ ◄ ► ►	E5 E9 E15	Biodiversity and nursery habitats Perceptive environmental modulation Leisure, recreation and psychophysical health	landscape [trees] influence on volume shape, cohabitation of habitat species [trees, humans, birds], accoustic and visual delight from nature, birdhouses, knowledge opportunities, semi-pervious pavement
37	House C	Hiroshi Nakamura	2008	1. Contemporary	Community participation and user's satisfaction Details and finishes Materials cycle [and waste]	A10 A21 A6	◄ ◆	E12 E1 E2	Raw materials, ornamental and medicinal resources Soil formation and fertility Photosynthesis and primary production	earth rammed walls, green roof with grass-plot species, "focus in designing this house was to make it an extension of gardening", views, use of onsite soil on the greenroof, with native grass species, [reduction of costs with roof materials], mix of onsite soil with other materials to clad concrete walls and protect them from sea salt corrosion, partial participation of owners in construction, flower and vegetable garden
38	Roku Museum	Hiroshi Nakamura	2010	1. Contemporary	Exterior areas and local pollution control Other senses: olfaction, tactility, motion perception Concept originality, innovation and creativity Adequacy to function, occupancy and circulation	A7 A16 A13 A20	◆ ◄ ◆ ►	E5 E9	Biodiversity and nursery habitats Perceptive environmental modulation	passive design with "designed vegetation", deciduous to south and evergreen wind blocking trees to north, plantation of tree grove to minimize street traffic noise and provide tranquil environment, views, trees "as part of building envelope" to control microclimate, purify air, and emit fragrances, mingle of the shape of the building to growing and moving pattern of trees (incluind very low ceiling areas)
39	River remediation and development scheme of Medina of Fez	Aziza Chaouni	2009 [Project]	1. Contemporary	Sense of place and cultural identity Community participation and user's satisfaction Exterior areas and local pollution control	A2 A10 A7	◄ ◆ ◆	E11 E15	Water purification and fresh water supply Leisure, recreation and psychophysical health	river restoration, bioremediation of tanneries with vegetation [botanical garden], restoration of historic fabric, improvement of water quality, remediation of contaminated soil, nursery for propagating riparian plants "The constructed wetlands will not only help manage excess floodwater, cleanse stormwater, and nurture new wildlife habitats but will also serve as tools for educating the public about healthy ecosystems", relocation of taneries, creation of public open spaces
40	Plaza Ecopolis	Ecosistema Urbano [Francisco Romero]	2010	1. Contemporary	Water cycle [and effluents] Exterior areas and local pollution control	A5 A7	◆	E5 E11	Biodiversity and nursery habitats Water purification and fresh water supply	wastewater treatment on-site on a lagoon with macrophite plants, greyfield renovation, educational purposes, building half-buried (50% of the building takes advantage of the land's thermal inertia), purified water storage, and its use for irrigation, (landscape emulation of a river bank)

Concretization	Environmental Assessment	Method	Rating	Country	Location	Geographic Cluster	Use | Function	Scale	Context	Sources
1. Built | Realized	2. Non-certified	[…]		India	Nandgaon, Maharashtra	3. S and E Asia-Oceania	1. Residential	2. Building	3. Non-urban	http://studiomumbaiarchitects.blogspot.jp/2007/12/palmyra-house.html http://www.archdaily.com/62136/palmyra-house-studio-mumbai/
1. Built | Realized	2. Non-certified	[…]		India	Kashid, Maharashtra	3. S and E Asia-Oceania	1. Residential	2. Building	3. Non-urban	http://www.archdaily.com/62621/tara-house-studio-mumbai/
1. Built | Realized	2. Non-certified	[…]		India	Bandra, Mumbai, Maharashtra	3. S and E Asia-Oceania	1. Residential	2. Building	1. Urban	http://www.archdaily.com/224966/house-on-pali-hill-studio-mumbai/
1. Built | Realized	2. Non-certified	[…]		India	Nagaon, Maharashtra	3. S and E Asia-Oceania	1. Residential	2. Building	3. Non-urban	http://indianbydesign.wordpress.com/2009/01/31/archifeature-bijoy-jain-studio-mumbai/
1. Built | Realized	2. Non-certified	[…]		South Korea	Seoul	3. S and E Asia-Oceania	1. Residential	1. Component	1. Urban	http://www.verticalgardenpatrickblanc.com/node/1444
1. Built | Realized	2. Non-certified	[…]		Japan	Tokyo	3. S and E Asia-Oceania	5. Commercial	1. Component	1. Urban	http://www.verticalgardenpatrickblanc.com/realisations/tokyo/costume-national-aoyama-complexe-wall-tokyo http://www.spoon-tamago.com/2011/09/02/costume-national-flagship-tokyo-ryuji-nakamura-patrick-blanc/
1. Built | Realized	2. Non-certified	[…]		Spain	Madrid	2. Europe-Africa-Middle East	3. Cultural	2. Building	1. Urban	http://www.verticalgardenpatrickblanc.com/node/1414
1. Built | Realized	2. Non-certified	[…]		U.S.A.	Miami	1. America-Pacific	3. Cultural	2. Building	1. Urban	http://www.archdaily.com/493736/perez-art-museum-herzog-and-de-meuron/ http://www.verticalgardenpatrickblanc.com/realisations/miami/perez-art-museum-miami
1. Built | Realized	2. Non-certified	[…]		Japan	Tokyo, Shinagawa	3. S and E Asia-Oceania	6. Offices	2. Building	1. Urban	http://www.worldbuildingsdirectory.com/project.cfm?id=4260 http://www.nikken.co.jp/en/projects/office/hq/sony-osaki-west-building.html
1. Built | Realized	1. Certified	CASBEE	2.2	Japan	Tokyo, Setagaya-ku	3. S and E Asia-Oceania	1. Residential	4. Ensemble	1. Urban	http://www.iwamura-at.com/index.html http://www.ibec.or.jp/jsbd/F/index.htm UIA Work Programme: Architecture of the Future "AOF Document"1999, Japan Institute of Architects, pp78-81 R.J. Cole et. al. "Buildings, Culture & Environment"2003, Blackwell Publishing, pp341-356
1. Built | Realized	2. Non-certified	[…]		U. S. A.	New York	1. America-Pacific	7. Public Space	3. Land Unit	1. Urban	http://en.wikipedia.org/wiki/High_Line_(New_York_City) http://www.thehighline.org/ http://www.asla.org/2010awards/173.html http://www.asla.org/2013awards/524.html
1. Built | Realized	2. Non-certified	[…]		U. S. A.	Pomona, California	1. America-Pacific	2. Educational	4. Ensemble	2. Sub-urban	LYLE: 1994 http://www.aiatopten.org/node/229
1. Built | Realized	2. Non-certified	[…]		Canada	Vancouver	1. America-Pacific	3. Cultural	2. Building	1. Urban	http://www.greenroofs.com/projects/pview.php?id=29
1. Built | Realized	1. Certified	LEED	Gold	U.S.A.	Gainesville, Florida	1. America-Pacific	2. Educational	2. Building	1. Urban	https://buildingdata.energy.gov/project/rinker-hall-university-florida
1. Built | Realized	2. Non-certified	[…]		U. K.	London	2. Europe-Africa-Middle East	3. Cultural	2. Building	1. Urban	http://en.wikipedia.org/wiki/The_Crystal_Palace
1. Built | Realized	2. Non-certified	[…]		Japan	Tokyo, Meguro-ku	3. S and E Asia-Oceania	1. Residential	2. Building	1. Urban	NAKAMURA: 2010 http://openbuildings.com/buildings/dancing-trees-singing-birds-profile-38607 http://www.nakam.info/english/hiroshinakamura/
1. Built | Realized	2. Non-certified	[…]		Japan	Minamiboso, Chiba, Boso Peninsula	3. S and E Asia-Oceania	1. Residential	2. Building	2. Sub-urban	NAKAMURA: 2010 http://www.nakam.info/english/hiroshinakamura/ http://www.archdaily.com/198413/house-c-hiroshi-nakamura-nap/
1. Built | Realized	2. Non-certified	[…]		Japan	Oyama, Toshigi	3. S and E Asia-Oceania	3. Cultural	2. Building	2. Sub-urban	NAKAMURA: 2010 http://www.nakam.info/english/hiroshinakamura/ http://www.archdaily.com/199001/roku-museum-hiroshi-nakamura-nap/
1. Built | Realized	2. Non-certified	[…]		Morocco	Fez	2. Europe-Africa-Middle East	7. Public Space	5. Plan	1. Urban	http://www.archdaily.com/79470/awards-competitions-lift-profile-of-sustainability-projects/ http://www.asla.org/2010awards/492.html http://blog.ted.com/2014/04/04/from-an-open-sewer-to-a-jewel-of-the-city-aziza-chaouni-on-uncovering-and-restoring-the-fez-river/
1. Built | Realized	1. Certified	ENERGY PERFORMANCE CERTIFICATE [Spain]	A	Spain	Rivas, Madrid	2. Europe-Africa-Middle East	2. Educational	2. Building	2. Sub-urban	http://ecosistemaurbano.com/portfolio/plaza-ecopolis/ http://www.archdaily.com/111143/ecopolis-plaza-ecosistema-urbano/

CODE	Project Name	Author	Year	Periodization	Ti[L]es Matrix {relevant reference correlations}					Ecosystem Integration | Description
41	Pasona Group Urban Farm	KONO Designs	2010	1. Contemporary	Indoor air quality Human health and well being Execution quality and process management	A18 A12 A22	◄ ►	E2 E10	Photosynthesis and primary production Food supply	underground and interior urban agriculture, exterior landscaping, renovation of existing structure, rooftop garden, agriculture products integrated on cafeterias menu, interior green partitions
42	Suginami-ku assembly hall	user's initiative	2008	1. Contemporary	Energy [and atmospheric emissions] Humidity and temperature Economic dynamics and lifecycle costs Community participation and user's satisfaction Customization possibilities and	A4 A19 A11 A10 A12	◄ ◄ ◆ ►	E12 E6 E9 E3	Raw materials, ornamental and medicinal resources Climatic regulation Perceptive environmental modulation Nutrient cycling and waste treatment	user's initiative courtain of deciduous climbing plants [loofah, cucumber, gourd, and morning glory], for microclimate control, and public environmental education, lower energy costs, and absorb carbon
43	Lady Landfill Skyscraper	Milorad Vidojević, Jelena Pucarević, Milica Pihler	2011	1. Contemporary	Energy cycle [and atmospheric emissions]	A4	◄	E3	Nutrient cycling and waste treatment	collection and recycling of ocean plastic waste, and production of energy from waste
44	Mountain Band-Aid	Yiting Shen, Nanjue Wang, Ji Xia, Zihan Wang	2012	1. Contemporary	Water cycle [and effluents] Sustainable life-style support systems	A5 A8	► ◆	E7	Erosion control and hazard protection	restoration of damaged mountain ecology, maintenance of villager's space organization, recycling domestic water for mountain irrigation, and stabilize the mountain's soil and grow plants
45	Bioclimatic Sea Garden Skyscraper	Bea Goller	2006	1. Contemporary	Details and finishes Water cycle [and effluents]	A21 A5	►	E9 E2	Perceptive environmental modulation Photosynthesis and primary production	vertical urban agriculture, "highly positive, repairing and productive results for the saturated urban environment", biomimicry (sponge structures), collection of water from the atmosphere, color responsive envelope to environmental conditions such as pollution or UV levels.
46	Leien Boulevard	Belgian Road Research Centre	2005	1. Contemporary	Details and finishes	A21	►	E3	Nutrient cycling and waste treatment	air depollutant surface materials [nanotechnology]
47	Masthusen development [in Bo01 District]	[diverse authors] Urban planning: White Architects Developer: Diligentia	2001	1. Contemporary	Sustainable life-style support systems Transports and functional articulation w/ context	A8 A3	◆ ►	E5 E9 E6	Biodiversity and nursery habitats Perceptive environmental modulation Climatic regulation	nesting boxes for birds, sustainable vegetation, stormwater drainage channels. + space available for food growing, providing internal community spaces, reducing light and noise pollution, whole life costing and considerate construction, regeneration of former industrial area, green roofs, broken up street and block layouts to break up the harsh sea winds and provide pleasant low mobility experience
48	Centre for Interactive Research on Sustainability [Univ. of British Columbia]	Perkins + Will Architects	2011	1. Contemporary	Energy cycle [and atmospheric emissions] Lighting	A4 A17	◄ ◄ ◆ ►	E9 E5 E3	Perceptive environmental modulation Biodiversity and nursery habitats Nutrient cycling and waste treatment	stormwater collection on roof, living roof, facade with deciduous plants (vines), purification of wastewater in an on-site solar aquatics biofiltration system, rain garden landscape and bioswales
49	Perkins+Will New Atlanta Office	Perkins + Will Architects	2011	1. Contemporary	Water cycle [and effluents]	A5	◆	E12	Raw materials, ornamental and medicinal resources	retrofit of existing structure and majority of materials, water collection and natural filtration system, low impact mobility location, donation of on-site materials to non-profit organizations, landscape with medicinal plants (Witch Hazel, Lavender and Magnolia Bark), expansion of existing tree wells and perviousity of soil, use of filtrated water to toilet fluxes and irrigation needs
50	Dockside Green	Perkins + Will Architects	2009	1. Contemporary	Economic dynamics and lifecycle costs Exterior areas and local pollution control	A11 A7	◆ ◆	E14	Landscape aesthetic fruition	redevelopement of former industrial area. holistic costing method, including site and community infrastructure costs. shoreline enhancement and restoration, waterfront and pedestrian walkways, leisure areas, trails and greenway with water features running through the site. rainwater collection, treated and reused in onsite treatment plant, constructed under the greenway. 100% sewage treated onsite. cogeneration plant, using biomass gasification to provide heat and hot water to all the buildings
51	Rice/Tree/Burial	Agnes Denes	1968 1977-1979	2. Post-Modern	Concept originality, innovation and creativity	A13	◄ ◆	E13 E1	Significant species and ecosytem values Soil formation and fertility	first site-specific performance piece with ecological concerns. [in the 2nd version, possible phytoremediation of toxic contaminants in soil]
52	Wheatfield, a Confrontation	Agnes Denes	1982	2. Post-Modern	Sense of place and cultural identity	A2	◆	E10	Food supply	planted field of golden wheat on two acres of rubble-strewn landfill near Wall Street and the World Trade Center in lower Manhattan, "She cleaned the land, covered it with 200 truckloads of soil, and then hand planted seeds that reaped 1,000 pounds of wheat. [..] then shipped that wheat to 28 cities around the world"
53	Tree Mountain-a living time capsule	Agnes Denes	1996	2. Post-Modern	Sense of place and cultural identity Community participation and user's satisfaction Adaption to eco-physical values and restraints	A2 A10 A1	◆ ◆ ►	E7 E13 E12	Erosion control and hazard protection Significant species and ecosytem values Raw materials, ornamental and medicinal resources	earthwork reclamation project and the first man-made virgin forest, restoration of gravel pit site, 11,000 people have planted 11,000 trees "convinced the Finnish government to promise to preserve it for four centuries; and gave the tree planters and their heirs the right to pass on their living legacy of a tree for at least 20 generations."
54	Time Landscape	Alan Sonfist	1965	2. Post-Modern	Sense of place and cultural identity	A2	◆	E13	Significant species and ecosytem values	placing the ancient indigenous plant species of New York in the modern landscape of the urban island.
55	House in Lisbon [Travessa do Patrocínio]	Luís and Tiago Rebelo de Andrade + Manuel Cachão Tojal	2012	1. Contemporary	Other senses: olfaction, tactility, motion perception	A16	◄ ◆	E12 E13	Raw materials, ornamental and medicinal resources Significant species and ecosytem values	swimming pool on the roof; green walls with mediterranean and iberian native plants, drought resistant; selection of fragrant/medicinal plants to diverse and specific sites
56	Regional Chamber of Commerce and Industry	Chartier-Corbasson Architects	2012	1. Contemporary	Visual	A14	◆	E2	Photosynthesis and primary production	green walls, volumetry (extension of the garden to the building), views
57	Ann Demeulemeester Shop in Seoul	Mass Studies	2007	1. Contemporary	Other senses: olfaction, tactility, motion perception	A16	◄	E12	Raw materials, ornamental and medicinal resources	interior (moss) and exterior green walls (geotextile planted with a herbaceous perennial), semi-pervious irregular pavement
58	EcoVillage Matsudo	Junich Takahashi Central Research Institute of Electric Power Industry Taisei Corporation	2000	1. Contemporary	Sustainable life-style support systems	A8	◆	E3	Nutrient cycling and waste treatment	passive/bioclimatic design, green roofs, louver/green wall, hybrid heat pump with thermal ice storage system, composter in the common garden, separate storage of solid and organic wastes is provided for each dwelling unit in service balcony, storm water reservoir of seepage water and reservoir tank
59	Bird apartment [for Ando Momofuku Center]	Nendo	2012	1. Contemporary	Visual Concept originality, innovation and creativity	A14 A13	◆	E5	Biodiversity and nursery habitats	sculptural bird's nests /nature observation cabin
60	Laketown "Miwa no Mori"	Daiwa House Industry Co.	2008	1. Contemporary	Exterior areas and local pollution control	A7	◆	E13	Significant species and ecosytem values	local ecology addressed in traditional landscape architecture (Planting mainly with indigenous species, Lines of motion secured by continuous arrangement of symbol trees and other tall trees, Wind-breaks formed by tall hedges of shirakashi (evergreen oak), Securing feeding places with trees that produce fruits and nuts. Securing refuges by arranging a good balance of tall, medium height and low trees), cobblestone pavement, composter, bird's bath, recycled timber, passive design

Concretization	Environmental Assessment	Method	Rating	Country	Location	Geographic Cluster	Use | Function	Scale	Context	Sources
1. Built | Realized	2. Non-certified	[…]		Japan	Tokyo	3. S and E Asia-Oceania	6. Offices	2. Building	1. Urban	http://konodesigns.com/cover/ http://nipponnews.photoshelter.com/gallery/Urban-Farm-Pasona-Group-Headquarters/G0000nvwJWPscXLc http://www.architizer.com/en_us/projects/view/pasona-h_q_tokyo/50110/#.UeP7HNL-KSr http://tokyogreenspace.com/?s=pasona
1. Built | Realized	2. Non-certified	[…]		Japan	Asagaya-Minami, Tokyo	3. S and E Asia-Oceania	15. Detail	1. Component	1. Urban	http://metropolis.co.jp/features/feature/tokyo-green-space/4/ http://tokyogreenspace.com/2009/03/31/government/
2. Unbuilt | Plan	2. Non-certified	[…]		[…]	[Pacific Ocean - great pacific garbage patch]	1. America-Pacific	4. Mixed Use	2. Building	3. Non-urban	http://www.evolo.us/competition/lady-landfill-skyscraper/ https://static.squarespace.com/static/5215e2e2e4b0fbb13f0b0b29/t/52299a4be4b052a273f83328/1378458187207/Notice%20-%20Lady%20Landfill%20Skyscraper%20TR.pdf
2. Unbuilt | Plan	2. Non-certified	[…]		China	[Yunnan mountain range]	3. S and E Asia-Oceania	1. Residential	4. Ensemble	3. Non-urban	http://www.evolo.us/competition/mountain-band-aid/
2. Unbuilt | Plan	2. Non-certified	[…]		Spain	Barcelona	2. Europe-Africa-Middle East	4. Mixed Use	2. Building	1. Urban	http://www.evolo.us/competition/bioclimatic-sea-garden-skyscraper/
1. Built | Realized	2. Non-certified	[…]		Belgium	Antwerp	2. Europe-Africa-Middle East	7. Public Space	1. Component	1. Urban	Nano Materials: in Architecture, Interior Architecture and Design [Sylvia Leydecker] A. Beeldens, "An Environmental Friendly Solution for Air Purification and Self-Cleaning Effect: the Application of TiO2 as Photocatalyst in Concrete," Belgian Road Research Centre, Belgium, 2006.
1. Built | Realized	1. Certified	BREEAM	Excellent	Sweden	Malmo	2. Europe-Africa-Middle East	4. Mixed Use	4. Ensemble	1. Urban	http://www.breeam.org/page.jsp?id=537
1. Built | Realized	1. Certified	LEED-NC [Living Building Challenge]	Platinum [Target]	Canada	Vancouver	1. America-Pacific	2. Educational	2. Building	2. Sub-urban	http://cirs.ubc.ca/building http://www.perkinswill.com/work/the-centre-for-interactive-research-on-sustainability-cirs.html
1. Built | Realized	1. Certified	LEED	Platinum	U.S.A.	Atlanta, Georgia	1. America-Pacific	6. Offices	2. Building	1. Urban	http://www.perkinswill.com/work/perkins-will-new-atlanta-office.html http://www.archdaily.com/215002/exemplar-of-sustainable-architecture-1315-peachtree-perkinswill/
1. Built | Realized	1. Certified	LEED-NC and LEED-ND	Platinum	Canada	Vancity, Victoria, British Columbia	1. America-Pacific	4. Mixed Use	4. Ensemble	1. Urban	http://www.perkinswill.com/work/dockside-green.html
1. Built | Realized	2. Non-certified	[…]		U.S.A.	Sulivan County, New York [1st] Artpark, Lewiston, New York [2nd]	1. America-Pacific	10. Art Project	3. Land Unit	3. Non-urban	http://weadartists.org/art-for-the-third-millennium http://kentwa.gov/content.aspx?id=7470
1. Built | Realized	2. Non-certified	[…]		U.S.A.	Manhattan, Battery Parkcity landfill	1. America-Pacific	10. Art Project	3. Land Unit	1. Urban	http://greenmuseum.org/c/aen/Issues/denes.php http://kentwa.gov/content.aspx?id=7470 http://www.americanscientist.org/issues/pub/regeneration-on-tree-mountain
1. Built | Realized	2. Non-certified	[…]		Finland	Ylöjärvi, Western Finland	2. Europe-Africa-Middle East	10. Art Project	3. Land Unit	3. Non-urban	http://greenmuseum.org/content/artist_content/ct_id-198__artist_id-63.html http://www.americanscientist.org/issues/pub/regeneration-on-tree-mountain
1. Built | Realized	2. Non-certified	[…]		U.S.A.	New York City	1. America-Pacific	10. Art Project	3. Land Unit	1. Urban	http://www.alansonfist.com/projects/project.html?time-landscape http://en.wikipedia.org/wiki/Time_Landscape
1. Built | Realized	2. Non-certified	[…]		Portugal	Lisbon	2. Europe-Africa-Middle East	1. Residential	2. Building	1. Urban	http://www.dezeen.com/2012/11/08/house-in-travessa-do-patrocinio-with-green-walls/
1. Built | Realized	2. Non-certified	[…]		France	Amiens	2. Europe-Africa-Middle East	6. Offices	2. Building	1. Urban	http://www.dezeen.com/2012/10/16/regional-chamber-of-commerce-and-industry-with-green-walls-by-chartier-corbasson-architectes/
1. Built | Realized	2. Non-certified	[…]		South Korea	Seoul, Gangham	3. S and E Asia-Oceania	5. Commercial	2. Building	1. Urban	http://www.dezeen.com/2007/12/26/ann-demeulemeester-shop-in-seoul-by-mass-studies/
1. Built | Realized	2. Non-certified	[…]		Japan	Matsudo City, Chiba	3. S and E Asia-Oceania	1. Residential	4. Ensemble	2. Sub-urban	HYDE: 2008 http://iisbe.org/gbc2k/teams/Japan/Matsudo/matsudo-murb.htm http://blog.naver.com/hanmiyi/140132094057 http://sealevel.ca/lowimpact/housing/action.lasso?-Response=search05.lasso&ID=1507
1. Built | Realized	2. Non-certified	[…]		Japan	Komoro, Nagano	3. S and E Asia-Oceania	8. Pavilion	2. Building	3. Non-urban	http://www.nendo.jp/en/works/bird-apartment-2/ https://www.domusweb.it/en/news/2012/09/12/nendo-tree-house-bird-apartment.html
1. Built | Realized	1. Certified	CASBEE	4.6	Japan	Koshigaya City, Saitama	3. S and E Asia-Oceania	1. Residential	4. Ensemble	2. Sub-urban	http://www.ibec.or.jp/jsbd/M/index.htm http://www.lowcarbonhomesworldwide.com/case-studies/countries/japan/laketown-miwa-no-mori.html

CODE	Project Name	Author	Year	Periodization	Ti[L]es Matrix {relevant reference correlations}					Ecosystem Integration	Description
61	ACROS Fukuoka Prefectural International Hall	Emilio Ambasz + Nihon Sekkei Landscape and construction: Takenaka Corporation	1995	1. Contemporary	Structure stability and design Concept originality, innovation and creativity Execution quality and process management	A23 A13 A22	▶ ◆ ▶	E5 E15	Biodiversity and nursery habitats Leisure, recreation and psychophysical health	vertical landscaping [terraces, green roofs], blend with adjacent park, landscape views, reflecting pools connected by upwardly spraying jets of water, and ladder-like climbing waterfall [climate and noise mitigation]
62	Bay Education Center	Croxton Collaborative Architects	2005	1. Contemporary	Structure stability and design	A23	◆	E4	Water cycling and regulation	bioremediation, water retention in a 7000 m² green roof, control and purification of water runoff, site at abandoned landfill, reused materials from site (salvaged waste concrete slabs, salvaged granite curbing), bioremediation ponds and marsh restoration with multiple types of grass, pervious landscape materials
63	Cheasapeake Bay Foundation	Smith Group + Greg Mella + J. Harrison	2000	1. Contemporary	Sustainable life-style support systems	A8	▶	E1	Soil formation and fertility	bioretention filters to treat stormwater runoff, xeriscaping with native vegetation, rainwater collection and reuse, conversion of organic waste to fertilizer used onsite
64	Forestech	Sedunary Lake & Partners Slap architects	2004	1. Contemporary	Durability & maintenance of systems and materials Adequacy to function, occupancy and circulation	A24 A20	◀ ▶	E12 E1	Raw materials, ornamental and medicinal resources Soil formation and fertility	water catchment rockeries and collection dam, (continuous) use of local timber, layout of building plan to passive ventilation and maximize solar gain, siting aboveground to eliminate excavation, along tree canopy
65	Institute for Forestry and Nature Research (IBN)	Behnisch Architekten	1998	1. Contemporary	Humidity and temperature	A19	◀ ◆	E6 E15	Climatic regulation Leisure, recreation and psychophysical health	covered gardens act as buffer zones and provide shading; vegetation improves the microclimate (inner courtyards). landscaping with dry stone walls, trees, hedges, berms, ponds, swamps, tree lanes, and water channels. rainwater from roofs and terraces is directed to a retaining pond, purified by plants, and used for watering plants in the covered gardens. passive design, with interior courtyards as buffers
66	Gwinnett Environmental & Heritage Center	Lord, Aeck & Sargent	2006	1. Contemporary	Water cycle [and effluents]	A5	▶	E14	Landscape aesthetic fruition	charrette processes, vegetated green roof, waterways of interactive learning [aesthetical/educational use of water features for cooling], increased water management, reduction of storm water runoff, pervious paving, bioswales, and wetlands.
67	Cassia Coop Training Center	TYIN Tegnestue Architects	2011	1. Contemporary	Materials cycle [and waste] Details and finishes Other senses: olfaction, tactility, motion perception	A6 A21 A16	◀ ◀	E12	Raw materials, ornamental and medicinal resources	local materials, ornamental resources, olfactory [cinnamon], local community impact, worker's rights and material sourcing, use of byproducts (trunks of cinnamon trees), natural ventilation, setting among trees, passive design [use of thermal mass, reduction of sunrays and maximized eaves], inclusion of trees in the courtyard, semi-pervious pavement
68	Pedras Salgadas Eco-Resort	Luís Rebelo de Andrade & Diogo Aguiar	2012	1. Contemporary	Adequacy to function, occupancy and circulation	A20	◆	E13	Significant species and ecosytem values	views, siting of the project around existing tree trunks (construction of diferent modular typologies based on this), light structures elevated from the ground (no interference with topology)
69	Stacking Green	Vo Trong Nghia + Daisuke Sanuki + Shunri Nishizawa	2011	1. Contemporary	Concept originality, innovation and creativity Visual Economic dynamics and lifecycle costs	A13 A14 A11	◆ ◆ ◀	E12 E3 E9	Raw materials, ornamental and medicinal resources Nutrient cycling and waste treatment Perceptive environmental modulation	concept originality, visual aspects, lighting, cultural relation (tradition of potscapes in Saigon), green roof, ornamental plants, collection of rain water to irrigation of planters, function of vegetaion wall to filter direct sunlight, street noise and pollution; natural ventilation, post-ocuppancy studies [energy consumption reduced from porous facade with plants and skylights, no need for active cooling]
70	Solaris	Ken Yeang	2010	1. Contemporary	Energy cycle [and atmospheric emissions] Humidity and temperature	A4 A19	◆	E5	Biodiversity and nursery habitats	planted area greater than building's footprint (original concept also of the planted ribbon ramp); rainwater reuse and recycling, lowflow efficient plumbing fixtures, strategic use of photovoltaic film, and carbon-footprint considerations in the use of building materials; green balconies, landscape ramp [continuity of green space, and thus green corridor] and green roofs, that enhance biodiversity and provide shade for building passive performance; selection of tropical site adapted specie plant species
71	DiGi Technical Office	Hamzah & Yeang	2010	1. Contemporary	Indoor air quality Details and finishes	A18 A21	◀ ▶	E5 E8	Biodiversity and nursery habitats Biological control & pollination	living wall linking greenery in all the facades, exterior and interior green walls "developed in conjunction with the building's ventilation design to act as a biological air filtration system" (resulting in increased air purification, regulation of humidity levels, dust filter, insulation, noise filter, biodiversity continuity, and attraction of pollinators); native species; bioswale (natural filtration and drainage systems, with pervious grass pavements), rainwater harvesting for irrigation.
72	Pocono Environmental Education Center	Bohlin Cywinski Jackson	2005	1. Contemporary	Transports and functional articulation w/ context Adaption to eco-physical values and restraints	A3 A1	▶ ▶	E5 E13	Biodiversity and nursery habitats Significant species and ecosytem values	indigenous low- maintenance landscaping, building placement, extensive use of reused, recycled, or recyclable materials, site selection and development: "Avoid properties that interfere with wildlife corridors, Design development to have pedestrian emphasis rather than automobile emphasis, Select already-developed sites for new development, Assess property for integration with local community and regional transportation corridors" (users arrive mainly by bus or other forms of mass transit, and many programs involve
73	Revival Fields I and II	Mel Chin	1990	1. Contemporary	Exterior areas and local pollution control	A7	◆	E1 E3	Soil formation and fertility Nutrient cycling and waste treatment	phytoremediation land art [gardens of hyperaccumulators--plants that can draw heavy metals from contaminated soil]
74	Torre de Especialidades	Elegant Embellishments [Allison Dring e Daniel Schwaag]	2013	1. Contemporary	Details and finishes Concept originality, innovation and creativity	A21 A13	▶ ◆	E3	Nutrient cycling and waste treatment	photocatalytic air depollutant façade system (also anti-microbial, decorative, and light filter); biomimetic tesselations that bear semblance to sponges or corals
75	Casa CorMAnca	Paul Cremoux studio	2013	1. Contemporary	Adequacy to function, occupancy and circulation	A20	◆	E12	Raw materials, ornamental and medicinal resources	green exterior wall, courtyard, extreme conditions lot
76	Makino Museum of Plants and People	Naito Architects and Associates / Takenaka corporation	1999	1. Contemporary	Water cycle [and effluents] Human health and well being Lighting Concept originality, innovation and creativity Structure stability and design	A5 A12 A17 A13 A23	◆ ◀ ◆ ◆	E6 E13 E5 E7	Climatic regulation Significant species and ecosytem values Biodiversity and nursery habitats Erosion control and hazard protection	sunlight screening efficiency due to large, deep canopy. trees and plants transplanted to avoid impact on landscape trees, based on surveys and studies of vegetation, plant phases and large-diameter trees in the construction site. More than 500 different trees were planted around the buildings, and a biotope was created using natural wind flow and water environment facilities. collection and filtration of rain water and utilization in ponds with cooling effects
77	Satonokaze daytime workshop for people with physical and intellectual disabilities	Seiji Nii Architect & Associates	2004	1. Contemporary	Sustainable life-style support systems	A8	◆	E12	Raw materials, ornamental and medicinal resources	transplanting of plants present before the construction, Roof greening, Biotope and rain water collection pond (used for sprinklers), trees and plants planted along the roads, coexistence with the community, eflected heat within the site is reduced by roof and parking area greening; recycling of organic kitchen garbage into compost and fertilizer for ornamental/aromatic plants (herb garden); also, herbs, fruits and vegetables grown in the site are used in the cafeteria
78	Incubation on Campus Honjo Waseda	Nihon Sekkei	2004	1. Contemporary	Details and finishes	A21	▶	E5	Biodiversity and nursery habitats	greenery planted on eaves and green roofs as a habitat for goshawks, buildings and landscaping designed along contours of original valley, greenery and shapes of buildings designed to match local character, façade with recessed glass surfaces in consideration for goshawks; fitting of the building layout to topography, prevailing winds and solar aspect
79	Frontier Center for Environmental Symbiosis Technology	Nikken Sekkei	2005	1. Contemporary	Other senses: olfaction, tactility, motion perception	A16	◆	E8	Biological control & pollination	renovation of existing structure, passive design, green wall with climbing plants [roses, fragrant], rooftop biotope and green roof (to mitigate heat island), rainwater utilization
80	Nissan Advanced Technology Center	Nihon Sekkei	2007	1. Contemporary	Materials cycle [and waste] Human health and well being Lighting Other senses: olfaction, tactility,	A6 A12 A17 A16	▶ ◀ ◀	E5 E14 E4	Biodiversity and nursery habitats Landscape aesthetic fruition Water cycling and regulation	rooftop greenery; reuse of onsite concrete waste rubble into green embakments; site design in harmony with natural vegetation and transplantion of existing mature trees; "green cube brings nature into workplace" and "top light glass on the north side provide natural lighting (...) glass surface is watered to generate evaporative cooling and provide a visual cooling sensation", rainwater infiltration facility, kitchen water reprocessing and organic kitchen waste processing facility.

Concretization	Environmental Assessment	Method	Rating	Country	Location	Geographic Cluster	Use | Function	Scale	Context	Sources
1. Built | Realized	1. Certified	Certificate of Environmental Architecture [JIA]	1st prize	Japan	Fukuoka city, Fukuoka	3. S and E Asia-Oceania	4. Mixed Use	2. Building	1. Urban	http://www.architecturenewsplus.com/project-images/6638 https://www.acros.or.jp/english/about/
1. Built | Realized	2. Non-certified	[…]		U.S.A.	Providence, Rhode Island	1. America-Pacific	4. Mixed Use	2. Building	2. Sub-urban	Moscow: 2008 http://www.croxtoncollaborative.com/proj_becenter.htm http://www.solaripedia.com/13/109/1000/save_the_bay_viewed_from_parking_area.html
1. Built | Realized	1. Certified	LEED	Platinum	U.S.A.	Annapolis, Maryland	1. America-Pacific	6. Offices	2. Building	2. Sub-urban	Moscow: 2008 http://inhabitat.com/chesapeake-bay-foundation-headquarters-greenest-building-ever/cbf-merrill-environmental-center-2/?extend=1
1. Built | Realized	2. Non-certified	[…]		Australia	Barnsdale	3. S and E Asia-Oceania	2. Educational	2. Building	3. Non-urban	Moscow: 2008 http://slaparchitects.com.au/forestech/
1. Built | Realized	2. Non-certified	[…]		Netherlands	Wageningen	2. Europe-Africa-Middle East	6. Offices	2. Building	2. Sub-urban	Moscow: 2008 http://behnisch.com/projects/22
1. Built | Realized	1. Certified	LEED	Gold	U.S.A.	Bufourd, Georgia	1. America-Pacific	3. Cultural	2. Building	2. Sub-urban	Moscow: 2008 https://gwinnettehc.org/about/ http://www.greenroofs.com/projects/pview.php?id=408 http://www.lordaecksargent.com/design/science-and-technology/government/the_gwinnett_environmental_heritage_center/
1. Built | Realized	2. Non-certified	[…]		Indonesia	Sungai Penuh, Kerinchi, Sumatra	3. S and E Asia-Oceania	4. Mixed Use	2. Building	3. Non-urban	http://www.archdaily.com/274835/casia-coop-training-centre-tyin-tegnestue-architects/ http://www.tyinarchitects.com/works/cassia-coop-training-centre/cctc-projectdescription/
1. Built | Realized	2. Non-certified	[…]		Portugal	Parque de Pedras Salgadas, Bornes de Aguiar	2. Europe-Africa-Middle East	11. Tourism	4. Ensemble	3. Non-urban	http://www.dezeen.com/2012/12/07/eco-resort-pedras-salgadas-by-luis-rebelo-de-andrade-diogo/
1. Built | Realized	2. Non-certified	[…] [but with post-ocuppancy research]		Vietnam	Saigon [Ho Chi Minh]	3. S and E Asia-Oceania	1. Residential	2. Building	1. Urban	http://inhabitat.com/vo-trong-nghias-stacking-green-house-is-an-urban-oasis-completely-wrapped-in-planters/stacking-green-vo-trong-nghia-daisuke-4/ http://www.archdaily.com/199755/stacking-green-vo-trong-nghia/ http://votrongnghia.com/projects/stacking-green/
1. Built | Realized	1. Certified	BCA Green Mark	Platinum	Singapore	Fusionopolis, Singapore	3. S and E Asia-Oceania	6. Offices	2. Building	1. Urban	greensource magazine http://www.hamzahyeang.com/solaris-sustainable-architecture/ http://blog.japhethlim.com/index.php/2011/06/14/green-architecture-is-underrated-a-case-study-on-solaris-by-tr-hamzah-and-ken-yeang/
1. Built | Realized	1. Certified	Green Building Index	Gold	Malaysia	Subang High Tech Park, Shah Alam, Selangor	3. S and E Asia-Oceania	6. Offices	2. Building	2. Sub-urban	http://www.hamzahyeang.com/caag-tower-green-building-technology/
1. Built | Realized	2. Non-certified	[…]		U.S.A.	National Park Service, Dingmans Ferry, Pennsylvania	1. America-Pacific	3. Cultural	2. Building	3. Non-urban	Moscow: 2008 http://www.bcj.com/public/projects/project/88.html http://www.buildinggreen.com/hpb/overview.cfm?projectid=1016 http://www2.aiatopten.org/hpb/overview.cfm?ProjectID=1016
1. Built | Realized	2. Non-certified	[…]		U.S.A.	old landfill near downtown St. Paul, Minnesota,	1. America-Pacific	10. Art Project	3. Land Unit	3. Non-urban	http://www.artsconnected.org/resource/85880/revival-field-projection-procedure
1. Built | Realized	2. Non-certified	[…]		Mexico	Tlalpan, Mexico City.	1. America-Pacific	14. Healthcare	1. Component	1. Urban	http://www.evolo.us/architecture/depolluting-quasicrystal-facade-cleans-mexico-citys-air/ http://www.prosolve370e.com/pr_torre.htm http://aedesign.wordpress.com/2013/07/09/torre-de-especialidades-mexico-city/
1. Built | Realized	2. Non-certified	[…]		Mexico	Mexico City	1. America-Pacific	1. Residential	2. Building	1. Urban	http://www.archdaily.com/375004/casa-cormanca-paul-cremoux-studio/?utm_source=dlvr.it&utm_medium=twitter
1. Built | Realized	1. Certified	CASBEE	2.9*	Japan	Kochi [Shikoku]	3. S and E Asia-Oceania	3. Cultural	2. Building	3. Non-urban	http://www.ibec.or.jp/jsbd/D/index.htm http://www.naitoaa.co.jp/090701/works/mak/works1.html http://www.makino.or.jp/index_e.html
		[*ratings should be referent to CASBEE version]								
1. Built | Realized	1. Certified	CASBEE	2.9	Japan	Mizukoshi, Osaka prefecture	3. S and E Asia-Oceania	12. Social	2. Building	2. Sub-urban	http://www.ibec.or.jp/jsbd/T/index.htm http://www.nii-aa.com/works/shogai/satonokaze/satonokaze.html
1. Built | Realized	1. Certified	CASBEE	3.0	Japan	Honjo City, Saitama Prefecture	3. S and E Asia-Oceania	2. Educational	4. Ensemble	3. Non-urban	http://www.ibec.or.jp/jsbd/AE/index.htm
1. Built | Realized	1. Certified	CASBEE	2.9	Japan	Yokohama City, Kanagawa	3. S and E Asia-Oceania	2. Educational	2. Building	1. Urban	http://www.ibec.or.jp/jsbd/AF/
1. Built | Realized	1. Certified	CASBEE	4.7	Japan	Atsugi, Kanagawa Prefecture	3. S and E Asia-Oceania	2. Educational	2. Building	2. Sub-urban	http://www.ibec.or.jp/jsbd/AL/

CODE	Project Name	Author	Year	Periodization	Ti[L]es Matrix {relevant reference correlations}					Ecosystem Integration | Description
81	House of Outlook	Iwamura Atelier	2006	1. Contemporary	Human health and well being Durability & maintenance of systems and materials	A12 A24	◄	E6 E12	Climatic regulation Raw materials, ornamental and medicinal resources	site-specific safer foundation system and form are developed on the basis of the ground survey, pergola, pervious surfaces, bioclimatic design, Existing trees are preserved as much as possible, and indigenous trees are to be newly planted where necessary. micro-climates are created around the house. associated with existing trees and pond on-site.
82	The Shimizu Institute of Technology	Shimizu Corporation	2006	1. Contemporary	Execution quality and process management	A22	►	E5 E8	Biodiversity and nursery habitats Biological control & pollination	roof biotope, ground biotope, insects and birds monitoring system, Pond, Wall greening, Greenery network
83	BIQ	SPLITTERWERK, Label für Bildende Kunst Arup GmbH B+G Ingenieure Immosolar GmbH	2013	1. Contemporary	Lighting	A17	◄	E2	Photosynthesis and primary production	microalgae bioreactor façade, to produce energy, and can also control light and provide shade. visible from outside the building, and is an intentional part of the architectural concept
84	Hanegi Forest apartment	Shigeru Ban	1997	1. Contemporary	Adequacy to function, occupancy and circulation	A20	◄	E12	Raw materials, ornamental and medicinal resources	preservation of all existing vegetation (trees), layout and structure (triangular grid system) design to fit tree trunks pattern; pervious soil materials
85	Pola Museum of Art/ Pola Art Foundation	Nikken Sekkei	2002	1. Contemporary	Adaption to eco-physical values and restraints Execution quality and process management	A1 A22	◆ ►	E5 E14	Biodiversity and nursery habitats Landscape aesthetic fruition	location adapted to existent trees, steep slopes, and aquifer flows. Reintroduction of native vegetation and control/erradication of exotic species
86	ZeroCO2 House [Zero Emission Center]	Sekisui House + NEDO; AIST; NEF	2008	1. Contemporary	Exterior areas and local pollution control	A7	◆	E8	Biological control & pollination	roof vegetation innovative material, gohon no ki gardening concept, recycled cement, compost and kitchen garden
87	Amami hospital	Nikken Sekkei	2003	1. Contemporary	Energy cycle [and atmospheric emissions] Customization possibilities and operation	A4 A9	◄ ►	E11 E15	Water purification and fresh water supply Leisure, recreation and psychophysical health	natural ventilation setting, inner garden, canopies to soft hard light and allow cross ventilation in the rain, "wind terrace" ("Wind Terrace" rooms allow "patients to comfortably enjoy the gentle natural breeze"), views of the natural landscape, use of groundwater local resources (well) for drinking and cooling, green roofs
88	Seto-chi Shinanodai Elementary school	Nikken Sekkei	1999	1. Contemporary	Sense of place and cultural identity	A2	◆	E15	Leisure, recreation and psychophysical health	diverse outdoor activies/learning opportunities with community integration, passive design [with diverse indoor light and ventilation strategies], redirection of local spring water to a marsh [biotope for native species and microclimate],
89	Research Institute for Humanity and Nature	Nikken Sekkei	2005	1. Contemporary	Adaption to eco-physical values and restraints Adequacy to function, occupancy and circulation Economic dynamics and lifecycle costs Durability & maintenance of systems and materials	A1 A20 A11 A24	► ◆ ◄ ◆	E14 E7	Landscape aesthetic fruition Erosion control and hazard protection	building layout adapted to topography and forest through plan and section, minimize visual and physical impact, protection from landslides through tree revegetation, underground freshwater redirected to constructed water garden, rainfall collection from roofs and supply for non potable use
90	House & Garden	Ryue Nishizawa	2011	1. Contemporary	Adequacy to function, occupancy and circulation	A20	◆	E12	Raw materials, ornamental and medicinal resources	different height layers of vegetation and integration, balcony with soil, gardens are interspersed with rooms on each of the four floors, screen of plants that mask the facade from the eyes of passing strangers
91	Kitakami Canal Museum	Kengo Kuma & Associates	1999	1. Contemporary	Adequacy to function, occupancy and circulation Visual	A20 A14	◆ ◄	E11 E1	Water purification and fresh water supply Soil formation and fertility	canal purification facility, green roof and walls [buried structure], protection from hazard
92	Tanpopo [Dandelion] House	Teronobu Fujimori	1995	1. Contemporary	Details and finishes Humidity and temperature Acoustics	A21 A19 A15	◆ ◄	E12 E1	Raw materials, ornamental and medicinal resources Soil formation and fertility	green roof and vertical landscaping [visual integration. stripes of plants and building material]. Design of details.The architect is his own client. Several envelope layers [concrete, space for air, platy andesite panels and grasses (on soil) leading to good insulation and heat preservation.
93	Nira House + shinken tearoom	Teronobu Fujimori	1997	1. Contemporary	Visual Details and finishes	A14 A21	◆	E1 E10	Soil formation and fertility Food supply	[visual integration: perfurated roof with nira (leek), which is used in japanese cuisine, and resilient in dry conditions]. Hiding of ugly metal guardrail (to the street) hidden with a small land elevation covered in grass[using geotextile method]. Client role in demanding something unusual. almost self-building [of the roof leeks system]
94	Chashitsu	Teronobu Fujimori	2005	1. Contemporary	Sense of place and cultural identity Visual Concept originality, innovation and creativity	A2 A14 A13	◆ ◄ ◆	E14 E12 E13	Landscape aesthetic fruition Raw materials, ornamental and medicinal resources Significant species and ecosytem	use of local (on-site) available raw materials [1 cypress was cut out and used out of the existing 2], as detail and finishes and structure. landscape integration and sense of place [cherry trees]
95	Tsubaki Castle [Camelia Castle]	Teronobu Fujimori	2000	1. Contemporary	Community participation and user's satisfaction Materials cycle [and waste]	A10 A6	◆ ►	E12 E2	Raw materials, ornamental and medicinal resources Photosynthesis and primary production	green roof and planted joints [self built/structure], green vertical joints, pervious joint surfaces [same "look" as walls], self-construction, visual reminiscence of traditional architecture [thatch roofs eaves], one singular camelia tree planted at the top of the roof, visual display of footholds for maintenance of roof, participation of the client, use of traditional japanese method "namakokabe" waterproof mortar
96	Nakijin village Comunity Centre	Team Zoo	1975	2. Post-Modern	Materials cycle [and waste]	A6	◄	E12	Raw materials, ornamental and medicinal resources	roof covered with greenery and palm trees, public participation methods, indigenous materials, regionalism
97	Yakushima Symbiotic Housing	Iwamura Atelier	2006	1. Contemporary	Customization possibilities and operation Sustainable life-style support systems	A9 A8	◆ ◆	E6 E5	Climatic regulation Biodiversity and nursery habitats	green networking, bio-garden, local natural materials, post-occupancy initiatives, pergolas
98	Kagoshima Museum of Environment: Planet Earth and its Future	Nikken Sekkei	2008	1. Contemporary	Structure stability and design	A23	◆	E6	Climatic regulation	green curved roof, pergolas, canopies, bioclimatic design, use of water from river
99	Loblolly House	Kieran Timberlake	2006	1. Contemporary	Adaption to eco-physical values and restraints Concept originality, innovation and creativity	A1 A13	► ◆	E1 E14	Soil formation and fertility Landscape aesthetic fruition	deasembly materials, patterns of the surrounding trees reflected in the striated cladding [cultural inspiration, etc], building elevated from ground (light intervention on site topography, etc.), reminescence of tree-house, irregular poles support the house, views
100	Water squares	De Urbanisten	2010	1. Contemporary	Concept originality, innovation and creativity Water cycle [and effluents]	A13 A5	◆ ◆	E4 E15	Water cycling and regulation Leisure, recreation and psychophysical health	aesthetic-funtional play with rain water storage, leisure, financial output; rainwater capture, flooding prevention from nearby areas and water filtration,

Concretization	Environmental Assessment	Method	Rating	Country	Location	Geographic Cluster	Use | Function	Scale	Context	Sources
1. Built | Realized	1. Certified	CASBEE	3.7	Japan	Misato-machi, Kodama, Saitama	3. S and E Asia-Oceania	1. Residential	2. Building	3. Non-urban	http://www.ibec.or.jp/jsbd/L/index.htm
1. Built | Realized	1. Certified	CASBEE	3.2	Japan	Koto-ku, Tokyo	3. S and E Asia-Oceania	2. Educational	2. Building	1. Urban	http://www.ibec.or.jp/jsbd/Y/ Shimizu Institute of Technology http://www.shimz.co.jp/english/theme/sit/index.html
1. Built | Realized	1. Certified	Passive-house standard [Energy]		Germany	Hamburg	2. Europe-Africa-Middle East	1. Residential	2. Building	2. Sub-urban	http://www.iba-hamburg.de/en/themes-projects/the-building-exhibition-within-the-building-exhibition/smart-material-houses/biq/projekt/biq.html http://www.biq-wilhelmsburg.de/die-fassade/biologie.html
1. Built | Realized	2. Non-certified	[…]		Japan	Hanegi forest, Setagaya, Tokyo	3. S and E Asia-Oceania	1. Residential	2. Building	1. Urban	http://www.shigerubanarchitects.com/works/1997_hanegi-forest/index.html http://www.tokyo.parallellt.se/2010/11/hanegi-forest-housing.html http://www.nytimes.com/2007/05/20/magazine/20shigeru-t.html?pagewanted=all&_r=0
1. Built | Realized	2. Non-certified	[…]		Japan	National Park of Fuji Hakone, Kanagawa	3. S and E Asia-Oceania	3. Cultural	2. Building	3. Non-urban	http://www.nikken.co.jp/en/projects/cultural/museum-auarium/pola-museum-of-arts.html http://www.polamuseum.or.jp/english/inquiry/01.html
1. Built | Realized	2. Non-certified	[…]		Japan	Ibaraki	3. S and E Asia-Oceania	1. Residential	2. Building	2. Sub-urban	http://www.sekisuihouse.com/zeh/eng/
1. Built | Realized	2. Non-certified	[…]		Japan	Naze-shi, Kagoshima	3. S and E Asia-Oceania	14. Healthcare	2. Building	2. Sub-urban	HASHIMOTO, IIDA, WADA: 2010 http://www.nikken.co.jp/en/projects/healthcare/jiai-kai-amami-hospital.html http://wenku.baidu.com/view/31bbb7fc770bf78a652954a2.html
1. Built | Realized	2. Non-certified	[…] CASBEE	2.7	Japan	Seto-shi, Aichi	3. S and E Asia-Oceania	2. Educational	2. Building	2. Sub-urban	SHINKENCHIKU-SHA: 2010 http://web-japan.org/kidsweb/meet/shinanodai/index.html http://www.ibec.or.jp/CASBEE/english/SB08_pdf/Nikken_Shinanodai.pdf http://web-
1. Built | Realized	2. Non-certified	[…]		Japan	Kita-ku, Kyoto	3. S and E Asia-Oceania	2. Educational	2. Building	2. Sub-urban	HASHIMOTO, IIDA, WADA: 2010 http://www.chikyu.ac.jp/rihn_e/access/index.html http://www.nikken.co.jp/en/projects/office/businesspark/research-institute-for-humanity-and-nature.html
1. Built | Realized	2. Non-certified	[…]		Japan	Tokyo	3. S and E Asia-Oceania	1. Residential	2. Building	1. Urban	http://www.dezeen.com/2013/01/23/garden-and-house-by-ryue-nishizawa/ http://architecturelinked.com/profiles/blogs/house-garden
1. Built | Realized	2. Non-certified	[…]		Japan	Ishinomaki-shi, Miyagi	3. S and E Asia-Oceania	3. Cultural	2. Building	2. Sub-urban	KKAA http://kkaa.co.jp/works/kitakami-canal-museum/ http://www.arch.mcgill.ca/prof/mellin/arch671/winter2001/fhsu/drm/precedents/Canal%20Museum.htm http://www.thr.mlit.go.jp/karyuu/mizu-no-dokutsu/top.html
1. Built | Realized	2. Non-certified	[…]		Japan	Kokubunji, Tokyo	3. S and E Asia-Oceania	1. Residential	2. Building	2. Sub-urban	Fujimori: 2007 http://www.michaelfreemanphoto.com/
1. Built | Realized	2. Non-certified	[…]		Japan	Machida, Tokyo (located near the Shin-ken tea house)	3. S and E Asia-Oceania	1. Residential	2. Building	2. Sub-urban	Fujimori: 2007
1. Built | Realized	2. Non-certified	[…]		Japan	Mount Kai-Komagatake, South Alps, near Mt Moriya	3. S and E Asia-Oceania	8. Pavilion	2. Building	3. Non-urban	Fujimori: 2007
1. Built | Realized	2. Non-certified	[…]		Japan	Izu Oshima island [top of a hill, near the ocean, near mt. Miharayama]	3. S and E Asia-Oceania	5. Commercial	2. Building	3. Non-urban	Fujimori: 2007
1. Built | Realized	2. Non-certified	[…]		Japan	Nakijin, Okinawa Honto	3. S and E Asia-Oceania	12. Social	2. Building	2. Sub-urban	Public Places in Asia Pacific Cities: Current Issues and Strategies http://10plus1.jp/photo-archives
1. Built | Realized	2. Non-certified	[…]		Japan	northern Miyanoura, Kamiyaku-cho, Yakushima, Kagoshima	3. S and E Asia-Oceania	1. Residential	4. Ensemble	2. Sub-urban	http://www.kkj.or.jp/contents/english/executedcases.html
1. Built | Realized	2. Non-certified	[…]		Japan	Kagoshima city, Kagoshima	3. S and E Asia-Oceania	3. Cultural	2. Building	1. Urban	http://www.nikken.co.jp/en/projects/cultural/museum-auarium/kagoshima-museum-of-environment-planet-earth-and-its-future.html
1. Built | Realized	2. Non-certified	[…]		U. S. A.	Taylors Island, Maryland	1. America-Pacific	1. Residential	2. Building	3. Non-urban	http://www.kierantimberlake.com/pages/view/20/loblolly-house/parent:3 http://www.archdaily.com/64043/loblolly-house-kieran-timberlake/ http://inhabitat.com/prefab-friday-loblolly-house/
2. Unbuilt | Plan	2. Non-certified	[…]		Netherlands	Rotterdam	2. Europe-Africa-Middle East	7. Public Space	3. Land Unit	1. Urban	http://www.urbanisten.nl/wp/?portfolio=waterpleinen

CODE	Project Name	Author	Year	Periodization	Ti[L]es Matrix {relevant reference correlations}					Ecosystem Integration | Description
101	Urban soil detoxying infrastructure - *A different brick*	**Ana Ilic, Yasemin Sahiner, Kyaw Htoo**	2013	1. Contemporary	Materials cycle [and waste]	A6	◆	E3	Nutrient cycling and waste treatment	material for soil decontamination, and urban regeneration of gas stations
102	Shimane Arts Center	**Naito and Associates**	2005	1. Contemporary	Visual Details and finishes	A14 A21	◄ ◄	E4 E9	Water cycling and regulation Perceptive environmental modulation	courtyard with water, local ceramic tiles that change color with light of day
103	Ise Shrine	[Shinto/vernacular architecture]	[3rd/5th century - 2013]	3. Pre-Modern	Sense of place and cultural identity	A2	◆	E13	Significant species and ecosytem values	protection of identity features of the ecosystem environment, and sacred area landscape and elements
104	Vine pergolas in South Europe	[vernacular architecture]	[...]	3. Pre-Modern	Sense of place and cultural identity	A2	◆	E9 E6	Perceptive environmental modulation Climatic regulation	microclimate control (shadow, and light filter), edible species,
105	Water mills	[vernacular architecture]	[...]	3. Pre-Modern	Energy cycle [and atmospheric emissions]	A4	◄	E4	Water cycling and regulation	use of water to produce mechanical work
106	Wind mills [landscapes]	[vernacular architecture]	[...]	3. Pre-Modern	Energy cycle [and atmospheric emissions]	A5	►	E14	Landscape aesthetic fruition	use of wind to produce mechanical work, formation of socio-cultural landscapes and landmarks
107	Micro-greenery [in Tokyo]	[user initiative]	[...]	3. Modern	Customization possibilities and operation Sense of place and cultural identity	A9 A2	► ◆	E12 E2	Raw materials, ornamental and medicinal resources Photosynthesis and primary production	vegetal ornamental and edible species, and water elements; performing functions as reduce traffic speed, embelish and showcase commercial entrances/attract costumers, recreation/leisure and control microclimate, etc
108	Real Alcázar of Seville	[unknown]	[712 - 1364]	3. Pre-Modern	Water cycle [and effluents] Humidity and temperature Sense of place and cultural identity	A5 A19 A2	► ◄ ◆	E15 E4 E6	Leisure, recreation and psychophysical health Water cycling and regulation Climatic regulation	pergolas and water courtyards in mediterranean architecture, rain water collection and storage [the "baths"], gardens
109	Coastal settlements protected by mangroves	[vernacular architecture]	[...]	3. Pre-Modern	Adaption to eco-physical values and restraints Sense of place and cultural identity Transports and functional articulation w/ context Human health and well being	A1 A2 A3 A12	◄	E7	Erosion control and hazard protection	hazard protection/mitigation from mangroves, and other ecosystem services [biodiversity, fisheries, water quality], formation of cultural landscapes, elevation to accommodate tidal change
110	Cliff dwellings of Anasazi	[vernacular architecture]	1100 -1300	3. Pre-Modern	Sense of place and cultural identity	A2	◄	E12	Raw materials, ornamental and medicinal resources	use of immediate local materials [soil and stone], and formation of local identity, passive design [use of ground stable temperatures]
111	Cappadocia dwellings	[vernacular architecture]	[~4th - 11th century]	3. Pre-Modern	Adaption to eco-physical values and restraints	A1	◄	E12	Raw materials, ornamental and medicinal resources	use of immediate local materials [soft stone: tuff], and formation of local identity through unique rock formations
112	Iceland turf houses	[vernacular architecture]	10th to 20th century	3. Pre-Modern	Humidity and temperature Sense of place and cultural identity	A19 A2	◄	E1	Soil formation and fertility	use of immediate local materials [soil], and formation of local identity
113	Jean-Marie Tijbaou Cultural Center	**Renzo Piano**	1998	1. Contemporary	Indoor air quality Sense of place and cultural identity Durability & maintenance of systems and materials	A18 A2 A24	◄ ◆ ◄	E6 E14 E8	Climatic regulation Landscape aesthetic fruition Biological control & pollination	shell shaped towers and site landscaping patterned on the traditional Kanak village design elements. ventilation strategies. low-maintenance, termite-repellent iroko wood. highly efficient passive ventilation system (double outer facade). facade designed to harness the monsoon winds coming in from the sea. airflow regulated by adjustable louvers, opening when the wind is light to allow for fresh air, but close when wind speeds pick up. "Operable roof skylights and use of laminated bamboo wood allows penetration of abundant
114	Palisade Bay, New York Harbor	**Guy Nordenson associates + Catherine Seavitt studio + Architecture Research Office [ARO]**	2009	1. Contemporary	Adaption to eco-physical values and restraints Concept originality, innovation and creativity	A1 A13	► ◆	E5 E7	Biodiversity and nursery habitats Erosion control and hazard protection	"boomerang" shaped barrier islands to slow and diffuse storm waves, to sediment accumulation, and creation of wildlife habitat earthen wetlands, and community parks
115	New York City (Steady) State	**Terreform | Center for Advanced Urban Research**	2012	1. Contemporary	Materials cycle [and waste] Durability & maintenance of systems and materials Sustainable life-style support systems Economic dynamics and lifecycle costs	A6 A24 A8 A11	◆	E10	Food supply	closed loop system city proposal only using local foods and resources, with "virtually every urban surface becoming a productive landscape".
116	Mãe d'Água Reservatory	**Carlos Mardel** [Martell Károly]	1834	3. Pre-Modern	Acoustics Structure stability and design	A15 A23	◄	E11	Water purification and fresh water supply	water supply [collection and distribution] and storage [reservatory]
117	KAIT workshop - Kanagawa Institute of Technology	**Junya Ishigami**	2007	1. Contemporary	Adequacy to function, occupancy and circulation Human health and well being Lighting	A20 A12 A17	◄ ► ◆	E12 E14	Raw materials, ornamental and medicinal resources Landscape aesthetic fruition	concept, ornamental plants, views interior/exterior, mimic in abstract way of sunlight filtered through the trees from topsurface,
118	APS - Active Phytoremediation System	**CASE** [Center for Architecture Science and Ecology]: Rensselaer Polytechnic Institute + SOM [Skidmore, Owings & Merrill]	2009	1. Contemporary	Indoor air quality Human health and well being Humidity and temperature	A18 A12 A19	◄ ◄	E3 E2	Nutrient cycling and waste treatment Photosynthesis and primary production	air purification [elimination of VOCs, particles, and other pollutants] modular system with integrated vegetation. Biomechanical hybrid that potentiates the capacity of plants to purify indoor air, by drawing air through the roots and rizomes, and from there distributing it to the space. Hydroponic plants, scalable modular system, design for dissassembly. Also contributes to balance air humidity in air-conditioned environments.
119	Row house	**Junya Ishigami**	2005	1. Contemporary	Lighting Visual	A17 A14	► ◆	E2 E10 E12 E15	Photosynthesis and primary production Food supply Raw materials, ornamental and medicinal resources Leisure, recreation and psychophysical health	interior vegetation, vegetable garden, "exterior" greenhouse garden whose rooftop can be opened, dissolution of borders between architecture and landscape; edible, medicinal and ornamental trees and plants as part as plan/furniture of the house
120	Tree Tenant + Humus Toilet	**Hundertwasser**	~1973	2. Post-Modern	Materials cycle [and waste] Water cycle [and effluents]	A6 A5	◆ ►	E1	Soil formation and fertility	green roofs, green balconies, organic waste recycling

Concretization	Environmental Assessment	Method	Rating	Country	Location	Geographic Cluster	Use | Function	Scale	Context	Sources
2. Unbuilt | Plan	2. Non-certified	[…]		Japan	Tokyo	3. S and E Asia-Oceania	8. Pavilion	1. Component	1. Urban	http://issuu.com/obuchilab/docs/different_brick-00_team_short
1. Built | Realized	2. Non-certified	[…]		Japan	Shimane, Masuda city	3. S and E Asia-Oceania	3. Cultural	2. Building	2. Sub-urban	http://atsukojoe.wordpress.com/2010/11/18/hiroshi-naito-grand-toit/ http://www.naitoaa.co.jp/090701/works/top/top.html http://www.kankou-shimane.com/eng/spot/detail/35
1. Built | Realized	2. Non-certified	[…]		Japan	Ise, Mie prefecture	3. S and E Asia-Oceania	3. Cultural	4. Ensemble	3. Non-urban	http://en.wikipedia.org/wiki/Ise_Grand_Shrine http://www.isejingu.or.jp/english/
1. Built | Realized	2. Non-certified	[…]		[…]	[South/Mediterranean Europe] Diverse locations: Portugal, Italy, etc.	2. Europe-Africa-Middle East	15. Detail	1. Component	1. Urban	http://en.wikipedia.org/wiki/Pergola
1. Built | Realized	2. Non-certified	[…]		[…]	[Europe] Diverse locations: Portugal, Great Britain, etc.	2. Europe-Africa-Middle East	13. Infrastructure	1. Component	3. Non-urban	http://en.wikipedia.org/wiki/Watermill
1. Built | Realized	2. Non-certified	[…]		[…]	Europe [Diverse locations: Portugal, Spain, Netherlands, etc.	2. Europe-Africa-Middle East	13. Infrastructure	4. Ensemble	3. Non-urban	http://en.wikipedia.org/wiki/Windmill
1. Built | Realized	2. Non-certified	[…]		Japan […]	Tokyo [Diverse locations]	3. S and E Asia-Oceania	15. Detail	1. Component	1. Urban	JONAS: 2008
1. Built | Realized	2. Non-certified	[…]		Spain	Seville	2. Europe-Africa-Middle East	1. Residential	2. Building	1. Urban	http://es.wikipedia.org/wiki/Reales_Alc%C3%A1zares_de_Sevilla http://en.wikipedia.org/wiki/Alc%C3%A1zar_of_Seville
1. Built | Realized	2. Non-certified	[…]		Phillipines […]	Coron [Diverse locations in East Asia, etc.]	3. S and E Asia-Oceania	1. Residential	4. Ensemble	3. Non-urban	http://archive.unu.edu/unupress/unupbooks/80607e/80607E09.htm http://www.pcsd.ph/protected_areas/coron.htm http://pcij.org/stories/1998/coron.html http://www.jacobimages.com/2012/04/coron-and-the-calamian-tagbanua
1. Built | Realized	2. Non-certified	[…]		U. S. A.	Mesa Verde National Park, Colorado	1. America-Pacific	1. Residential	4. Ensemble	3. Non-urban	HOSEY: 2012 http://commons.wikimedia.org/wiki/File:Cliff_Palace_Mesa_Verde_National_Park_Colorado_USA.JPG http://en.wikipedia.org/wiki/Mesa_Verde_National_Park
1. Built | Realized	2. Non-certified	[…]		Turkey	Göreme National Park, Cappadocia	2. Europe-Africa-Middle East	1. Residential	4. Ensemble	2. Sub-urban	http://secondglobe.com/item/cave-dwellings-of-cappadocia-turkey/ http://en.wikipedia.org/wiki/Cappadocia
1. Built | Realized	2. Non-certified	[…]		Iceland	Diverse locations	2. Europe-Africa-Middle East	1. Residential	2. Building	3. Non-urban	http://en.wikipedia.org/wiki/Icelandic_turf_house http://whc.unesco.org/en/tentativelists/5589
1. Built | Realized	2. Non-certified	[…]		New Caledonia	Tinu Peninsula, Nouméa	3. S and E Asia-Oceania	3. Cultural	2. Building	3. Non-urban	http://en.wikipedia.org/wiki/Jean-Marie_Tjibaou_Cultural_Centre http://inhabitat.com/jean-marie-tjibaou-cultural-center-inspired-by-native-architecture/ http://www.rpbw.com/project/41/jean-marie-tjibaou-cultural-center/
2. Unbuilt | Plan	2. Non-certified	[…]		U. S. A.	New York [Harbor]	1. America-Pacific	7. Public Space	5. Plan	1. Urban	HOSEY: 2012 http://www.palisadebay.org.pdf http://greensource.construction.com/news/2012/11/121105-in-sandys-wake-revisiting-momas-prescient-rising-currents-exhibition.asp
2. Unbuilt | Plan	2. Non-certified	[…]		U. S. A.	New York	1. America-Pacific	4. Mixed Use	5. Plan	1. Urban	HOSEY: 2012 http://nycsteadystate.tumblr.com/
1. Built | Realized	2. Non-certified	[…]		Portugal	Lisbon	2. Europe-Africa-Middle East	13. Infrastructure	2. Building	1. Urban	http://www.adp.pt/content/index.php?action=detailfo&rec=2793&t=Reservatorio-Mae-dAgua-das-Amoreiras--Lisboa http://pt.wikipedia.org/wiki/Reservat%C3%B3rio_da_M%C3%A3e_d'%C3%81gua_das_Amoreiras
1. Built | Realized	2. Non-certified	[…]		Japan	Atsugi, Kanagawa	3. S and E Asia-Oceania	2. Educational	2. Building	2. Sub-urban	ISHIGAMI: 2008 p. 28-37 http://www.archdaily.com/66661/66661/ http://www.designboom.com/architecture/junya-ishigami-kait/
1. Built | Realized	2. Non-certified	[…]		U. S. A.	Diverse locations [Testbed Site: Public Safety Answering Center II, Bronx, New York. 2015]	1. America-Pacific	15. Detail	1. Component	1. Urban	LOVELL: 2010 http://imaginationforpeople.org/en/project/active-phytoremediation-wall-system/ http://www.architectmagazine.com/green-technology/green-wall-systems-active-phytoremediation-wall-system.aspx
2. Unbuilt | Plan	2. Non-certified	[…]		Japan	Tokyo	3. S and E Asia-Oceania	1. Residential	2. Building	1. Urban	ISHIGAMI: 2008 p.54-59
2. Unbuilt | Plan	2. Non-certified	[…]		[…]	Non specified [Europe]	2. Europe-Africa-Middle East	1. Residential	1. Component	1. Urban	RESTANY: 2002 http://www.hundertwasser-haus.info/en/blog/2011/07/19/the-house-should-not-be-measured-by-normal-standards/

CODE	Project Name	Author	Year	Periodization	Ti[L]es Matrix {relevant reference correlations}					Ecosystem Integration | Description
121	House Hundertwasser	**Hundertwasser** **+ co-author Josef Krawina, architect**	1985	2. Post-Modern	Structure stability and design Concept originality, innovation and creativity	A23 A13	►	E2	Photosynthesis and primary production	green roofs, green balconies, climbing plants walls, concept
122	Thermal Village Blumau - Rolling Hills	**Hundertwasser** **+ Planning: Architect Peter Pelikan**	1997	1. Contemporary	Structure stability and design Economic dynamics and lifecycle costs	A23 A11	► ◄	E15	Leisure, recreation and psychophysical health	green roofs that connect with the floor, architecture mixed with topography
123	Roppongi Nouen Farm	**On Design**	2010	1. Contemporary	Visual	A14	◄	E10	Food supply	urban farm display and restaurant, economy, community
124	City Farm	[City Farm]	~ 2012	1. Contemporary	Exterior areas and local pollution control	A7	◄	E10	Food supply	rooftop urban farm, with fruits, vegetables and rice cultivation, and rentable lots; climate regulation with evapotranspiration
125	Ginza Honeybee Project	[Ginza Honeybee Project]	~ 2006	1. Contemporary	Sustainable life-style support systems	A8	◆	E8	Biological control & pollination	rooftop garden and bee hive, honey production ["with a range of about 4 kilometers in any direction, the bees are surely helping out plants all over town."] harvested by nonprofit group's volunteers and sold to local restaurants and shops
126	Habitat 67	**Moshe Safdie**	1967	2. Post-Modern	Customization possibilities and operation Structure stability and design	A9 A23	◆ ►	E14 E9 E15	Landscape aesthetic fruition Perceptive environmental modulation Leisure, recreation and psychophysical health	low income and affordable housing (initial target), with privately own green rooftops and balconies
127	Tassafaronga Village	**David Baker Architects** [Landscape: PGA Design]	2010	1. Contemporary	Execution quality and process management	A22	►	E7	Erosion control and hazard protection	remediation of soil, green water infrastructure; affordable housing; solar power for on-site generation of electricity and hot water; renovation/refurbishment of some existing building; integration of habitat for humanity housing [with participation in construction by future residents]; local community farm; erosion control during construction, drought tolerant plants, permeable lot,
128	Sierra Bonita Apartments	**Tighe Architecture**	2010	1. Contemporary	Adequacy to function, occupancy and circulation	A20	◆	E6	Climatic regulation	affordable green housing for people with disabilities, internal courtyard (with bamboo forest). eccentric brace frame core that is a fundamental structural component expressed as a five-story organic garden lattice; passive design [solar orientation, and natural ventilation]
129	Bloom [Aquatic Farm]	**Sitbon Architectes**	2011	1. Contemporary	Energy cycle [and atmospheric emissions]	A4	◆	E3 E2 E11	Nutrient cycling and waste treatment Photosynthesis and primary production Water purification and fresh water supply	geoengineering, conceptual phytoplankton farm, science monitoring, nutrient cycling, absorb C02 excesses and create 02.
130	Dormitories for ITRI Southern Taiwan Campus	**Bio-Architecture Formosana**	2010	1. Contemporary	Exterior areas and local pollution control Adequacy to function, occupancy and circulation	A7 A20	◆	E4 E6	Water cycling and regulation Climatic regulation	pond in the courtyard to adjust the micro-climate and co-work with a nearby retention pool, bamboo forest and use of bamboo in construction; locally produced brick; application of bamboo ranges from planting to architectural elements like exterior screening of the staircase, soft partition in the entrance area, and in the courtyard to define the outdoor corridor.
131	HK Farm / HK Honey	**Michael Leung** [HK Farm/ HK Honey]	2012	1. Contemporary	Community participation and user's satisfaction	A10	◆	E8	Biological control & pollination	rooftop farming, bee farming with native species, community and creativity-artistic engagement, production of workshops, learning and creative activities
132	Dakakker Shieblock	**ZUS [Zones Urbaines Sensibles]** in collaboration with: Stadsinitiatief Rotterdam, the 5th IABR, Binder Groenprojecten, Rotterdams Milieucentrum and the municipality of Rotterdam	2012	1. Contemporary	Economic dynamics and lifecycle costs Transports and functional articulation w/ context	A11 A3	◄ ◆	E10	Food supply	reclaimed building, green urban farm rooftop [vegetables, herbs, and apiculture], sells to local restaurants and shops
133	*Garden in a Sack* Project	**NGO Solidarités**	2007	1. Contemporary	Human health and well being Community participation and user's satisfaction Economic dynamics and lifecycle costs	A12 A10 A11	◄	E10	Food supply	social practices, reducing life cycle costs and providing income and wellbeing through food production. "6000 families were given sacks filled with earth (...) producing tomatoes, onions, kales or spinach. A nursery was established in the slum to supply the initial seedlings while a group was assembled to train the project's beneficiaries. On average, it was estimated that each household increased its weekly income by 5.00 US$ " (aproximately the value of monthly rent)
134	Brooklyn Grange	[Brooklyn Grange]	2009	1. Contemporary	Materials cycle [and waste] Transports and functional articulation w/ context	A6 A3	◆ ◆	E1 E2 E10	Soil formation and fertility Photosynthesis and primary production Food supply	large extension urban rooftop farming: vegetables, egg-laying chickens, apiary, mushrooms; production of compost through collection of organic waste, wood chips and shavings
135	Lufa Farms	[Lufa Farms]	2011	1. Contemporary	Sustainable life-style support systems Economic dynamics and lifecycle costs	A8 A11	◆ ◄	E8	Biological control & pollination	urban rooftop greenhouse farming, water conservation [rain water collection and recirculation of 100% of irrigation water, nutrient saving], biological pest control, energy saving, composting; reduction of transportation needs (food mileage); no pesticides, fungicides or herbicides
136	FSMA Tower	**Dave Edwards**	2011	1. Contemporary	Human health and well being	A12	◄	E2	Photosynthesis and primary production	conceptual skyscraper, green wall used for food and improving air quality, with algae absorbing CO2 emissions and also harvested as bio-methane to provide heat and power, waste water would be sent through the algae to be recycled. ground source heat pump would store summer heat and enable surplus heat from the waste biomass and from London Underground to be circulated through the tower in the winter.
137	Symbiotic Office	**Richard Black**	2012	1. Contemporary	Human health and well being	A12	◄	E12	Raw materials, ornamental and medicinal resources	orchid farm [indoor garden and nursery] mixed with office space, ornamental, diferentiation of spaces, psico-physical health
138	Dailai Conference Hall	**Vo Trong Nghia**	2012	1. Contemporary	Sense of place and cultural identity	A2	◄	E12	Raw materials, ornamental and medicinal resources	use of local materials (local stone, fast growing bamboo, thatch: abundant natural resources near the area); soft (pervious) landscaping materials; integration in the landscape, wall support for climbing plants
139	Trees Building for ABBANK	**Vo Trong Nghia**	2012	1. Contemporary	Structure stability and design	A23	►	E12	Raw materials, ornamental and medicinal resources	integration of trees in the façade-terrace like, greenroof (150 % more trees into the facade of the building than would be able to grow on a comparable piece of flat land), integration of tree pits into large structural columns to allow more root space
140	Edge Hill Halls of Residence	**Maria-Cristina Banceanu**	2010	1. Contemporary	Sense of place and cultural identity	A2	◆	E5	Biodiversity and nursery habitats	biodiversity habitats in building fabric and landscape, reconversion of abandoned rail site, rainwater collection and filtering, waste water onsite treatment, noise and pollution mitigated by bund area raised around the student housing, local native vegetation with little maintenance requirements. biodiverse green roofs and green terraces, swifts and swallows nesting boxes in the facades, space for owls refuge in roof, and bat boxes at top of chimneys.

Concretization	Environmental Assessment	Method	Rating	Country	Location	Geographic Cluster	Use | Function	Scale	Context	Sources
1. Built | Realized	2. Non-certified	[…]		Austria	Viena	2. Europe-Africa-Middle East	1. Residential	2. Building	1. Urban	http://www.hundertwasser-haus.info/en/ http://en.wikipedia.org/wiki/Hundertwasserhaus
1. Built | Realized	2. Non-certified	[…]		Austria	Blumau, Estiria	2. Europe-Africa-Middle East	11. Tourism	4. Ensemble	3. Non-urban	http://www.hundertwasser.at/english/oeuvre/arch/arch_rogner-bad.php http://www.hundertwasser.com/arch/view-100 http://www.austria.info/uk/discover/rogner-bad-blumau-1682426.html
1. Built | Realized	2. Non-certified	[…]		Japan	Tokyo, Roppongi	3. S and E Asia-Oceania	5. Commercial	2. Building	1. Urban	http://www.projectnoen.com/ http://www10.aeccafe.com/blogs/arch-showcase/2011/04/20/roppongi-nouen-farm-in-tokyo-japan-by-on-design/ http://becomingadesigner.blogspot.jp/2012/11/roppongi-nouen-tokyo.html
1. Built | Realized	2. Non-certified	[…]		Japan	Tokyo, Odaiba [on top of DiverCity Tokyo Plaza]	3. S and E Asia-Oceania	9. Agriculture	1. Component	1. Urban	http://www.city-farm.jp/ http://en.rocketnews24.com/2013/09/01/green-tokyo-5-cool-examples-of-urban-agriculture/
1. Built | Realized	2. Non-certified	[…]		Japan	Tokyo, Ginza	3. S and E Asia-Oceania	9. Agriculture	1. Component	1. Urban	https://www.facebook.com/ginzamitsubachi/photos_stream http://en.rocketnews24.com/2013/09/01/green-tokyo-5-cool-examples-of-urban-agriculture/
1. Built | Realized	2. Non-certified	[…]		Canada	Montreal	1. America-Pacific	1. Residential	4. Ensemble	1. Urban	http://inhabitat.com/habitat-67-montreals-prefab-pixel-city/habitat67-7/ http://en.wikipedia.org/wiki/Habitat_67 http://www.e-architect.co.uk/montreal/habitat-67 http://www.msafdie.com/#/projects/habitat67
1. Built | Realized	1. Certified	LEED for Neighborhood Dev. LEED for Homes	Gold Platinum	U. S. A.	Oakland, California	1. America-Pacific	1. Residential	4. Ensemble	2. Sub-urban	http://greensource.construction.com/green_building_projects/2011/1102_Tassafaronga_Village.asp http://www.dbarchitect.com/project_detail/2/Tassafaronga%20Village.html http://www.dbarchitect.com/project_detail/2/Tassafaronga%20Village.html#project_details
1. Built | Realized	1. Certified	[Pilot project for the City of West Hollywood's new Green Building Ordinance]		U. S. A.	West Hollywood, California	1. America-Pacific	1. Residential	2. Building	2. Sub-urban	http://www.tighearchitecture.com/#!sierrabonita/c1552 http://inhabitat.com/west-hollywoods-stylish-green-low-income-housing/new-8-69/ http://www.archiplanet.org/wiki/Sierra_Bonita_Affordable_Housing,_West_Hollywood,_California
2. Unbuilt | Plan	2. Non-certified	[…]		[…]	[Diverse locations: Indian Ocean]	3. S and E Asia-Oceania	4. Mixed Use	2. Building	3. Non-urban	http://www.treehugger.com/green-architecture/bloom-phytonplankton-farm-regulate-sea-oxygen-carbon-dioxide-sitbon-architectes.html http://architizer.com/projects/bloom-aquatic-farm/media/385445/
1. Built | Realized	2. Non-certified	[…]		Taiwan	Liujia District	3. S and E Asia-Oceania	1. Residential	2. Building	3. Non-urban	http://www.archdaily.com/311890/dormitories-for-itri-southern-taiwan-campus-bio-architecture-formosana/ http://www.bioarch.com.tw/
1. Built | Realized	2. Non-certified	[…]		China	Hong Kong	3. S and E Asia-Oceania	9. Agriculture	1. Component	1. Urban	http://www.hkfarm.org/home.html http://www.hkhoney.org/us.html http://popupcity.net/top-5-of-the-greatest-urban-rooftop-farms/
1. Built | Realized	2. Non-certified	[…]		Netherlands	Rotterdam	2. Europe-Africa-Middle East	9. Agriculture	1. Component	1. Urban	http://popupcity.net/top-5-of-the-greatest-urban-rooftop-farms/ http://2012.iabr.nl/EN/news/120918_GreenBuildingAward.php http://www.foodurbanism.org/dakakker-urban-rooftop-farm/
1. Built | Realized	2. Non-certified	[…]		Kenya	Kibera slum, Nairobi	2. Europe-Africa-Middle East	9. Agriculture	1. Component	2. Sub-urban	http://www.foodurbanism.org/bagsack-gardens/
1. Built | Realized	2. Non-certified	[…]		U. S. A.	New York	1. America-Pacific	9. Agriculture	1. Component	1. Urban	http://brooklyngrangefarm.com/about/ http://popupcity.net/top-5-of-the-greatest-urban-rooftop-farms/ http://www.foodurbanism.org/brooklyn-grange-2/1039-brooklyn-grange/
1. Built | Realized	2. Non-certified	[…]		Canada	Montreal	1. America-Pacific	9. Agriculture	1. Component	1. Urban	http://montreal.lufa.com/en/about-the-farm
2. Unbuilt | Plan	2. Non-certified	[…]		U. K.	London	2. Europe-Africa-Middle East	4. Mixed Use	2. Building	1. Urban	http://www.dezeen.com/2012/08/01/fsma-tower-by-dave-edwards/
2. Unbuilt | Plan	2. Non-certified	[…]		U. K.	London	2. Europe-Africa-Middle East	6. Offices	2. Building	1. Urban	http://www.dezeen.com/2012/07/11/the-symbiotic-office-by-richard-black/
1. Built | Realized	2. Non-certified	[…]		Vietnam	Ngọc Thanh, Phúc Yên, near Dailai lake	3. S and E Asia-Oceania	11. Tourism	2. Building	3. Non-urban	http://inhabitat.com/vo-trong-nghias-gorgeous-dai-lai-resort-is-made-from-local-stone-and-bamboo/ http://votrongnghia.com/projects/dailai-conference-hall/
2. Unbuilt | Plan	2. Non-certified	[…]		Vietnam	Danang	3. S and E Asia-Oceania	6. Offices	2. Building	1. Urban	http://inhabitat.com/vo-trong-nghia-architects-to-build-vertical-forest-office-building-in-vietnam/trees-building-2/?extend=1 http://www.archdaily.com/335675/trees-building-for-abbank-proposal-vo-trong-nghia-architects/ http://votrongnghia.com/projects/abbank/
2. Unbuilt | Plan	2. Non-certified	[…]		U. K.	Liverpool	2. Europe-Africa-Middle East	1. Residential	4. Ensemble	2. Sub-urban	GRANT: 2012 http://ihdc.org.uk/#/resources/4561950846 http://maria-cristinabanceanu.blogspot.pt/p/competitions.html IHDC 2010 Competition Booklet

CODE	Project Name	Author	Year	Periodization	Ti[L]es Matrix {relevant reference correlations}					Ecosystem Integration | Description
141	Matripolis	Paul Jones & David Dobereiner	2010	1. Contemporary	Sustainable life-style support systems Transports and functional articulation w/ context	A8 A3	◆ ▶	E14 E15	Landscape aesthetic fruition Leisure, recreation and psychophysical health	green roofs, domestic waste recycle and compost, food production in roofs and greenhouses, reuse of regional traditional form/adaptation to topography (the terrace house), energy from hydroturbines in adjacent river, light mobility transport within site, reconversion of brownfield site, interconnected multilevels networks of wildlife, compact building solution
142	Happy Habitats	Buro Happold & Grant Associates [Phil Hampshire, Katherine Sydney, Aylin Ludwig, Laura Crawford, Celia Way, Victoria Wilson & Tamasine Scott]	2010	1. Contemporary	Community participation and user's satisfaction Sustainable life-style support systems	A10 A8	◆ ◆	E10 E2	Food supply Photosynthesis and primary production	food production, community involvement with the environment, liveability and biodiversity, greenroofs, vertical garden and climbing wall, multifunctional approach
143	Shrubhill Works	Michael Bryan	2011	1. Contemporary	Sustainable life-style support systems Transports and functional articulation w/ context	A8 A3	◆ ◆	E4 E9	Water cycling and regulation Perceptive environmental modulation	sustainable lifestyle and social interaction encouraged by communal shared facilities, development on brownfield, onsite waste and wastewater treatment, use of permaculture principles, connection with macroscale eco corridors, and sustainable transport, renovation and retrofit of existing housing, greenroofs with food and bee-keeping, bat spiral, wind and noise break with seminatural area available for foraging
144	Neepsend	Radu Costin Sava & Xiao Guo	2011	1. Contemporary	Adaption to eco-physical values and restraints	A1	▶	E6	Climatic regulation	reconversion of industrial site area to biodiverse landscape, job opportunities in agriculture, green network and ecological corridor for local threatned bird species, greenroofwalls, fusion of building with landscape architecture, improvement of drainage and microclimate
145	Rehabilitation	Architecture for Change with Chloe Rayfield & Cristina Blanco	2011	1. Contemporary	Economic dynamics and lifecycle costs Customization possibilities and operation	A11 A9	▶ ▶	E5 E13	Biodiversity and nursery habitats Significant species and ecosytem values	rehabilitation of existing built stock, and incorporation of several strategies for urban wildlife habitats and biodiversity. Low budget version and sky-thinking version
146	Sharp Centre for Design	Alsop Architects	2004	1. Contemporary	Adequacy to function, occupancy and circulation	A20	▶ ◆	E15 E14	Leisure, recreation and psychophysical health Landscape aesthetic fruition	elevated building above ground, with production of shadow and release of the soil surface, allowing "for the creation of a new outdoor public space to the south of the existing building, and provided pedestrian access from the street to the existing park to the west, while preserving views for the condominium residents to the east of the college." (inspiration/analogy from trees)
147	World Birding Center Headquarters	Lake Flato Architects	2004	1. Contemporary	Sense of place and cultural identity Water cycle [and effluents] Exterior areas and local pollution control	A2 A5 A7	◆◆ ▶	E4 E8 E5 E13	Water cycling and regulation Biological control & pollination Biodiversity and nursery habitats Significant species and ecosytem values	rainwater harvesting and use of irrigation of gardens, ponds-swamps, courtyard-like setting with courtyards for habitat observation; on previously developed land; forms, systems, and materials relate to the agricultural vernacular, which dominates the valley's architectural landscape; only native plants
148	Somis Hay Barn	Studio Pali Fekete Architects	2004	1. Contemporary	Visual Humidity and temperature	A14 A19	◀	E12	Raw materials, ornamental and medicinal resources	thermal control with material resources [hay blocks], as cladding material, and visual/conceptual quality
149	Dutch Embassy, Warsaw	Erick van Egeraat Associate Architects	2004	1. Contemporary	Visual	A14	◀	E14	Landscape aesthetic fruition	inspiration into ornamental and functional form [fence for protection], preservation of most of existing trees, public courtyard with views of the surrounding landscape
150	Kurimoto Millennium City	Hiroshi Iguchi / Fifth World Architects	2005	1. Contemporary	Community participation and user's satisfaction	A10	◆	E6	Climatic regulation	sustainable communities eco-villages integrating urban areas, farmlands and forests. self-supporting renewable energy system and 50% self-sufficient food system. water heating system using plastic bottles, biotope to purify the effluent water from the sewage treatment tank, summer cooling and winter warming environment provided by tall deciduous trees around the houses. community currency earned through volunteer activities.
151	Tokyo Plan 2107	Terunobu Fujimori	2001	1. Contemporary	Materials cycle [and waste] Details and finishes	A3 A21	◀	E2 E12	Nutrient cycling and waste treatment Raw materials, ornamental and medicinal resources	future scenario where Tokyo is covered by water: CO2 present in the atmosphere stabilized in two ways: made into coral by the action of coral polyps in the ocean and turned into wood by photosynthesis. the proposal called for new cities to be built in place of the old cities that are now under water using these two materials (wood + coral lime stucco). coral made into stucco and applied on the buildings
152	Willow School	Farewell Architects [consultants: Regenesis] [landscape architecture: Back to Nature]	2003 - [...]	1. Contemporary	Economic dynamics and lifecycle costs Execution quality and process management	A11 A22	◀ ◆	E11 E6	Water purification and fresh water supply Climatic regulation	public participation charrettes. soil regeneration, replanting native plants. constructed wetland for wastewater and stormwater treatment; permeable paving, living roofs, bio swales and adapted species plantings to reduce runoff; rainwater collection for irrigation and toilet water supply, wastewater onsite recyclage reducing operation costs; passive solar design, diverse wildlife habitats, high albedo surfaces reflecting solar heat gain; school furniture from onsite harvested trees
153	Brattleboro Coop	Natural Logic [Regenesis]	2003 - 2006	1. Contemporary	Transports and functional articulation w/ context	A3	◆	E10	Food supply	program/brief reformulation and negotiation [decision not to build but take other measures]; application of story of the place process, locally-sourced food production capability, energy assessment and strategy, reduction of carbon footprint through transport and food production measures; community participation
154	Museum Brandhorst	Sauerbruch Hutton	2008	1. Contemporary	Energy cycle [and atmospheric emissions]	A4	◆	E4	Water cycling and regulation	noise absorption façade; regulation and use of groundwater for cooling/heating [cooled water is returned to the groundwater cycle, thus aleviating the problem of temperature rise of groundwater in urban areas] and reduction of energy consumption/costs; abundant use of natural light
155	Low Cost House	Vo Trong Nghia Architects	2012	1. Contemporary	Visual Lighting Transports and functional articulation w/ context	A14 A17 A3	◀	E12	Raw materials, ornamental and medicinal resources	communal facilities, low cost, natural/local/recyclable fast-growing materials (bamboo), collection of rain water in a pent roof, communal bathrooms and kitchen. transformable space. "dwellers are encouraged to participate in the construction process" steel frame structure, "which is easy to assemble without the use of machines, nor special techniques".
156	Experimental House	Loco Architects Manabu + Nez	2005	1. Contemporary	Materials cycle [and waste]	A6	◀	E12	Raw materials, ornamental and medicinal resources	use of local ramned earth walls generated by site excavation and preparation, that can be simply demolished and returned to the ground when the house becomes redundant. loose arrangement of interconnected spaces. tapering profiles of the walls form a new topography, as if the land has been cut and fashioned by forces of nature, aims to impinge as little as possible on the environment.
157	CH2 [Council House 2]	Mick Pearce + DesignInc	2006	1. Contemporary	Exterior areas and local pollution control Humidity and temperature Human health and well being	A7 A19 A12	◀	E9	Perceptive environmental modulation	biomimicry. designed to be a holistic system with its occupants as participants. passive energy systems. literal and metaphorical expressions of environmental intentions. façades that moderate climate, tapered ventilation ducts integrate with daylighting strategies ; north green wall with lateral landscape planters protecting from low angle sun, overheating, and glare, and providing healthy interaction with nature and evocative undulating concrete floor structure that plays a central role in the building's
158	East Hills Center (of the Universe)	Bazzani and Associates [+ East Hills Council of Neighbors]	2005	1. Contemporary	Water cycle [and effluents] Economic dynamics and lifecycle costs	A5 A11	◆ ◀	E1	Soil formation and fertility	brownfield redevelopment, with soil decontamination, Stormwater Management, extensive greenroof, Social Benefits, Materials Use, Funding Sources, rain garden near parking lot, design charrette. Zero-Stormwater Discharge. Passive Solar Design. Extensive green roof, that helps reduce cooling costs, help extend the life of the roof membrane, and help manage the storm water runoff.
159	Nitshill Integrated Green Infrastructure Design Study	Glasgow & Clyde Valley Green Network, Glasgow City Council, International Resources & Recycling Institute, ERZ Limited and Glasgow EnviroCentre	2012	1. Contemporary	Economic dynamics and lifecycle costs	A11	▶	E13	Significant species and ecosytem values	surface water management, habitat networks, access networks, green and open space, cost-effective stewardship over time. Integrated green infrastructures. Simultaneous urban regeneration and habitat/ecological improvement. realistic and cost-effective project
160	The Hanging Gardens of the Circle Line	Chris Hildrey	2012	1. Contemporary	Transports and functional articulation w/ context Community participation and user's satisfaction	A3 A10	▶ ◀	E5	Biodiversity and nursery habitats	transformation of non used infrastructure (defunct ventilation shafts along London's Circle Line) into species rich habitats. community and potential stakeholders engagement

Concretization	Environmental Assessment	Method	Rating	Country	Location	Geographic Cluster	Use | Function	Scale	Context	Sources
2. Unbuilt | Plan	2. Non-certified	[…]		U. K.	Tyneside	2. Europe-Africa-Middle East	1. Residential	5. Plan	2. Sub-urban	GRANT: 2012 http://ihdc.org.uk/#/resources/4561950846 IHDC 2010 Competition Booklet
2. Unbuilt | Plan	2. Non-certified	[…]		U. K.	Bath	2. Europe-Africa-Middle East	4. Mixed Use	4. Ensemble	2. Sub-urban	GRANT: 2012 http://ihdc.org.uk/#/resources/4561950846 http://www.metrofieldguide.com/ihdc-2010-happy-habitats/ IHDC 2010 Competition Booklet
2. Unbuilt | Plan	2. Non-certified	[…]		U.K.	Leith, Edinburgh	2. Europe-Africa-Middle East	1. Residential	4. Ensemble	2. Sub-urban	GRANT: 2012 http://ihdc.org.uk/#/resources/4561950846 http://www.creactivistas.com/2012/10/gaia-education-case-studio.html IHDC 2011 Competition Booklet
2. Unbuilt | Plan	2. Non-certified	[…]		U.K.	Sheffield	2. Europe-Africa-Middle East	4. Mixed Use	5. Plan	1. Urban	GRANT: 2012 http://ihdc.org.uk/#/resources/4561950846 IHDC 2011 Competition Booklet
2. Unbuilt | Plan	2. Non-certified	[…]		U. K.	North London	2. Europe-Africa-Middle East	1. Residential	4. Ensemble	2. Sub-urban	GRANT: 2012 http://ihdc.org.uk/#/resources/4561950846 http://www.architectureforchange.com/projects.html IHDC 2011 Competition Booklet
1. Built | Realized	2. Non-certified	[…]		Canada	Toronto	1. America-Pacific	2. Educational	2. Building	1. Urban	BAHAMÓN, PÉREZ, CAMPELLO: 2006 http://www.designbuild-network.com/projects/sharpe-centre/
1. Built | Realized	2. Non-certified	[…]		U.S. A.	Mission, Texas	1. America-Pacific	3. Cultural	2. Building	3. Non-urban	BAHAMÓN, PÉREZ, CAMPELLO: 2006 http://www.lakeflato.com/projects/world-birding-center/ http://www.aiatopten.org/node/146
1. Built | Realized	2. Non-certified	[…]		U.S. A.	Somis, Los Angeles, California	1. America-Pacific	9. Agriculture	2. Building	3. Non-urban	BAHAMÓN, PÉREZ, CAMPELLO: 2006 http://spfa.com/projects_residential/somis-hay-barn/
1. Built | Realized	2. Non-certified	[…]		Poland	Warsaw	2. Europe-Africa-Middle East	6. Offices	2. Building	1. Urban	BAHAMÓN, PÉREZ, CAMPELLO: 2006 http://www.architektura.net/a/ambasada/index.html http://poland.nlembassy.org/organization/the-building
1. Built | Realized	2. Non-certified	[…]		Japan	Chiba	3. S and E Asia-Oceania	1. Residential	4. Ensemble	3. Non-urban	http://www.japanfs.org/en/news/archives/news_id029080.html http://www.dwell.com/green/article/low-tech-utopia http://www.fifthworld-inc.com/main_menu/house_forestry.html
2. Unbuilt | Plan	2. Non-certified	[…]		Japan	Tokyo	3. S and E Asia-Oceania	4. Mixed Use	5. Plan	1. Urban	FUJIMORI: 2007 http://www.operacity.jp/ag/exh82/e/exhibition/02.html
1. Built | Realized	1. Certified	LEED [New Construction] LEED [New Construction]	**Gold** (phase 1) **Platinum** (phase 2 and 3)	U. S. A.	Gladstone, Bedminster, New Jersey	1. America-Pacific	2. Educational	2. Building	2. Sub-urban	http://www.farewell-architects.com/WILLOW.htm http://www.globallearningnj.org/WillowSchool.pdf http://regenerationalliance.com/projects/willow-school/ http://www.globallearningnj.org/WillowSchool.pdf http://www.co.somerset.nj.us/planweb/greenbldg/Willow
1. Built | Realized	2. Non-certified	[…]		U. S. A.	Brattleboro, Vermont	1. America-Pacific	5. Commercial	5. Plan	2. Sub-urban	http://www.greenrightnow.com/keye/2010/02/15/beyond-green-buildings-sustainable-communities/2/ http://regenerationalliance.com/projects/brattleboro-food-co-op/ http://www.brattleborofoodcoop.com
1. Built | Realized	2. Non-certified	[…]		Germany	Munich	2. Europe-Africa-Middle East	3. Cultural	2. Building	1. Urban	http://www.archdaily.com/36193/brandhorst-museum-sauerbruch-hutton/ http://www.mimoa.eu/projects/Germany/Munich/Museum%20Brandhorst http://www.museum-brandhorst.de/en/building/architecture.html
1. Built | Realized	2. Non-certified	[…]		Vietnam	Dong Nai	3. S and E Asia-Oceania	1. Residential	2. Building	1. Urban	http://www.archdaily.com/307274/low-cost-house-vo-trong-nghia-architects/ http://votrongnghia.com/projects/low-cost-house/
1. Built | Realized	2. Non-certified	[…]		Japan	Tsukuba, Ibaraki	3. S and E Asia-Oceania	1. Residential	2. Building	3. Non-urban	http://arquitecologia.org/loco_highc.htm LOTUS INTERNATIONAL, 140; 93, 2009
1. Built | Realized	1. Certified	Green Building Council of Australia	**6 STARS**	Australia	Melbourne	3. S and E Asia-Oceania	6. Offices	2. Building	1. Urban	http://www.melbourne.vic.gov.au/sustainability/ch2/Pages/CH2Ourgreenbuilding.aspx http://en.wikipedia.org/wiki/Council_House_2 http://www.archdaily.com/395131/ch2-melbourne-city-council-house-2-designinc/
1. Built | Realized	1. Certified	LEED - CS LEED - CI	**Gold** **Gold**	U. S. A.	Grand Rapids, Michigan	1. America-Pacific	5. Commercial	2. Building	2. Sub-urban	ACUFF et al: 2005 http://www.bazzani.com/projects/ http://www.greenroofs.com/projects/pview.php?id=658
2. Unbuilt | Plan	2. Non-certified	[…]		U. K.	Nitshill, southwest Glasgow	2. Europe-Africa-Middle East	4. Mixed Use	5. Plan	2. Sub-urban	http://www.gcvgreennetwork.gov.uk/220-integrating-green-infrastructure-design-study-nithsill-south-west-glasgow http://iale.org.uk/autumn-2012/news/554 http://issuu.com/gcvgreennetworkpartnership/docs/integrating_green_infrastructure_de/19?e=0/7720673
2. Unbuilt | Plan	2. Non-certified	[…]		U. K.	London	2. Europe-Africa-Middle East	7. Public Space	3. Land Unit	1. Urban	http://www.chrishildrey.com/skill-type/architecture/

CODE	Project Name	Author	Year	Periodization	Ti[L]es Matrix {relevant reference correlations}					Ecosystem Integration | Description
161	Hotel for Bees *K-abeilles*	AtelierD	2012	1. Contemporary	Visual	A14	◆	E8 E5	Biological control & pollination Biodiversity and nursery habitats	honeycomb installation for bees [micro-habitats for wild bees], and resting-observatory pavillion for humans
162	Cascading Gardens	Ken Rinaldo, art and technology department at Ohio State University's School of Architecture	2013	1. Contemporary	Customization possibilities and operation	A9	◆	E10	Food supply	hydroponics, aquaponics, windowfarming and vermicomposting (compost from worm waste), vegetable growth
163	Bronx Blue-and-Green Roof	NYC Department of Environmental Protection + Osborne Association + Hazen and Sawyer	2013	1. Contemporary	Economic dynamics and lifecycle costs Execution quality and process management	A11 A22	◆ ▶	E4	Water cycling and regulation	integrated blue and green rooftop on existing building, green infrastructure system for stormwater management, improve air quality, and provide habitat for urban beekeeping, (lighter and more cost effective than a traditional green roof), it also insulates the building, reducing heating and cooling costs, and supports the creation of local employment
164	California Academy of Sciences	Renzo Piano	2008	1. Contemporary	Energy cycle [and atmospheric emissions] Durability & maintenance of systems and materials	A4 A24	◀ ◆	E1 E2 E5	Soil formation and fertility Photosynthesis and primary production Biodiversity and nursery habitats	undulating green roof, conservation of existing building structures [planetarium, a rain forest habitat, aquarium, and exhibition spaces]. native species, with no extra maitenance or water need, habitat conditions for local biodiversity, planted roof superior thermal insulating layer, prevention of pollutant runoff water into the ecosystem (nitrate wastes purified with natural systems, ensuring that aquarium water can be recycled), 20 tons of greenwaste recycled on site.
165	The Allotment	Dean Moran	2013	1. Contemporary	Concept originality, innovation and creativity	A13	◆	E10	Food supply	hotel and restaurant with food production in every surface, engagement of the guests on food production, modular façade, food market, allotment garden rooftop, generator of social interaction and user participation
166	Green Screen Home	Hideo Kumaki Architect Office	2012	1. Contemporary	Lighting Other senses: olfaction, tactility, motion perception Sense of place and cultural identity	A17 A16 A2	◀ ◆	E9 E6	Perceptive environmental modulation Climatic regulation	comtemporary version of climbing plants wall, microclimate regulation, shadow and light modulation, etc, natural ventilation, use of local cultural significant ecosystem integration
167	Green Float	Shimizu Corporation	2010 [for 2025]	1. Contemporary	Exterior areas and local pollution control Energy cycle [and atmospheric emissions]	A7 A4	◆ ◀	E2 E15	Photosynthesis and primary production Leisure, recreation and psychophysical health	floating mega-city, carbon negative (through efficiency, forest and ocean carbon sequestration), food self sufficiency (mega urban vertical farm), purifying and waste removal from ocean waters, energy self sufficiency from renewable sources, artificial ecosystems (terrestrial and marine forests, beach): recreation and nature proximity; biobusinesses: farming, medicinal (pharmaceuthical, cosmetic, etc), structural materials from magnesium alloys whose primary raw material is sea water.
168	Phoenix Garden	Covent Garden Open Spaces Association [neighborhood community initiative]	1984	2. Post-Modern	Community participation and user's satisfaction	A10	◆ ◆	E5 E15	Biodiversity and nursery habitats Leisure, recreation and psychophysical health	community participation, exterior areas, pond, compost bay, etc, biodiversity and habitats, and polinnation, leisure and recreation, waste and material recycling, minimal intervention needs (water, pest and weed control, waste), reclamation of war-damaged vacant lots
169	Patio de los Naranjos [orange patios] in Andalusia	[unknown]	~10-12th century	3. Pre-Modern	Details and finishes	A21	◆	E4	Water cycling and regulation	tree pits designed to receive storm water runoff, and excess water flowing redirection to surface channels
170	Moos Water filtration plant [Seewasserwerk Moos Wollishofen]	[Zurich Wasserwerk] [unknown]	1914	3. Modern	Durability & maintenance of systems and materials	A24	◀	E1	Soil formation and fertility	protection and maintenance long cycle of building materials through a layer of gravel and local soil [green roof] that protected for around 90 years the asphalt covered concrete roofs, and also help insulate the interior of the building, decrease indoor temperature and prevent the growth of pathogenic criteria into the water, water cleaning, develop of unique and rare flora biodiversity
171	Pine Grove Park Pavillion 7191[Cyanophyta Algae in Tetuan]	amid.Cero9 [Cristina Díaz Moreno + Efrén García Grinda]	2008	1. Contemporary	Details and finishes	A21	▶	E9	Perceptive environmental modulation	pavillion with air purification façade, metaphor, biomimicry, light filtration, crops of Spirulina platensis microalgae, a species that produces large amounts of oxygen, humidifies, oxygenises and purifies the air inside the pavilion naturally
172	The Magic Mountain - Ecosystem Mask for Ames Thermal Power Station	amid.Cero9 [Cristina Díaz Moreno + Efrén García Grinda]	2002	1. Contemporary	Concept originality, innovation and creativity Other senses: olfaction, tactility, motion perception	A13 A16	◆	E8	Biological control & pollination	"remediation" of existing industrial structure, with a membrane of roses, lights and honeysuckle shrouding, potentially atracting butterflies and providing rest spaces for migratory birds
173	Charles David Keeling Apartments	KieranTimberlake Associates	2011	1. Contemporary	Transports and functional articulation w/ context Water cycle [and effluents]	A3 A5	◆ ▶	E14 E7	Landscape aesthetic fruition Erosion control and hazard protection	residence with attractive views, and in close proximity to core academic buildings, reducing transport needs. apartments standing among eucalyptus trees on campus edge, overlooking La Jolla coastal cliffs. water-efficient landscaping and plumbing address water scarcity, and onsite greywater recycling system provides irrigation for landscape and green roof.cooling strategy that takes advantage of coastal breezes. solar heat gain controlled with deep overhangs and shading.
174	Special NO 9 House	KieranTimberlake Associates / John C. Williams Architects	2009	1. Contemporary	Customization possibilities and operation	A9	◆ ▶	E9 E2	Perceptive environmental modulation Photosynthesis and primary production	environmentally sensitive housing for hazard preparedness, rainwater collection, sustainable waterdrainage. community participation to rebuild ravaged neighborhoods. optional customization possibilities, as occupant-controlled external shading devices, vine trellis, providing natural aesthetic resource, moderate urban surroundings, protection from excessive glare from low western sun and climate regulation . "The structure and organization of the house are comparable to the chassis of an
175	Mill Creek Canyon Earthworks	Herbert Bayer	1982	2. Post-Modern	Visual Other senses: olfaction, tactility, motion perception Adaption to eco-physical values and restraints	A14 A16 A1	◆ ◀ ◆ ◆	E7 E1 E15	Erosion control and hazard protection Soil formation and fertility Leisure, recreation and psychophysical health	solution to urban runoff as a storm water retention basin in suburban Seattle. design includes a high berm to prevent erosion and a series of five geometric earth forms to control runoff into Mill Creek Canyon, leisure area, remediation art
176	Les Habitarbres / Vegetal city	Luc Schuiten	~ 2008	1. Contemporary	Humidity and temperature	A19	◀	E9	Perceptive environmental modulation	hybrid of house and tree, with external walls made up of a basic skin of translucent or transparent proteins, inspired by dragonflies' wings, and protected by tree canopies. floor slabs and internal walls of lime stabilised earth reinforced by vegetal structures, creating thermal mass for storing calories and redistributing heat. natural ventilation modelled after termite mounds. illuminated at night by bioluminescence, biomimicry of the procedure used by glow-worms or deep ocean fish
177	The Woven City	Luc Schuiten	~ 2008	1. Contemporary	Materials cycle [and waste]	A6	▶	E13	Significant species and ecosytem values	vegetal mesh produced by a strangler fig tree roots grown around a host tree, offering stable and resistant structure for buildings. outer walls made from biotextiles (as silkworms' cocoons or spiders' webs), semi-transparent and capturing solar power to supply heating and electricity. footbridges overhang the uncultivated plain, allowing soil and water natural cycles. host trees irrigated and nourished by nutrients produced by the decomposition of organic waste.
178	The perfumed jungle	Vincent Callebaut	2007	1. Contemporary	Transports and functional articulation w/ context	A3	▶	E3	Nutrient cycling and waste treatment	new built spaces are auto-sufficient and "produce more energies and biodiversity that they consume". vertical garden terraces, and built towers that capture water from the sea. air purification, management of spaces, low-impact transports
179	Physalia	Vincent Callebaut	2010	1. Contemporary	Details and finishes	A21	▶	E11 E3	Water purification and fresh water supply Nutrient cycling and waste treatment	floating garden, at boat scale, with water cleaning/purification photocalytic materials
180	Tyson Living Learning Center	Hellmuth + Bicknese Architects	2009	1. Contemporary	Adaption to eco-physical values and restraints Details and finishes	A23 A21	◆ ◀	E11 E12	Water purification and fresh water supply Raw materials, ornamental and medicinal resources	sustainable landscaping, conversion of grayfield, potable water provided through rain garden, native species, pervious materials, locally harvested materials, on-site treatment of all water effluents, energy sufficiency. "site has been transformed from a degraded asphalt parking lot to a native landscaped garden replete with pervious concrete, local stone pavers, and a central raingarden"; exterior and interior wood finishes harvested onsite.

Concretization	Environmental Assessment	Method	Rating	Country	Location	Geographic Cluster	Use | Function	Scale	Context	Sources
1. Built | Realized	2. Non-certified	[…]		France	Muttersholtz [Muttersholtz Archi Festival]	2. Europe-Africa-Middle East	8. Pavilion	1. Component	3. Non-urban	http://inhabitat.com/atelierd-builds-a-giant-honeycomb-pavilion-to-attract-bees-humans-alike/ http://www.ajeance.fr/projets/construction-dune-cabane-hotel-a-abeilles-muttersholtz-67/ http://architizer.com/blog/featured-project-human-scale-honeycomb-by-atelierd/#.URJ81Fo4Ja5
1. Built | Realized	2. Non-certified	[…]		[Diverse locations] U. S. A. Russia	[…] Ohio, Ohio State University Pervouralsk	1. America-Pacific	9. Agriculture	1. Component	1. Urban	http://www.treehugger.com/sustainable-product-design/ken-rinaldo-cascading-garden-vermiponics.html http://artsandsciences.osu.edu/news/ken-rinaldo%E2%80%99s-%E2%80%9Ccascading-garden%E2%80%9D-travels-to-russia
1. Built | Realized	2. Non-certified	[…]		U. S. A.	Bronx, New York	1. America-Pacific	15. Detail	1. Component	1. Urban	http://www.hazenandsawyer.com/news/pioneering-blue-and-green-roof-improves-the-health-of-the-east-river-create/ http://inhabitat.com/nyc/osborne-associations-innovative-blue-and-green-roof-brings-urban-beekeeping-to-the-south-bronx/
1. Built | Realized	1. Certified	LEED	[double] Platinum	U. S. A.	California, San Francisco	1. America-Pacific	3. Cultural	2. Building	1. Urban	http://www.archdaily.com/6810/ "California Academy of Sciences / Renzo Piano" 28 Sep 2008. ArchDaily. Accessed 09 Sep 2014. http://greensource.construction.com/projects/2009/03_California-Academy-of-Sciences.asp
2. Unbuilt | Plan	2. Non-certified	[…]		U. S. A.	New York	1. America-Pacific	11. Tourism	2. Building	1. Urban	http://www.deanmoran.com/project_Allotment01.htm http://magazine.tablethotels.com/en/2013/02/rethink-hotels-first-place/ https://www.jovoto.com/projects/rethink-hotels/ideas/21873
1. Built | Realized	2. Non-certified	[…]		Japan	Saitama	3. S and E Asia-Oceania	1. Residential	2. Building	2. Sub-urban	http://www.decorationarticle.com/decorating-inspirations/lovely-green-wall-integrated-in-the-style-of-a-japanese-contemporary-crib/ http://www.archdaily.com/421607/green-screen-house-hideo-kumaki-architect-office/
2. Unbuilt | Plan	2. Non-certified	[…]		Japan	[equatorial] Pacific Ocean	3. S and E Asia-Oceania	4. Mixed Use	5. Plan	3. Non-urban	http://www.shimz.co.jp/english/theme/dream/greenfloat.html
1. Built | Realized	2. Non-certified	[…]		U. K.	London West End	2. Europe-Africa-Middle East	7. Public Space	3. Land Unit	1. Urban	GRANT: 2012 http://www.thephoenixgarden.org/
1. Built | Realized	2. Non-certified	[…]		Spain	Andalusia [Cordoba, Seville..etc.]	2. Europe-Africa-Middle East	7. Public Space	1. Component	1. Urban	GRANT: 2012 http://es.wikipedia.org/wiki/Patio_de_los_Naranjos_(Sevilla)
1. Built | Realized	2. Non-certified	[…]		Switzerland	Zurich, Wollishofen	2. Europe-Africa-Middle East	13. Infrastructure	2. Building	2. Sub-urban	GRANT: 2012 http://www.greenroofs.com/projects/pview.php?id=680 http://de.wikipedia.org/wiki/Seewasserwerk_Moos
2. Unbuilt | Plan	2. Non-certified	[…]		Spain	Madrid, Tetuan	2. Europe-Africa-Middle East	8. Pavilion	2. Building	1. Urban	http://www.cero9.com/amidmagazine/carnal-naps/cyanophyta/
2. Unbuilt | Plan	2. Non-certified	[…]		U. S. A.	Iowa, Ames	1. America-Pacific	13. Infrastructure	1. Component	1. Urban	http://www.cero9.com/amidmagazine/carnal-naps/roses/ https://www.youtube.com/watch?v=6nBI_-1A3Vo
1. Built | Realized	1. Certified	LEED	Platinum	U. S. A.	University of California, La Jolla, San Diego	1. America-Pacific	1. Residential	4. Ensemble	2. Sub-urban	http://kierantimberlake.com/pages/view/21 http://www.aiatopten.org/node/79
1. Built | Realized	1. Certified	LEED	Platinum	U. S. A.	New Orleans	1. America-Pacific	1. Residential	2. Building	2. Sub-urban	http://kierantimberlake.com/pages/view/197 http://www.aiatopten.org/node/108
1. Built | Realized	2. Non-certified	[…]		U. S. A.	Kent, Washington	1. America-Pacific	7. Public Space	3. Land Unit	2. Sub-urban	http://www.sitespecificarts.org/site/mill-creek-canyon-earthwork/
2. Unbuilt | Plan	2. Non-certified	[…]		[…]	Non specified [Europe]	2. Europe-Africa-Middle East	4. Mixed Use	5. Plan	1. Urban	http://www.archiborescence.net/archiborescence/habitarbres.htm http://vegetalcity.net/09.html
2. Unbuilt | Plan	2. Non-certified	[…]		[…]	Non specified [Europe]	2. Europe-Africa-Middle East	4. Mixed Use	5. Plan	1. Urban	http://vegetalcity.net/08.html
2. Unbuilt | Plan	2. Non-certified	[…]		China	Hong Kong	3. S and E Asia-Oceania	4. Mixed Use	5. Plan	1. Urban	http://vincent.callebaut.org/page1-img-hong_kong.html http://www.archello.com/en/project/perfumed-jungle
2. Unbuilt | Plan	2. Non-certified	[…]		Diverse […]	Europe [waterways]	2. Europe-Africa-Middle East	13. Infrastructure	2. Building	1. Urban	http://www.designboom.com/architecture/vincent-callebaut-architectures-physalia-amphibious-garden-to-clean-waterways/
1. Built | Realized	1. Certified	Living Building Challenge 1.3	Certified	U. S. A.	Eureka, Missouri	1. America-Pacific	2. Educational	2. Building	2. Sub-urban	http://www.talkitect.com/2012_09_01_archive.html http://inhabitat.com/three-buildings-achieve-worlds-first-living-building-certification/certified-living-buildings-tyson-living-learning-center-2/ http://living-future.org/case-study/tysonllc

CODE	Project Name	Author	Year	Periodization	Ti[L]es Matrix {relevant reference correlations}					Ecosystem Integration | Description
181	Painters Hall Community Center	Opsis Architecture	2010	1. Contemporary	Durability & maintenance of systems and materials Economic dynamics and lifecycle costs	A24 A11	◄	E12	Raw materials, ornamental and medicinal resources	converting existing building stock. low-cost solutions for energy reduction (natural daylighting and passive cooling). geothermal loop serves the building for highly efficient heating and air conditioning. key pieces of furniture fashioned out of heavy timbers and slabs from trees milled onsite. materials collected from deconstructed buildings onsite, all local native and drought-tolerant species, providing year-round color without the need for irrigation, educational program
182	Edible Garden [Atlanta Botanical Garden]	Tres Fromme + Atlanta Botanical Garden Staff + EDAW Atlanta + Axios Architecture	2010	1. Contemporary	Visual Other senses: olfaction, tactility, motion perception	A14 A16	◆ ◄	E10	Food supply	edible aromatic herbs wall; edible landscaping and outdoor kitchen
183	San Telmo Museum Extension	Nieto Sobejano Architects	2011	1. Contemporary	Details and finishes	A21	►	E14	Landscape aesthetic fruition	beautiful porous green wall in metal (that mimetizes porous stone), on the edge of urban/natural landscape, link with program organization and circulation, access and landscape views to mount Urgull
184	Anthropologie shop, Regent Street	Biotecture	2009	1. Contemporary	Indoor air quality	A18	◄	E12	Raw materials, ornamental and medicinal resources	interior green wall, recieving water irrigation from collected rainwater on the roof, plant species which are known to have beneficial effects on improving air quality, including Spatyphillum (Peace Lily) which is the number one for air quality improvement according to NASA, and Chlorophytum (Spider Plant).
185	LOTT Regional Services Center	Miller Hull Partnership	2010	1. Contemporary	Acoustics Energy cycle [and atmospheric emissions]	A15 A4	◄ ◄	E4 E3	Water cycling and regulation Nutrient cycling and waste treatment	innovative approaches to wastewater, use of methane from wastewater to help heat, cool, and power the facility, ponds [water surface] with sounds and other acoustic features
186	Queens Botanical Garden Interpretation Center	BKSK Architects	2007	1. Contemporary	Acoustics Visual Other senses: olfaction, tactility, motion perception Water cycle [and effluents]	A15 A14 A16 A5	◄ ◆ ◄ ►	E4 E9	Water cycling and regulation Perceptive environmental modulation	water cascades from a folded canopy over the building's entry, falling into a catchment area below. green roof planted with sedum, grasses, and perennial flowers. stormwater management system that collects runoff, cleanses it with aquatic plants, and keeps it out of the city's overtaxed combined sewer-and-wastewater infrastructure. graywater recycling system, which, along with other conservation strategies, makes the facility 82% more water efficient
187	Marine and Freshwater Resources Institute	Lyons Architects [with ARUP consulting]	2005	1. Contemporary	Structure stability and design Water cycle [and effluents]	A23 A5	◆ ◆	E14 E13	Landscape aesthetic fruition Significant species and ecosytem values	turf-roofed structure follows the curve of the site and interacts with the surrounding wetlands, dunes and bay, Located on a former landfill site adjacent to protected wetland [reclamation of contaminated land], water strategies include extensive rainwater use and treatment of stormwater runoff, passive design with diagonal walls, operable windows
188	Vertical Garden Kit	Nguyen Van Quy	~ 2011	1. Contemporary	Economic dynamics and lifecycle costs Customization possibilities and operation	A11 A9	◆ ►	E10 E2	Food supply Photosynthesis and primary production	low-cost vertical garden kits for household production of fresh vegetables and ornamental plants. provision of food self-sufficient resources for daily meals, allowing people living in sandy areas or soils with high salinity levels, and wetlands to grow fresh vegetables. capacity to produce 12kg of cabbage or lettuce in 30 days, where a family of four members can enjoy vegetables all year round with only two to three kits.
189	Housemartin nests in roof eaves	[unknown/vernacular architecture]	[…]	3. Pre-Modern	Details and finishes	A21	►	E13	Significant species and ecosytem values	biodiversity habitats and creation of sense of place
190	Adachi Museum of Art Garden	Adachi Zenko	1970	2. Post-Modern	Visual	A14	◆	E14	Landscape aesthetic fruition	shakkei, borrowed scenery in the garden
191	Shishi-odoshi	[unknown/vernacular]	[…]	3. Pre-Modern	Acoustics	A15	◄	E4	Water cycling and regulation	sound in japanese gardens, made with running water, to keep at distance birds and mammals, sense of place, accoustic delight
192	Pavements and landscape design in Obuse	[Obuse town council]	> ~1983	2. Post-Modern	Other senses: olfaction, tactility, motion perception	A16	◄	A12	Raw materials, ornamental and medicinal resources	local harvested materials [chestnut wood, stone], surface tactility and irregularity, and motion perception, pervious pavements, connection with site history
193	Commerce Square [Terreiro do Paço]	Eugénio dos Santos	1775	3. Pre-Modern	Other senses: olfaction, tactility, motion perception	A16	◆	E14	Landscape aesthetic fruition	hazard protection, pavement steepness, landscape fruition
194	Geraniums-lavender windows pots and gardens	[unknown/vernacular]	[…]	3. Pre-Modern	Customization possibilities and operation Sense of place and cultural identity Human health and well being	A9 A2 A12	► ◆ ◄	E8	Biological control & pollination	use of ornamental/aromatic plants to drive off mosquitoes, pest control, costumization possibilities
195	Marsh reeds and bamboo shutters	[unknown/vernacular]	[…]	3. Pre-Modern	Customization possibilities and operation	A9	◄	E12	Raw materials, ornamental and medicinal resources	marsh reeds and bamboo curtains for passive design, local materials, light filter, user control and costumization
196	*A Recipe To Live*	Masaki Ogasawara, Keisuke Tsukada and Erika Mikami [Waseda University]	2012	1. Contemporary	Humidity and temperature	A19	◄	E3	Nutrient cycling and waste treatment	use of available and cultural significant local resources (pasture grass forage), used for raising dairy cattle. shelves fastened to the exterior walls allow forage drying and, interior shelves with acrylic cases ferment the dried grass in winter, so as to produce heat. Temperature comfort and energy consumption reduction through the use of compost as source of heat through microbial fermentation, enhanced air-tightness and insulation of walls. organic and slow-release fertilizer production
197	NASA Sustainability Base	William McDonough + Partners	2012	1. Contemporary	Exterior areas and local pollution control	A7	◆	E9	Perceptive environmental modulation	exoskeleton approach offers increased structural performance during seismic events, provides an armature for daylighting and shading strategies; glare-free daylight, fresh air and abundant connections to the outdoors, serviced by systems that, in time, will use only renewable energy and will maintain water in closed loops; sustainable landscape, climbing trellises in the structure for shading and avoid glare
198	House like a Tree	William McDonough + Partners	2009	1. Contemporary	Materials cycle [and waste] Sustainable life-style support systems Water cycle [and effluents]	A6 A8 A5	◆ ◄	E3 E11 E2	Nutrient cycling and waste treatment Water purification and fresh water supply Photosynthesis and primary production	home design that functions like a tree [biomimicry and metaphor]. The house uses sunlight to generate energy, cleans water, sequesters carbon, provides natural habitats, and produces oxygen and food. several nanotechnologies are incorporated into the design. its materials are designed to be easily disassembled to return as safe nutrients for human industry or the biosphere in cradle-to-cradle cycles.
199	901 Cherry Offices	William McDonough + Partners	1997	1. Contemporary	Acoustics Durability & maintenance of systems and materials	A15 A24	◄ ◄ ◆	E9 E1 E9	Perceptive environmental modulation Soil formation and fertility Perceptive environmental modulation	undulating 70,000 square foot roof covered in native grasses and wildflowers, echoing the coastal savannah ecosystem. this grass roof reduces stormwater from the site, provides tempering thermal mass, protects the roof membrane, and dampens noise from the nearby airport.
200	Phipps' Center for Sustainable Landscapes	The Design Alliance	2012	1. Contemporary	Sense of place and cultural identity Community participation and user's satisfaction Execution quality and process management Adaption to eco-physical values and	A2 A10 A22 A1	◆ ◆ ►	E13 E14 E3 E8	Significant species and ecosytem values Landscape aesthetic fruition Nutrient cycling and waste treatment Biological control & pollination	development on an existing brownfield; managing stormwater on site; using primarily all native plants; responsibly sourcing landscape materials from appropriate distances and origin; and sustainably managing the project's waste stream.

Concretization	Environmental Assessment	Method	Rating	Country	Location	Geographic Cluster	Use | Function	Scale	Context	Sources
1. Built | Realized	1. Certified	Living Building Challenge 2.0 LEED Net-Zero Energy Building	**Certified** **Platinum** **Certified**	U. S. A.	Pringle Creek, Salem, Oregon	1. America-Pacific	12. Social	2. Building	2. Sub-urban	http://live.living-future.org/case-study/paintershall
1. Built | Realized	2. Non-certified	[…]		U. S. A.	Atlanta, Georgia	1. America-Pacific	7. Public Space	3. Land Unit	1. Urban	http://www.gardendesign.com/ideas/three-new-reasons-visit-atlanta-botanical-garden?pnid=109072#gallery-content http://3frommedesign.com/design_atlanta.html http://www.atlantabotanicalgarden.org/plan-your-visit/locations/canopy-walk
1. Built | Realized	2. Non-certified	[…]		Spain	San Sebastian	2. Europe-Africa-Middle East	3. Cultural	2. Building	1. Urban	http://europaconcorsi.com/projects/168143-San-Telmo-Museum-Extension http://www.nietosobejano.com/project.aspx?i=3&t=SAN_TELMO_MUSEUM#
1. Built | Realized	2. Non-certified	[…]		U. K.	London	2. Europe-Africa-Middle East	5. Commercial	1. Component	1. Urban	http://www.biotecture.uk.com/portfolio/anthropologie-regent-street/
1. Built | Realized	1. Certified	LEED	**Platinum**	U. S. A.	Olympia, Washington	1. America-Pacific	4. Mixed Use	2. Building	1. Urban	http://greensource.construction.com/green_building_projects/2011/1104_LOTT_Regional_Services_Center.asp http://www.archdaily.com/128516/lott-clean-water-alliance-regional-services-center-miller-hull-partnership/
1. Built | Realized	1. Certified	LEED	**Platinum**	U. S. A.	Flushing, New York	1. America-Pacific	3. Cultural	2. Building	1. Urban	http://greensource.construction.com/projects/0807_QueensBotanicalGarden.asp http://www2.aiatopten.org/hpb/overview.cfm?ProjectID=1018
1. Built | Realized	1. Certified	Green Star [before official launch]	**6 star** [preliminary]	Australia	Queenscliff, Victoria	3. S and E Asia-Oceania	2. Educational	2. Building	2. Sub-urban	http://www.arup.com/Projects/DPI%20Marine_and_Freshwater_Resources_Institute/Details.aspx http://phaidonatlas.com/building/marine-and-freshwater-resource-institute/67666
1. Built | Realized	2. Non-certified	[…]		Vietnam	[diverse locations]	3. S and E Asia-Oceania	9. Agriculture	1. Component	1. Urban	http://vn.e-idea.org/en/eidealist_en/start-ups6/ http://vietnamnews.vn/sunday/features/215564/vertical-garden-perfect-for-crowded-city-.html
1. Built | Realized	2. Non-certified	[…]		[…]	Europe [diverse locations]	2. Europe-Africa-Middle East	15. Detail	1. Component	1. Urban	http://www.arcadedarwin.com/2013/06/29/andorinha-dos-beirais-uma-das-minhas-bandas-preferidas/ WILLIAMS: 2010
1. Built | Realized	2. Non-certified	[…]		Japan	Yasugi-city, Shimane Prefecture	3. S and E Asia-Oceania	3. Cultural	3. Land Unit	2. Sub-urban	http://www.adachi-museum.or.jp/e/garden.html
1. Built | Realized	2. Non-certified	[…]		Japan	Diverse locations	3. S and E Asia-Oceania	15. Detail	1. Component	1. Urban	http://en.wikipedia.org/wiki/Shishi-odoshi
1. Built | Realized	2. Non-certified	[…]		Japan	Obuse town	3. S and E Asia-Oceania	7. Public Space	3. Land Unit	2. Sub-urban	http://www.machizukuri-lab.com/en/about_obuse.html
1. Built | Realized	2. Non-certified	[…]		Portugal	Lisbon	2. Europe-Africa-Middle East	7. Public Space	3. Land Unit	1. Urban	http://pt.wikipedia.org/wiki/Pra%C3%A7a_do_Com%C3%A9rcio
1. Built | Realized	2. Non-certified	[…]		[…]	Europe [diverse locations around the mediterraneum sea]	2. Europe-Africa-Middle East	15. Detail	1. Component	1. Urban	
1. Built | Realized	2. Non-certified	[…]		Japan	[diverse locations]	3. S and E Asia-Oceania	15. Detail	1. Component	1. Urban [all]	
1. Built | Realized	2. Non-certified	[…]		Japan	Taiki-cho, Hokkaido	3. S and E Asia-Oceania	1. Residential	2. Building	3. Non-urban	http://inhabitat.com/japanese-students-create-straw-home-heated-by-agricultural-fermentation/waseda-university-students-a-recipe-to-live-straw-house-2/?extend=1 https://www.japlusu.com/news/recipe-live
1. Built | Realized	1. Certified	LEED	**Platinum**	U.S.A.	Moffett Field, California	1. America-Pacific	6. Offices	2. Building	2. Sub-urban	http://mcdonoughpartners.com/project/nasa-sustainability-base/ http://www.archdaily.com/231211/nasa-sustainability-base-william-mcdonough-partners-and-aecom/
2. Unbuilt | Plan	2. Non-certified	[…]		[…]	Temperate climate	1. America-Pacific	1. Residential	2. Building	2. Sub-urban	http://mcdonoughpartners.com/project/house-like-a-tree/
1. Built | Realized	2. Non-certified	[…]		U.S.A.	San Bruno, California	1. America-Pacific	6. Offices	2. Building	2. Sub-urban	http://mcdonoughpartners.com/project/901-cherry-offices/
1. Built | Realized	1. Certified	SITES LEED NC Living Building Challenge	**4 stars** **[SITES]** **Platinum** **[LEED]**	U.S.A.	Pittsburgh, Pennsylvania	1. America-Pacific	2. Educational	2. Building	1. Urban	http://www.sustainablesites.org/cert_projects/show.php?id=55 http://www.world-architects.com/en/projects/42835_Phipps_Conservatory_and_Botanical_Gardens_Center_for_Sustainable_Landscapes http://phipps.conservatory.org/project-green-heart/green-

CODE	Project Name	Author	Year	Periodization	Ti[L]es Matrix {relevant reference correlations}					Ecosystem Integration | Description
201	Scenic Hudson's Long Dock Park	Landscape: Reed Hilderbrand, LLC Pavillion + Hudson River Center: Architecture ResearchOffice	2011	1. Contemporary	Community participation and user's satisfaction Adaption to eco-physical values and restraints Execution quality and process	A10 A22	◆ ▶ ▶	E15 E3 E13	Leisure, recreation and psychophysical health Nutrient cycling and waste treatment Significant species and ecosytem values	returned public access to the river, remediated contaminated soils and rehabilitated degraded wetlands, with voluntary cleanup of brownfield site. reused found materials (concrete slabs) in innovative ways and restored ecological diversity to upland, wetland, and intertidal zones. weekly site monitoring, and volunteer park corps for trash and litter management, pull invasive plants, serve as park stewards. regular specialized monitoring of wetlands and manage and replace plants when necessary.
202	National Renewable Energy Lab (NREL) Research Support Facility (RSF)	RNL	2010	1. Contemporary	Transports and functional articulation w/ context Materials cycle [and waste]	A3 A6	▶ ▶	E13 E14	Significant species and ecosytem values Landscape aesthetic fruition	high performance buildings + sustainable landscape; water conservation, waste reduction, environmental stewardship and behavior change towards sustainable living (low impact mobility). surface stormwater irrigate vegetation and water quality before returning to watershed. drainage through bioswales, vegetated forebays, and bioretention areas, porous pavers. recycled materials: salvaged onsite bedrock for retaining walls; design of transport structures to avoid bird in-flight collisions
203	George 'Doc' Cavalliere Park	JJR/Floor associates [Landscape Architect: Christopher Brown, FASLA Architect: Weddle Gilmore Architects]	2012	1. Contemporary	Materials cycle [and waste] Details and finishes	A6 A21	▶ ◆	E4 E14	Water cycling and regulation Landscape aesthetic fruition	community input, regional stormwater retention facility, preservation and restoration of plants and soils, reuse of materials salvaged on site, elimination of unnecessary paints and finishes, 100% native plant palette, Parking, driveways, and paths were paved with stabilized decomposed granite, which utilized only site-salvaged materials and dramatically reduced drainage runoff and the urban heat island effect, while retaining a natural desert character.
204	Burbank Water and Power - EcoCampus	AHBE Landscape Architects – Landscape Architect + Tyler Gonzalez Architects – Architect	2005	1. Contemporary	Water cycle [and effluents] Materials cycle [and waste] Execution quality and process management	A5 A6 A22	◆ ▶	E5 E4 E3 E6 E1	Nutrient cycling and waste treatment Water cycling and regulation Biodiversity and nursery habitats Climatic regulation Soil formation and fertility	regeneration of industrial complex. permeable pavers, manufactured bio-filters, filtration planters, Silva cells, and planted infiltration planter bulb-outs. vegetated green roofs, a photovoltaic array that hosts a rainwater catchment system, a canal that uses plants to treat storm water, salvaged and repurposed concrete and gravel. annual soils test to monitor the performance and quality of the restored soils within the project site. vegetation beds planted with drought tolerant species
205	National Exhibition Centre (NEC) Birmingham	[Constructor: Scotscape Living Walls]	2009	1. Contemporary	Execution quality and process management	A22	▶	E12	Raw materials, ornamental and medicinal resources	design possibilities of living walls. unique columnular design on a steel sub-structure ('ANS Living Wall System™') separates a parking area from one of the entrances to the arena.
206	Urban Savannah, Alley Midlands, Understory Dwellings	Constructive Form Architecture & Design LLC	2008	1. Contemporary	Sustainable life-style support systems Adaption to eco-physical values and restraints	A8 A1	◆ ▶	E13 E12	Significant species and ecosytem values Raw materials, ornamental and medicinal resources	habitat connectivity, passive design, greenhouses, greencorridors-connection of canopies, stormwater management and green infrastructure, oak trees and woodlands preserved, restored and reintegrated with existing and expanding urban development
207	Urban Ecotones	GreenWorks PC Ankrom Moisan Associated Architects Bruce Rodgers Design Illustration	2008	1. Contemporary	Economic dynamics and lifecycle costs Transports and functional articulation w/ context	A11 A3	◀ ▶	E3 E4	Nutrient cycling and waste treatment Water cycling and regulation	parking spaces reconverted into community gardens and urban agriculture. building setting and sloping eco-roof to create urban forest and habitat connectivity. marshland with 2 natural runoff lakes. wetland pond for on-site filtration of stormwater. 16,600 sq.foot composting from construction fill and yard waste, to fertilize plants in the site's greenhouse and garden center or sell as nutrient-rich blend of soil. rooftop cafe with views of adjacent woods and wetlands.
208	Roots, Nests & Canopies	Thalweg Studio	2008	1. Contemporary	Sustainable life-style support systems	A9	◆	E9	Perceptive environmental modulation	diferentiation of typologies as canopy house, nest house or root house, alley as urban woodland, permeable pavers which allow water to infiltrate, backyard swales and seasonal pond, habitat mix, wild and domesticated edible plants offer food sources, stewardship opportunities for its human occupants, planting strategy mimics the growth of native oak woodland and savannah habitats, stewardship strategies
209	Symbiotic Existence Through Transactional Awareness	Georgia Institute of Technology Amanda Cook Katherine Creason Shraddha Srivastav	2008	1. Contemporary	Customization possibilities and operation	A9	◆ ▶	E5 E4	Biodiversity and nursery habitats Water cycling and regulation	'site rule' combining variety of native grasses, and at least 1 oak tree. 'house rule' allowing choice between green, pitched roof or hybrid roof (planted with sedums and wildflowers to attract pollinators and birds), and between 'waterwall' (providing grey water needs for kitchen and bathroom) or living wall. stormwater management plan. accessory dwelling units elevated a minimum of two feet from the ground, providing canopy views, corridors for small wildlife and additional area for stormwater retention
210	Prince Edward Island Ark	Solsearch Architects [now BGHJ Architects] John Todd	1976	2. Post-Modern	Humidity and temperature Human health and well-being	A19 A12	◆ ◀	E10 E11	Food supply Water purification and fresh water supply	combines greenhouse, residential house, storage/barn space, solar aquaculture ponds, and active solar hot air and hot water heating systems. autonomous building
211	Meandering Greenway	Malcolm Wells [on sketch by John Todd]	1981	2. Post-Modern	Humidity and temperature	A19	◀	E11	Water purification and fresh water supply	year-round greenway meandering, through landscape, adapting to slopes and contours - lines of solar ponds inside serve as thermal mass [and also aquaculture, irrigation, rainwater storage, and wastewater purification, and as linear rivers to move water from place to place.]
212	Europe in Bloom	Johanna Roßbach [architecture] + LIFE (Faculty of Life Sciences), University of Copenhagen; municipality of Copenhagen; Ramboll Denmark; and Green Fortune	2010	1. Contemporary	Visual	A14	◆	E12	Raw materials, ornamental and medicinal resources	5000 plants arranged on a scaffolding structure attached to a building façade [with plants inserted into felt 'pockets' attached to the metal scaffold]. selected native species from across the European continent. European Environment Agency project with intention to raise awareness into growing and allowing biodiversity to flourish in urban centers. aesthetics-visual, light filter.
213	Center for Urban Agriculture	Mithun Architects	2007	1. Contemporary	Water cycle [and effluents]	A5	◆	E11	Water purification and fresh water supply	conceived as a "living building" which draws resources from its immediate environment to become self-sufficient, the proposal features gray and rain water collection systems, photovoltaic cells, vegetable gardens, greenhouses and a chicken farm. designed to be completely independent of city water — even providing its own drinking water.
214	Le 56 – Ecointerstice	Atelier d'Architecture Autogérée (AAA)	2006	1. Contemporary	Community participation and user's satisfaction	A10	◆ ▶	E10 E1	Food supply Soil formation and fertility	participation of inhabitants in the self-management of abandoned and under-used urban spaces. urban void filled with productive plant beds, a mobile greenhouse and a shared collective space. elevated building, reinforcing the street front while creating a permeable threshold that invites people in. energy consumption reduced by the use of solar panels, a green roof and a closed water cycle. collectively self-managed space.minimal ecological footprint and a compost laboratory.
215	Evergreen Brick Works - Centre for Green Cities	Diamond Schmitt Architects [+ Joe Lobko, du Toit Allsopp Hillier/du Toit Architects Ltd. — ERA — Claude Cormier Architectes Paysagistes — Stantec — A+A Adams & Associates]	2010 [site since 1994]	1. Contemporary	Sense of place and cultural identity Adaption to eco-physical values and restraints	A2 A1	◆ ▶	E3 E2	Nutrient cycling and waste treatment Photosynthesis and primary production	brownfield remediation of soil and groundwater. food production. [industrial] heritage conservation. green roofs, solar chimneys for natural ventilation, low-flush toilets, and greywater use from rainwater cisterns (for cooling-tower and toilet flushing). environmentally-based community landmark within 16 heritage buildings in the heart of the city's ravine system, with educational programs for children and adults, farmers market, plant nursery, park and wildlife habitat, and open-air museum.
216	Peter Doherty Institute for Infection and Immunity [University of Melbourne]	Grimshaw Architects	2013	1. Contemporary	Structure stability and design Humidity and temperature	A23 A19	▶ ◀	E4 E1	Water cycling and regulation Soil formation and fertility	a green roof installation that also works to treat greywater. the combination of these two technologies required significant design modifications of both systems, including layout configuration, hydraulic function, plant selection, and the selection of construction materials, active and passive solar design, health and well being, aesthetics
217	Lilyfield Housing Redevelopment	HBO+EMTB	2011	1. Contemporary	Sustainable life-style support systems	A8	◆	E15	Leisure, recreation and psychophysical health	light pollution strategies, energy consumption reduction, habitats, social housing, initiatives to foster community and healthy living among residents, communal garden facilities/opportunity to grow their own vegetables and produce and to enjoy nature/reducing the carbon mileage accumulated through the mass transportation of fresh produce. 10% of housing units are specifically designed to the latest standards of accessibility for occupants with disabilities.
218	Umow Lai's Melbourne Office Tenancy	DesignInc and Kyle Design [interior design] Architectus [base building]	2009	1. Contemporary	Indoor air quality	A18	◀	E12	Raw materials, ornamental and medicinal resources	13% improvement in staff productivity, and other environmental and social benefits: improvements to indoor air quality, noise, lighting and thermal comfort through maximum floor plate depth of 8m which provides superior levels of natural light to work-stations; access to large balconies and opening windows; five bio-filtration walls throughout the tenancy (as natural biological filters to remove voc's). 93 % of waste materials recycled during construction
219	Pixel	Studio505 [Landscape Design: studio505 + University of Melbourne]	2010	1. Contemporary	Transports and functional articulation w/ context	A3	◀	E11	Water purification and fresh water supply	pixilated' sun shade panels. design for 100% water and energy self-sufficiency. Reed beds on northern and western façades filter grey water, and cool air temperature before entering the building. plant beds on roof to control temperature, and reintroduce native grassland species. anaerobic digester installed on ground level for energy production through methane extraction. living edge spandrels for shading, greywater treatment and personal greenery to each office floor.
220	Ausgrid Learning Centre	DEM	2011	1. Contemporary	Water cycle [and effluents]	A5	◀	E3	Nutrient cycling and waste treatment	bioswales [channels filled with native plants to filter stormwater] used extensively around the site. green roof further reduces run off and has the added benefit of insulating the building below, making the electrical workshops, spray booths and offices much more comfortable. Green roofs also contribute to improving air quality and can reduce urban air temperatures

Concretization	Environmental Assessment	Method	Rating	Country	Location	Geographic Cluster	Use | Function	Scale	Context	Sources
1. Built | Realized	1. Certified	SITES LEED (Hudson River Center only)	3 stars Gold	U.S.A.	Beacon, New York	1. America-Pacific	7. Public Space	4. Ensemble	2. Sub-urban	http://www.sustainablesites.org/cert_projects/show.php?id=48 http://aasarchitecture.com/2013/01/boat-pavilion-for-long-dock-park.html http://inhabitat.com/nyc/hudson-river-brownfield-site-transformed-into-sustainable-long-dock-park/aro_beacon-
1. Built | Realized	1. Certified	SITES LEED	3 stars Platinum	U.S.A.	Golden, Colorado	1. America-Pacific	6. Offices	4. Ensemble	2. Sub-urban	http://www.sustainablesites.org/cert_projects/show.php?id=52 http://www.aiatopten.org/node/103
1. Built | Realized	1. Certified	SITES	3 stars	U.S.A.	Scottsdale, Arizona	1. America-Pacific	7. Public Space	3. Land Unit	2. Sub-urban	http://www.sustainablesites.org/cert_projects/show.php?id=45 http://architizer.com/projects/george-doc-cavalliere-park/
1. Built | Realized	1. Certified	SITES [LEED]* new building	1 star [Platinum]	U.S.A.	Burbank, California	1. America-Pacific	13. Infrastructure	4. Ensemble	2. Sub-urban	https://www.burbankwaterandpower.com/community/ecocampus http://www.sustainablesites.org/cert_projects/show.php?id=42 http://worldlandscapearchitect.com/burbank-water-and-power-ecocampus-ahbe-landscape-architects/
1. Built | Realized	2. Non-certified	[…]		U. K.	Birmingham	2. Europe-Africa-Middle East	15. Detail	1. Component	2. Sub-urban	http://www.ansgroupeurope.com/living-walls-galleria http://www.scotscapelivingwalls.net/project-gallery/nec-birmingham.html
2. Unbuilt | Plan	2. Non-certified	[…]		U.S.A.	Portland, Oregon	1. America-Pacific	1. Residential	4. Ensemble	2. Sub-urban	http://library.oregonmetro.gov/files/urbanalley_no9web.pdf
2. Unbuilt | Plan	2. Non-certified	[…]		U.S.A.	Portland, Oregon	1. America-Pacific	5. Commercial	2. Building	2. Sub-urban	http://library.oregonmetro.gov/files/ih_poster_urbanecotones.pdf
2. Unbuilt | Plan	2. Non-certified	[…]		U.S.A.	Portland, Oregon	1. America-Pacific	1. Residential	4. Ensemble	2. Sub-urban	http://library.oregonmetro.gov/files/rootsnests_final_web.pdf
2. Unbuilt | Plan	2. Non-certified	[…]		U.S.A.	Portland, Oregon	1. America-Pacific	1. Residential	4. Ensemble	2. Sub-urban	http://library.oregonmetro.gov/files//symbiotic_existence_no15_web.pdf
1. Built | Realized	2. Non-certified	[…]		Canada	Charlotte Town, Prince Edward Island	1. America-Pacific	1. Residential	2. Building	3. Non-urban	BARNHART: 2007 http://en.wikipedia.org/wiki/John_Todd_(biologist)
2. Unbuilt | Plan	2. Non-certified	[…]		[…]	North America [non specified]	1. America-Pacific	9. Agriculture	2. Building	3. Non-urban	BARNHART: 2007
1. Built | Realized	2. Non-certified	[…]		Denmark	Copenhagen	2. Europe-Africa-Middle East	15. Detail	1. Component	1. Urban	http://www.urbangardensweb.com/2010/11/12/green-facade-mirrors-shape-of-europe/ http://www.foodurbanism.org/europe-in-bloom/ http://www.flickr.com/photos/kmardahl/4942261577/
2. Unbuilt | Plan	2. Non-certified	[…]		U. S. A.	Seattle, Washington	1. America-Pacific	4. Mixed Use	2. Building	1. Urban	http://www.foodurbanism.org/mithun-center-for-urban-agriculture/ http://mithun.com/projects/project_detail/center_for_urban_agriculture/
1. Built | Realized	2. Non-certified	[…]		France	Paris	2. Europe-Africa-Middle East	3. Cultural	2. Building	1. Urban	http://www.foodurbanism.org/le-56-ecointerstice/ http://www.urbantactics.org/projects/passage%2056/passage56html.html http://rmitallchange.weebly.com/passage-56--eco-interstice.html
1. Built | Realized	1. Certified	LEED [only 2010 building]	Platinum [only 2010 building]	Canada	Toronto	1. America-Pacific	4. Mixed Use	4. Ensemble	1. Urban	http://www.ryerson.ca/carrotcity/board_pages/community/evergreen_brickworks.html http://www.foodurbanism.org/evergreen-brick-works/ http://www.archdaily.com/241503/evergreen-brick-works-diamond-schmitt-architects/
1. Built | Realized	1. Certified	Green Star [Education Design v1]	5 stars	Australia	Parkville, Melbourne, Victoria	3. S and E Asia-Oceania	2. Educational	2. Building	1. Urban	http://www.gbca.org.au/green-star/green-building-case-studies/the-university-of-melbourne-peter-doherty-institute-for-infection-and-immunity/
1. Built | Realized	1. Certified	Green Star	5 stars	Australia	Lilyfield, Sydney	3. S and E Asia-Oceania	4. Mixed Use	4. Ensemble	2. Sub-urban	http://www.gbca.org.au/green-star/green-building-case-studies/lilyfield-housing-redevelopment/ http://www.housing.nsw.gov.au/Changes+to+Social+Housing/Redevelopment/Lilyfield+Redevelopment.htm http://www.worldbuildingsdirectory.com/project.cfm?id=3411
1. Built | Realized	1. Certified	Green Star [Office Interiors v1.1]	6 stars	Australia	South Yarra, Victoria	3. S and E Asia-Oceania	6. Offices	1. Component	1. Urban	http://www.gbca.org.au/green-star/green-building-case-studies/umow-lai/ http://www.umowlai.com.au/projects.asp?PageID=68 http://www.thomas-daily.de/project/detail/id/5143ed76-5239-44ab-b36c-81d4e14d0fc7/lt/Melbourne,-Australia/t/Umow-Lai-
1. Built | Realized	1. Certified	Green Star LEED	6 stars Platinum	Australia	Melbourne, Victoria	3. S and E Asia-Oceania	6. Offices	2. Building	1. Urban	http://www.gbca.org.au/green-star/green-building-case-studies/pixel/ http://www.studio505.com.au/work/project/pixel/8
1. Built | Realized	1. Certified	Green Star [Education Design v1 and As Built v1]	6 stars	Australia	Sydney	3. S and E Asia-Oceania	2. Educational	2. Building	2. Sub-urban	http://www.gbca.org.au/green-star/green-building-case-studies/ausgrid-learning-centre/ http://www.gbca.org.au/uploads/216/4056/Ausgrid_Learning_Centre.pdf

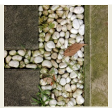
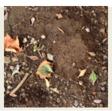
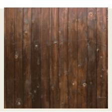
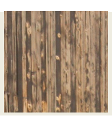
CODE	Project Name	Author	Year	Periodization	Ti[L]es Matrix {relevant reference correlations}					Ecosystem Integration | Description
221	60 Richmond Housing Cooperative	Teeple Architects	2010	1. Contemporary	Transports and functional articulation w/ context Structure stability and design	A3 A23	◄ ►	E10	Food supply	low-cost cooperative housing [construction and operation] with food production. small-scale “urban permaculture”. openings and terraces at various levels creating kitchen gardens, drawing light into the building and providing outdoor green space, cooling and cleansing the air and limiting heat island effect. resident-owned and operated restaurant and training kitchen supplied with onsite produced vegetables, fruit and herbs. irrigation by stormwater and compost derived from organic waste
222	Edible Terrace + Edible Terrace2	Anthony Campbell & James West	2009	1. Contemporary	Sustainable life-style support systems Sense of place and cultural identity	A8 A2	◆	E10	Food supply	re-interpretation of english terraced house, with food production: vegetable patch at the front, planters on the rear terrace, fruit trees in the rear yard; herbs grown on green roof, encouraging local biodiversity and house insulation; mushroom cultivation in dark spaces on the north side; south-facing, double-skin glazed façade allows for cultivation extending the growing season. chickens and pigs kept in a 21m2-pen, whose manure provides feed for tilapia fish kept in the basement.
223	Agro Housing	Knafo Klimor Architects	2007	1. Contemporary	Energy cycle [and atmospheric emissions]	A4	◆	E10	Food supply	integration of food production as a means to increase urban resilience. Community and private spaces for food growth, as way of empowering migrants from rural areas, grey water re-use, a ground-source heat pump system, and passive heating and ventilation through the south-facing greenhouse space
224	Vertical Farm Arcology	Gordon Graff	2009	1. Contemporary	Sustainable life-style support systems Transports and functional articulation w/ context	A8 A3	◆ ◄	E15 E10	Leisure, recreation and psychophysical health Food supply	food production (for 1,000 people year-round), green roofs (5,200 m2 of space available for community gardens, source of exercise and social interaction); cyclical metabolism through Living Machine, Hydroponic Farm, and Methane Digester - on-site generation of food, power, and water, as well as on-site processing of waste water and biological waste; Also chicken breeding, for both meat and eggs, and tilapia (aquaculture).
225	Zenora-Noda	Viguier & Associates	2009	1. Contemporary	Exterior areas and local pollution control	E7	◆	E5	Biodiversity and nursery habitats	use of an ecologist for the development of landscapes areas and to enhance biodiversity, achievement of Site and Ecology score of 100 %
226	Welsh Assembly Government Offices [Ceredigion County Council Offices]	Powell Dobson Architects	2009	1. Contemporary	Execution quality and process management	A22	►	E5	Biodiversity and nursery habitats	biomass heating system using wood fuel from local sources, combined with wind turbine and solar panels, supplying 42% of the site’s total energy demand. recycled rain water for flushing toilets. site landscaping with locally sourced indigenous species. increase of land ecological value. briefing the site workforce on ecological protection measures. management plan detailing landscape and local biodiversity maintenance and protection.
227	Marks & Spencer Cheshire Oaks	Aukett Fitzroy Robinson	2012	1. Contemporary	Acoustics Execution quality and process management Materials cycle [and waste]	A15 A22 A6	◆ ► ►	E5 E8	Biodiversity and nursery habitats Biological control & pollination	water efficiency, with SUDs to slow surface water infiltration with permeable hard standing and swale. ecologically selected species of plants and trees. green wall covering the majority of car park south elevation , protecting it from the elements, trap particulates from car exhausts, providing thermal and acoustic insulation and habitat for birds and other wildlife. 100% of construction waste diverted from landfill. insect houses made from timber hoardings and log piles.
228	Casa Batroun	Maha Nasrallah Architects	2013	1. Contemporary	Water cycle [and effluents] Humidity and temperature	A5 A19	◄ ◄	E12	Raw materials, ornamental and medicinal resources	building renovation, green roof with native species with low-water maintenance, salvaged materials (tiles) from demolished houses, Insulation with sheep’s wool and rigid wood fibre, Reuse of existing building façade, Natural, low toxicity, breathable materials, Bio-climatic design with cross-ventilation and eliminating the need for cooling systems,Solar water heating panels for domestic water, Wood pellet stoves for space heating, Rainwater harvesting for irrigation and toilet flushing
229	Living Tower	SOA Architects	2005	1. Contemporary	Visual Adequacy to function, occupancy and circulation Structure stability and design	A14 A20 A23	◆	E10	Food supply	rainwater filtration system collects water to be filtered and later used by residents, black water produced by the tower is filtered and used to fertilize plants, and wind turbines also generate power using the strong currents from the roof level. All elements use natural means of convection to ventilate the building’s core in order to minimize its mechanical functions. visual characteristics. vertical farm
230	Seeds of Life Skyscraper	Mekano	2011	1. Contemporary	Materials cycle [and waste]	A6	►	E1	Soil formation and fertility	recycle the city’s waste and use it as building material; terraces are used for agriculture and rainwater collection, while specific sites are used to bury organic waste and produce biogas, electricity, and fertilizers. birdnests, etc.
231	Propagate Skyscraper: Carbon Dioxide Structure	YuHao Liu, Rui Wu	2014	1. Contemporary	Structure stability and design	A23	►	E3	Nutrient cycling and waste treatment	carbon-philic resins and material processes that transform carbon dioxide into solid construction material. hypothesized a material capable of assimilating carbon dioxide. a skyscraper that grows. with a simple vertical grid scaffold as a framework
232	Water Re-Balance Skyscraper	Zhang Zhiyang, Liu Chunyao	2013	1. Contemporary	Water cycle [and effluents]	A5	►	E7	Erosion control and hazard protection	rainwater collection and flooding mitigation. collection and purification of rainwater. provision of clean, drinkable water, and mitigation of rising river levels before flooding occurs; sinking subsidence control. collection of organic matter from water filtering to develop and feed farmland, wetlands, and to grow green algae. farm and wetlands purify the air, and algae is cultivated and processed within the tower by a generator to create energy.
233	Infill Aquifer	Jason Orbe-Smith	2014	1. Contemporary	Adequacy to function, occupancy and circulation Structure stability and design	A20 A23	◆ ◆	E4	Water cycling and regulation	minimum soil (elevated building setting) occupation, and maximum soil perviousity. Increased aquifer recharge. Concept, analogy. Green roof. Water filtration, fresh and grey water storage
234	BedZED	Bill Dunster Architects [+ Ellis & Moore Consulting Engineers, BioRegional, Arup and the cost consultants Gardiner and Theobald]	2002	1. Contemporary	Human health and well being	A12	◆	E15	Leisure, recreation and psychophysical health	brownfield site. designed to use only energy from renewable sources generated on site (some of it biofuel). Most rain water falling on the site is collected and reused. community and private gardens and vegetable gardens, composting. roof garden terraces. the 'Living Machine' water recycling facility had been unable to clean the water sufficiently. The cost of the facility also made it unviable. 'pedestrian priority’ streets, locally sourced materials
235	Ekostaden Augustenborg	Augustenborg District	2010	1. Contemporary	Human health and well being Community participation and user's satisfaction	A12 A10	◄ ►	E4 E2	Water cycling and regulation Photosynthesis and primary production	building and urban regeneration (ecologically, socially and economically). local residents and stakeholders participation workshops, design information sessions, cultural events, and community-run cafes and activities. botanical roof garden covering 9,000 m2 of industrial area. locally designed storm-water management system with green roofs that intercept half of total yearly runoff, avoiding flooding, and draining into channels and ponds, supporting local biodiversity.
236	Ecobarrio Suerte 90	FENAVIP + local community	2005	1. Contemporary	Sustainable life-style support systems Community participation and user's satisfaction	A8 A10	◆ ◆	E10 E15	Food supply Leisure, recreation and psychophysical health	low-cost earthquake-resistant self-construction through mutual help. individual and collective vegetable and medicinal gardens. ‘Native Germoplasm Bank’ for cultivation of 12 endangered species of native fruit trees. integrated system for solid waste management. agricultural cooperatives and cultural programmes for young people. recreational parks for sports and leisure activities. cement, bricks and blocks made from locally available recycled debris and sugar cane ashes.
237	El Coso municipal office building and public space - *the mysterious story of the garden that makes water*	Monica García Fernández + Javier Rubio Montero	2003	1. Contemporary	Adaption to eco-physical values and restraints	A1	►	E4	Water cycling and regulation	biodiversity, water recycling, harvest and retention [the project capitalizes topography to collect and retain water and create green resorts that preserve, recycle, and purify water, supporting flora and fauna species], erosion prevention and mitigation [revegetation of slope areas]. unrestricted access to all visitors, including handicapped and those with reduced mobility. flora and fauna species plan, and time phasing. water purification and nutrient cycling
238	Dune [anti-desertification architecture]	Magnus Larsson	2008	1. Contemporary	Materials cycle [and waste] Concept originality, innovation and creativity	A6 A13	◆	E7 E6	Erosion control and hazard protection Climatic regulation	refugee housing and “green wall” barrier to further expansion of the desert. insitu materials. creation of human habitats through micro-biotechnology [bacillus pasteurii metabolic processes that bind sand into sandstone and structurally stable formations for semi-natural dwellings; regenerative and permacultural feedback loops. rainwater swales, tunnel digging down to aquifer, creation of microclimates through diging to find shadow and underground water.
239	Putrajaya 2C5 Commercial Development	Ken Yeang - T. R. Hamzah & Yeang International	2011	1. Contemporary	Energy cycle [and atmospheric emissions] Exterior areas and local pollution control	A4 A7	◄ ◆	E6	Climatic regulation	bioswales, rain water harvest, green wall, green balconies, species selection for macro and microclimate, green connectivity, use of local ornamental pattern
240	Grotão Community Center [urban remediation and civic infrastructure hub]	Urban Think Tank [Alfredo Brillembourg]	[2011 project] 2014 [estimated]	1. Contemporary	Community participation and user's satisfaction Exterior areas and local pollution control	A10 A7	◆ ◆	E7	Erosion control and hazard protection	urban remediation in a zone of increased erosion and dangerous mudslides, high-risk site in the favela. Connection between building and landscape. Water reused onsite, wetlands filtering

Concretization	Environmental Assessment	Method	Rating	Country	Location	Geographic Cluster	Use | Function	Scale	Context	Sources
1. Built | Realized	1. Certified	LEED	Gold	Canada	Toronto	1. America-Pacific	1. Residential	2. Building	1. Urban	Carrot City: http://www.ryerson.ca/carrotcity/board_pages/housing/60_richmond.html "60 Richmond Housing Cooperative / Teeple Architects" 02 Nov 2010. ArchDaily. Accessed 07 Apr 2014. <http://www.archdaily.com/?p=85762>
2. Unbuilt | Plan	2. Non-certified	[...]		U. K.	Bolton	2. Europe-Africa-Middle East	1. Residential	2. Building	2. Sub-urban	Carrot City: http://www.ryerson.ca/carrotcity/board_pages/housing/edible_terrace.html
2. Unbuilt | Plan	2. Non-certified	[...]		China	Wuhan	3. S and E Asia-Oceania	1. Residential	2. Building	1. Urban	Carrot City: http://www.ryerson.ca/carrotcity/board_pages/housing/agro-housing.html http://www.archdaily.com/228981/agro-housing-knafo-klimor-architects/
2. Unbuilt | Plan	2. Non-certified	[...]		U. S. A.	Non specified	1. America-Pacific	4. Mixed Use	2. Building	1. Urban	http://www.agro-arcology.com/ Carrot City: http://www.ryerson.ca/carrotcity/board_pages/housing/vertical_farm_arcology.html
1. Built | Realized	1. Certified	BREEAM [Europe 2009 version 1.1] HQE ISSEO – Issy les Moulineaux Charter	Outstanding Exceptionnel Certified	France	Issy-les-Moulineaux, Paris	2. Europe-Africa-Middle East	6. Offices	2. Building	1. Urban	http://www.breeam.org/podpage.jsp?id=679 http://www.viguier.com/en/project/5/Zenora
1. Built | Realized	1. Certified	BREEAM version: Offices 2006	Excellent	U. K.	Aberystwyth	2. Europe-Africa-Middle East	6. Offices	2. Building	2. Sub-urban	http://www.powelldobson.com/en/projects/offices/regional-offices
1. Built | Realized	1. Certified	BREEAM	Excellent	U. K.	Cheshire Oaks, Chester	2. Europe-Africa-Middle East	5. Commercial	2. Building	2. Sub-urban	http://www.breeam.org/podpage.jsp?id=655 http://www.aukettfitzroyrobinson.com/03_expertise/3C_sustainability/3C_02_im.htm http://corporate.marksandspencer.com/blog/stories/mands-cheshire-oaks-store
1. Built | Realized	1. Certified	BREEAM	Excellent	Lebanon	Batroun	2. Europe-Africa-Middle East	1. Residential	2. Building	2. Sub-urban	http://www.breeam.org/page.jsp?id=695 http://mahanasrallaharchitects.blogspot.pt/2014_01_07_archive.html http://www.archileb.com/article.php?id=774 http://www.ajbuildingslibrary.co.uk/projects/display/id/6778
2. Unbuilt | Plan	2. Non-certified	[...]		France	Paris	2. Europe-Africa-Middle East	4. Mixed Use	2. Building	1. Urban	http://rathausartprojects.com/blog/2008/11/06/living-tower-soa-architects/ http://www.ateliersoa.fr/verticalfarm_fr/pages/images/press_urban_farm.pdf http://www.soa-architectes.fr/en/#/en/projects/show/27
2. Unbuilt | Plan	2. Non-certified	[...]		Egypt	Cairo	2. Europe-Africa-Middle East	4. Mixed Use	2. Building	1. Urban	http://www.evolo.us/competition/seeds-of-life-skyscraper/
2. Unbuilt | Plan	2. Non-certified	[...]		[...]	[non specified]	3. S and E Asia-Oceania	1. Residential	1. Component	1. Urban	http://www.evolo.us/competition/propagate-skyscraper-carbon-dioxide-structure/
2. Unbuilt | Plan	2. Non-certified	[...]		China	Shanghai	3. S and E Asia-Oceania	4. Mixed Use	2. Building	1. Urban	http://www.evolo.us/competition/water-re-balance-skyscraper-collects-and-purifies-rainwater/
2. Unbuilt | Plan	2. Non-certified	[...]		[...]	[non specified]	1. America-Pacific	4. Mixed Use	2. Building	1. Urban	http://www.evolo.us/competition/infill-aquifer/
1. Built | Realized	2. Non-certified	[...]		U. K.	Hackbridge, London	2. Europe-Africa-Middle East	1. Residential	4. Ensemble	2. Sub-urban	http://www.oneplanetcommunities.org/communities/bedzed/ http://en.wikipedia.org/wiki/BedZED http://upload.wikimedia.org/wikipedia/commons/0/05/BedZED_2007.jpg
1. Built | Realized	2. Non-certified	[...]		Sweden	Malmo	2. Europe-Africa-Middle East	1. Residential	4. Ensemble	2. Sub-urban	http://www.worldhabitatawards.org/winners-and-finalists/project-details.cfm?lang=00&theProjectID=8A312D2B-15C5-F4C0-990FBF6CBC573B8F http://www.malmo.se/download/18.af27481124e354c8f1800015944/1383649554009/AugustenborgBroschyr_
1. Built | Realized	2. Non-certified	[...]		Colombia	Cali	1. America-Pacific	4. Mixed Use	4. Ensemble	1. Urban	http://www.worldhabitatawards.org/winners-and-finalists/project-details.cfm?lang=00&theProjectID=290 https://www.facebook.com/pages/Ecobarrio-Suerte-90/268315423264941?sk=timeline
1. Built | Realized	2. Non-certified	[...]		Spain	Cehegín, Murcia	2. Europe-Africa-Middle East	7. Public Space	3. Land Unit	1. Urban	http://src.holcimfoundation.org/dnl/6bc41d1a-77e8-426b-a0f0-2ffdaff1a48f/HolcimAwards05_EUR_acknC.pdf http://comocrearhistorias.com/?p=632
2. Unbuilt | Plan	2. Non-certified	[...]		Nigeria	Sokoto [Sahara Desert]	2. Europe-Africa-Middle East	4. Mixed Use	5. Plan	3. Non-urban	http://src.holcimfoundation.org/dnl/6751e406-9386-4d28-a880-4c1e4b3cf696/HolcimAwards08_AME_NextGen1st_B.pdf http://islamicartsmagazine.com/magazine/view/sahara_surreal_-_magnus_larsson/
2. Unbuilt | Plan	1. Certified	GBI	Silver	Malaysia	Putrajaya	3. S and E Asia-Oceania	5. Commercial	2. Building	1. Urban	http://src.holcimfoundation.org/dnl/8e2951e5-b125-4f25-952f-40f1b8e73a4b/HolcimAwards11_APAC_bronze.pdf http://www.trhamzahyeang.com/project/large-buildings/Putrajaya_01.html http://src.holcimfoundation.org/dnl/6b53ad12-1492-4e6d-
1. Built | Realized	2. Non-certified	[...]		Brazil	São Paulo	1. America-Pacific	3. Cultural	2. Building	1. Urban	http://src.holcimfoundation.org/dnl/9287d7b2-4dda-4741-aa5a-052ea7f2c647/HolcimAwards11_LATAM_gold.pdf http://www.u-tt.com/projects_Grotao.html

Appendix III. Specific Target Cases Data Records

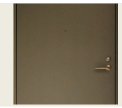
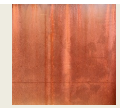
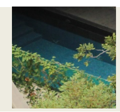
Dancing Trees, Singing Birds

Identification and location of surface materials and textures

	Identification: [image]	designation	Surface Integration: enclosure	base envelope	lateral envelope	top envelope	on-site landscape
1		Concrete slabs + grass pavement	.	.	.	.	●
2		Pebbles #1	.	.	.	.	●
3		Pebbles #2	.	.	.	.	●
4		Vegetation area #1 [natural soil + trees]	.	.	.	.	●
5		Concrete slabs	.	.	.	.	●
6		Japanese Cypress Board [wall]	.	.	●	●	.
7		Grey plastered concrete	.	.	●	.	.
8		White plastered concrete	.	.	●	.	.
9		Wood deck	.	.	.	●	.
10		Glass [windows, and mirror surfaces]	.	.	●	.	.

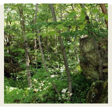
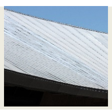
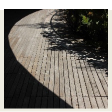
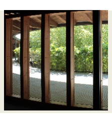
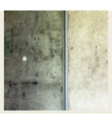
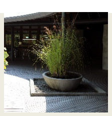
Dancing Trees, Singing Birds

Identification and location of surface materials and textures

	Identification: [image]	designation	Surface Integration: enclosure	base envelope	lateral envelope	top envelope	on-site landscape
11		Metal [doors]	.	.	●	.	.
12		Corten Steel [wall]	.	.	.	.	●
13		Metal Grid [wall]	.	.	●	.	●
14		Water [pool and ponds]	.	.	.	.	●
15		Stone slabs	.	.	.	.	●
16		Ceramic Tiles	.	.	.	●	.
17		Flower beds	.	.	.	●	.

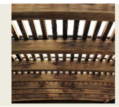
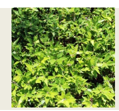
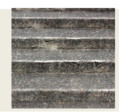
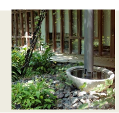
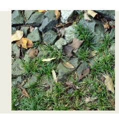
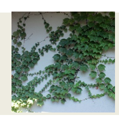
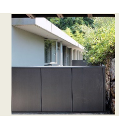
Makino Museum of Plants and People

Identification and location of surface materials and textures

	Identification: [image]	designation	Surface Integration: enclosure	base envelope	lateral envelope	top envelope	on-site landscape
1		Vegetation area # 1 [Kochi Ecological Garden]	.	.	.	.	●
2		Aggregate pavement	.	.	.	.	●
3		Stone wall	.	.	.	.	●
4		Galvanized steel [Roof]	.	.	.	●	.
5		Hinoki Wood [walls and roof cladding]	●	.	●	●	.
6		Concrete	.	.	●	.	.
7		Wood deck	.	●	.	.	●
8		Glass and Wood [windows and doors]	.	.	●	.	.
9		Glass and Metal [windows and doors]	.	.	●	.	.
10		Water collecting ponds	.	.	.	●	●

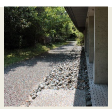
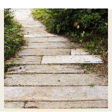
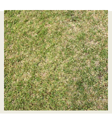
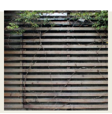
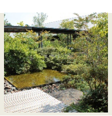
Makino Museum of Plants and People

Identification and location of surface materials and textures

	Identification: [image]	designation	Surface Integration: enclosure	base envelope	lateral envelope	top envelope	on-site landscape
11		Covered gallery	.	.	.	●	●
12		Pebbles #1	.	.	.	.	●
13		Courtyard 1	.	.	.	.	●
14		Pebbles #2	.	.	.	.	●
15		Bamboo area	.	.	.	.	●
16		Concrete [stairs]	.	.	.	.	●
17		Water collecting ponds #2 [courtyard BF1]	.	.	.	.	●
18		Big pebbles #3	.	.	.	.	●
19		White plastered concrete [partialy covered with ivy]	.	.	●	.	.
20		Metal [walls, and doors]	.	.	●	.	●

Makino Museum of Plants and People

Identification and location of surface materials and textures

	Identification:		Surface Integration				
	[image]	designation	enclosure	base envelope	lateral envelope	top envelope	on-site landscape
21		Concrete pavement [pavement]	.	.	.	.	●
22		Stone pavement	.	.	.	.	●
23		Metal covered gallery	.	.	.	●	●
24		Unpaved [dirt] road	.	.	.	.	●
25		Betuminous pavement [pavement]	.	.	.	.	●
26		Square Ponds	.	.	.	.	●
27		Reclaimed wood boards pavement	.	.	.	.	●
28		Lawn	.	.	.	.	●
29		Wood louver	.	.	●	.	●
30		Courtyard 2 [Exhibition hall]	.	.	.	.	●

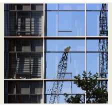
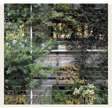
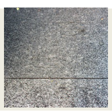
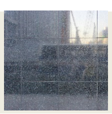
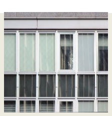
Makino Museum of Plants and People

Identification and location of surface materials and textures

	Identification:		Surface Integration				
	[image]	designation	enclosure	base envelope	lateral envelope	top envelope	on-site landscape
31		Other vegetated areas	.	.	.	.	●

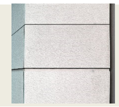
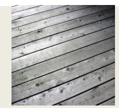
Pasona Urban Farm

Identification and location of surface materials and textures [abridged version]

	Identification: [image]	designation	Surface Integration enclosure	base envelope	lateral envelope	top envelope	on-site landscape
1		Glass façade	.	.	●	.	.
2		Living wall	.	.	●	.	.
3		Stone cladding	.	.	●	.	.
4		Rail	.	.	●	.	.
5		Metal cladding	.	.	●	.	.
6		Granite pavement	.	.	.	.	●
7		Glass windows	.	.	●	.	.
8		Grey plaster	.	.	●	.	.
9		Granite cladding	.	.	●	.	.
10		Glass façade #2	.	.	●	.	.

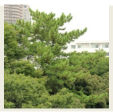
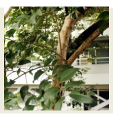
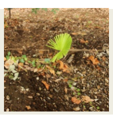
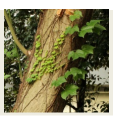
Pasona Urban Farm

Identification and location of surface materials and textures [abridged version]

	Identification: [image]	designation	Surface Integration enclosure	base envelope	lateral envelope	top envelope	on-site landscape
11		Stone cladding	.	.	●	.	.
12		Metal doors	.	.	●	.	.
13		Wood deck	.	.	.	●	.
14		Extensive green roof	.	.	.	●	.
15		Glass skylights	.	.	.	●	.

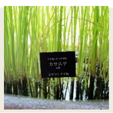
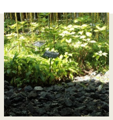
Dancing Trees, Singing Birds

Identification and location of flora species [abridged version]

	Identification:		Strata and growth				Life span and leaf drop			Origin			Surface Integration						Location
	[image]	designation	herb(aceous)	climber	shrub	tree	evergreen	deciduous	bi/annual	native	exotic	invasive	enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	areas
1		Grass [Non identified]	●	.	.	.	●	.	.	(●)	.	.	.	.	.	.	●	.	• Entrance
2		Other herbaceous [Non identified]	●	.	.	.	●	.	●	(●)	.	.	.	.	.	.	●	.	• Entrance • South limit vegetation area
3		Pine tree *Pinus thunbergii*	.	.	.	●	●	.	.	●	.	.	.	.	.	.	●	.	• South limit vegetation area
4		Trees [Non identified]	.	.	.	●	.	●	.	(●)	.	.	.	.	.	.	●		• South limit vegetation area
5		Trees [Non identified]	.	.	.	●	●	.	.	(●)	.	.	.	.	.	.	●		• South limit vegetation area
6		Fan Palm Arecaceae sub. Corypheae *[Rhapidophyllum]*	.	.	●	●	●	.	.	.	(●)	.	.	.	.	.	●		• South limit vegetation area
7		Creeper plants [Non identified]	.	●	.	.	(●)	.	.	.	.	.	.	.	.	.	●		• South limit vegetation area
8		Ornamental species [Non identified]	●	.	.	.	(●)	(●)	.	.	.	.	.	.	.	●	.		• Rooftop

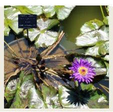
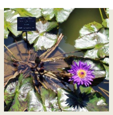
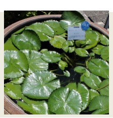
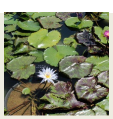
Makino Museum of Plants and People

Identification and location of flora species [abridged version]

	Identification:		Strata and growth				Life span and leaf drop			Origin			Surface Integration						Location
	[image]	designation	herb(acious)	climber	shrub	tree	evergreen	deciduous	bi/annual	native	exotic	invasive	enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	areas
1		Bamboo *Shibataea kumasasa* オカメザサ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Entrance ● Research & Administration Building
2		Triangular club-rush *Schoenoplectus triqueter* サンカクイ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Research & Administration Building - Water collecting ponds ● Exhibition Hall - Water collecting Pond #9
3		[...] *Juncus decipiens* イ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Research & Administration Building - Water collecting ponds
4		Kasasuge *Carex dispalata* カサスゲ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Research & Administration Building - Water collecting ponds
5		Hitomotosusuki *Cladium jamaicence subsp. Chinense* ヒトモトススキ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Research & Administration Building - Water collecting ponds
6		Makino Bamboo *Phyllostachys makinoi Hayata* タイワンマダケ	●	.	.	.	●	.	.	● [origin: Taiwan, introduced in Japan]	.	.	.	.	.	.	●	.	● Research & Administration Building - Courtyard BF1
7		Sakakikazura *Anodendron affine* サカキカズラ	.	●	●	.	●	.	.	●	.	.	.	.	.	.	●	.	● Research & Administration Building - Courtyard BF1
8		*Syneilesis tagawae* ヤブレガサモドキ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Research & Administration Building - Courtyard BF1
9		Kudzu /Japanese arrowroot *Pueraria lobata f. leucostachya*	.	●	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Research & Administration Building - Courtyard BF1
10		*Alpinia intermedia* アオノクマタケラン	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Research & Administration Building - Courtyard BF1

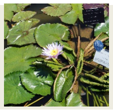
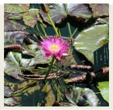
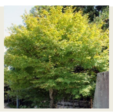
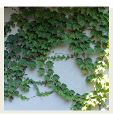
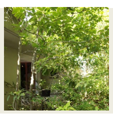
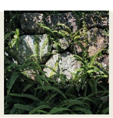
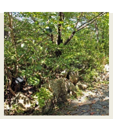
Makino Museum of Plants and People

Identification and location of flora species [abridged version]

	Identification:		Strata and growth				Life span and leaf drop			Origin			Surface Integration						Location
	[image]	designation	herb(acious)	climber	shrub	tree	evergreen	deciduous	bi/annual	native	exotic	invasive	enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	areas
11	 wikipedia	Ezo hydrangea *Hydrangea serrata var. megacarpa* エゾアジサイ	·	·	●	·	·	●	·	●	·	·	·	·	·	·	●	·	● Research & Administration Building - Courtyard BF1
12		*Hydrangea involucrata var. tokarensis* トカラタマアジサイ	·	·	●	·	·	●	·	●	·	·	·	·	·	·	●	·	● Research & Administration Building - Courtyard BF1
13		Big leaf hydrangea *Hydrangea macrophylla f. normalis* ガクアジサイ	·	·	●	·	·	●	·	●	·	·	·	·	·	·	●	·	● Research & Administration Building - Courtyard BF1
14		Water lilies *Nymphaea* [diverse cultivars]	●	·	·	·	●	·	·	●	·	·	·	·	·	·	●	·	● Research & Administration Building - Courtyard BF1 ● Exhibition Hall - Courtyard Garden [also some on square ponds]
14a		Nymphaea "Murasaki Shikibu"	●	·	·	·	●	·	·	● [cultivar]	·	·	·	·	·	·	●	·	● Research & Administration Building - Courtyard BF1
14b		Nymphaea "Tanzanite"	●	·	·	·	●	·	·	·	● [cultivar]	·	·	·	·	·	●	·	● Research & Administration Building - Courtyard BF1
14c		Nymphaea "Albert Greenberg"	●	·	·	·	●	·	·	·	● [cultivar]	·	·	·	·	·	●	·	● Research & Administration Building - Courtyard BF1
14d		Nymphaea "St Louis Gold	●	·	·	·	●	·	·	·	● [cultivar]	·	·	·	·	·	●	·	● Research & Administration Building - Courtyard BF1
14e		Nymphaea lotus	●	·	·	·	●	·	·	·	●	·	·	·	·	·	●	·	● Research & Administration Building - Courtyard BF1
14f		Nymphaea "Marmorata"	●	·	·	·	●	·	·	·	● [cultivar]	·	·	·	·	·	●	·	● Research & Administration Building - Courtyard BF1

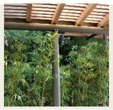
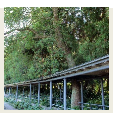
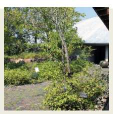
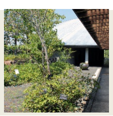
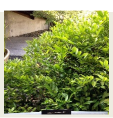
Makino Museum of Plants and People

Identification and location of flora species [abridged version]

Identification:			Strata and growth				Life span and leaf drop			Origin			Surface Integration						Location
	[image]	designation	herb(acious)	climber	shrub	tree	evergreen	deciduous	bi/annual	native	exotic	invasive	enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	areas
14g		Nymphaea "Alexis"	●	.	.	.	●	.	.	.	● [cultivar]	.	.	.	.	.	●	.	● Research & Administration Building - Courtyard BF1
14h		Nymphaea "Miami Rose"	●	.	.	.	●	.	.	.	● [cultivar]	.	.	.	.	.	●	.	● Research & Administration Building - Courtyard BF1
15		Japanese Maple *Acer palmatum var. amoenum*	.	.	.	●	.	●	.	●	.	.	.	.	.	.	●	.	● Research & Administration Building - [around]
16		Ivy *Hedera*	.	●	.	.	●	.	.	●	.	.	.	.	●	.	.	.	● Research & Administration Building
17		Longstalk Holly *Ilex pedunculosa* ソヨゴ	.	.	.	●	●	.	.	●	.	.	.	.	.	.	●	.	● Research & Administration Building - [around]
18		*Eurya japonica var. japonica* ヒサカキ	.	.	.	●	●	.	.	●	.	.	.	.	.	.	●	.	● Research & Administration Building - [around]
19		Sendai-ya *Prunus jamasakura* センダイヤ	.	.	.	●	.	●	.	●	.	.	.	.	.	.	●	.	● Research & Administration Building - [around]
20		Japanese wood fern *Dryopteris erythrosora* [ベニシダ]	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Research & Administration Building - [around]
21		Malva stonecrop *Sedum makinoi Maxim.* マルバマンネングサ	●	●	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Research & Administration Building - [around] ● Exhibition Hall - Courtyard Garden
22		*Clethra barbinervis* リョウブ	.	.	.	●	.	●	.	●	.	.	.	.	.	.	●	.	● Research & Administration Building - [around]

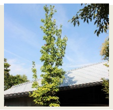
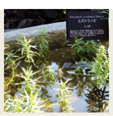
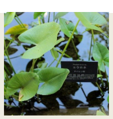
Makino Museum of Plants and People

Identification and location of flora species [abridged version]

	Identification:		Strata and growth				Life span and leaf drop			Origin			Surface Integration						Location
	[image]	designation	herb(acious)	climber	shrub	tree	evergreen	deciduous	bi/annual	native	exotic	invasive	enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	areas
23		Kichijousou *Reineckea carnea* キチジョウソウ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Research & Administration Building - [around]
24		Narihira bamboo *Semiarundinaria fastuosa Makino* アオナリヒラ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Walkway
25		*Cremastra appendiculata* (D. Don) Makino サイハイラン	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Walkway
26		Monkey Grass *Ophiopogon japonicus* [リュウノヒゲ]	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Walkway
27		Japanese Ceddar [Sugi] *Cryptomeria japonica* 杉	.	.	.	●	●	.	.	●	.	.	.	.	.	.	●	.	● Walkway
28		*Berchemia berchemiaefolia* (Makino)Koidz. ヨコグラノキ（横倉の木）	.	.	.	●	.	●	.	●	.	.	.	.	.	.	●	.	● Walkway
29		*Rhodotypos scandens* シロヤマブキ	.	.	●	.	.	●	.	●	.	.	.	.	.	.	●	.	● Walkway
30		Ashitaba *Angelica keiskei [Angelica utilis Makino]* アシタバ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
31		Laurel-leaved snail tree *Cocculus laurifolius DC*. イソヤマアオキ	.	.	●	.	●	.	.	●	.	.	.	.	.	.	●	.	● Research & Administration Building ● Exhibition Hall - Courtyard Garden
32		*Chionanthus retusus* Lindl & Paxton ヒトツバタゴ	.	.	.	●	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden

Makino Museum of Plants and People

Identification and location of flora species [abridged version]

	Identification:		Strata and growth				Life span and leaf drop			Origin			Surface Integration						Location
	[image]	designation	herb(acious)	climber	shrub	tree	evergreen	deciduous	bi/annual	native	exotic	invasive	enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	areas
33		Red Maple *Acer rubrum* アメリカハナノキ	·	·	·	●	·	●	·	·	●	·	·	·	·	·	●	·	● Exhibition Hall - Courtyard Garden
34		*Nuphar subintegerrima* (Casp.) Makino ヒメコウホネ	●	·	·	·	●	·	·	●	·	·	·	·	·	·	●	·	● Exhibition Hall - Courtyard Garden
35		Pygmy Water-lily *Nymphaea tetragona* ヒツジグサ	●	·	·	·	●	·	·	●	·	·	·	·	·	·	●	·	● Exhibition Hall - Courtyard Garden
36		*Sparganium subglobosum* ヒメミクリ	●	·	·	·	●	·	·	●	·	·	·	·	·	·	●	·	● Exhibition Hall - Courtyard Garden
37		Water chestnut *Eleocharis kuroguwai* クログワイ	●	·	·	·	●	·	·	●	·	●	·	·	·	·	●	·	● Exhibition Hall - Courtyard Garden
38		*Persicaria hastatosagittata* (Makino) Nakai メガバノ ウナギツカミ	●	·	·	·	·	·	●	●	·	·	·	·	·	·	●	·	● Exhibition Hall - Courtyard Garden
39		*Dysophylla yatabeana Makino* ミズトラノオ	●	·	·	·	●	·	·	●	·	·	·	·	·	·	●	·	● Exhibition Hall - Courtyard Garden
40		*Rotala hippuris Makino* ミズスギナ	●	·	·	·	●	·	·	●	·	·	·	·	·	·	●	·	● Exhibition Hall - Courtyard Garden
41		Rabbit-ear Iris / Kakitsubata *Iris laevigata* カキツバタ	●	·	·	·	●	·	·	●	·	·	·	·	·	·	●	·	● Exhibition Hall - Courtyard Garden
42		*Nuphar japonica* コウホネ	●	·	·	·	●	·	·	●	·	·	·	·	·	·	●	·	● Exhibition Hall - Courtyard Garden

Makino Museum of Plants and People

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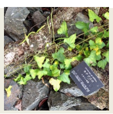
43		Buckbean *Menyanthes trifoliata* ミツガシワ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
44		Sweet Flag [or Calamus] *Acorus calamus* ショウブ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
45		*Scirpus tabernaemontani Gmel.* フトイ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
46		*Sagittaria trifolia* L. var typica Makino f. suitensis Makino スイタクワイ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
47		*Dioscorea gracillima* タチドコロ	●	●	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
48		*Asplenium antiquum Makino* オオタニワタリ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
49		Wild cherry *Prunus jamasakura* ヤマザクラ	.	.	.	●	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
50		Makinoi's Holly Fern *Polystichum makinoi* カタイノデ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
51		*Coptis quinquefolia* Miq. Var. shikokumontana Kadota, and Var. stolonifera makino シコクバイカオウレン	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Research & Administration Building ● Kochi Ecological Garden ● Exhibition Hall - Courtyard Garden [Plants associated with Dr. Makino]	representative or identified species [in Makino Botanical Garden Map]
52		*Tricyrtis hirta* サツマホトトギス	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	

Makino Museum of Plants and People

Identification and location of flora species [abridged version]

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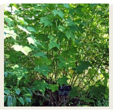
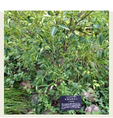
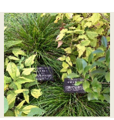
	[image]	designation	herb(acious)	climber	shrub	tree	evergreen	deciduous	bi/annual	native	exotic	invasive	enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	areas
53		*Camellia japonica* [Tosa Uraku] ヤブツバキ	.	.	●	●	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
54		*Hibiscus mutabilis* L. Versicolor スイフヨウ	.	.	●	.	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
55		*Salvia nipponica* Miq. キバナアキギリ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
56		Sweet Osmanthus *Osmanthus fragrans Lour. Var. thunbergil Makino (1927)*	.	.	●	●	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
57		*Weigela Coraeensis* ハコネウシギ	.	.	●	.	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
58		Magnolia *Magnolia×soulangeana* (M. dorsopurpurea) ソトベニハクモクレン	.	.	.	●	.	●	.	. [hybrid cultivar]	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
59		*Hibiscus makinoi* Jotani H. Ohba サキシマフヨウ	.	.	●	●	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
60		*Euonymus chibai Makino* ヒゼンマユミ	.	.	●	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
61		*Microtropis japonica / Otherodendron japonicum Makino* モクレイシ	.	.	●	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
62		*Clematis speciosa* オオクサボタン	●	●	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden

Identification and location of flora species [abridged version]

	Identification:		Strata and growth				Life span and leaf drop			Origin			Surface Integration						Location	
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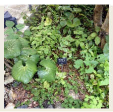
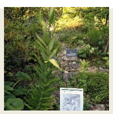
63		*Persicaria filiformis* ギンミズヒキ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
64		Orange Osmanthus *Osmanthus fragrans* var. aurantiacus キンモクセイ	.	.	●	●	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
65		*Epimedium grandiflorum* var. thunbergianum イカリソウ	●	.	.	.	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
66		*Chloranthus spicatus* チャラン	●	.	.	.	●	.	.	.	● [China - introduced in Edo]	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
67		*Rhododendron latoucheae* Franch. セイシカ	.	.	.	●	●	.	.	●	● [China]	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
68		Sakuyuri *Lilium Auratum var. Platyphyllum* サクユリ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden [Plants associated with Dr. Makino]	representative or identified species [in Makino Botanical Garden Map]
69		*Corchoropsis crenata* カラスノゴマ	●	.	.	.	.	.	●	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
70		*Hosta sieboldiana* var. condensata/var. glauca Makino トクダマ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
71		Winged spindle *Euonymus alatus* ニシキギ	.	.	●	.	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
72		Bellflower *Campanula punctata* ホタルブクロ	●	.	.	.	●	.	.	●	● [Korea]	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	

Makino Museum of Plants and People

Identification and location of flora species [abridged version]

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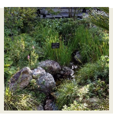
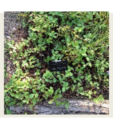
73		Rosegold pussy willow *Salix graciiistyla Miq.* クロヤナギ	.	.	●	.	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
74		*Agrimonia pilosa* var. japonica キンミズヒキ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
75		Japanese sago palm *Cycas revoluta* ソテシ	.	.	●	●	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
76		*Mentha japonica* ヒメハッカ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
77		*Iris ensata* var. spontanea / Iris ensata var. ensata ノハナシヨウブ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
78		*Lythrum anceps* (Koehne) Makino ミソハギ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
79		*Disporum sessile* ホウチヤクソウ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
80		*Pittosporum illicioides Makino* コヤスノキ	.	.	●	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
81		*Fragaria nipponica Makino* シロバナ　ノヘビイチゴ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
82		*Puisatilla cernua* オキナグサ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden

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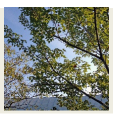
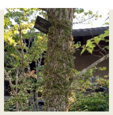
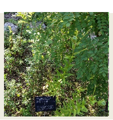
83		*Elaeagnus umbellata* var. rotundifolia Makino マルバアキグミ	.	.	●	.	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
84		*Hydrangea macrophylla* var. acuminata シチダンカ	.	.	●	.	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
85		Viburnum *Viburnum dilatatum* ガマズミ	.	.	●	.	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
86		*Hydrangea macrophylla* var. serrata var. japonica ベニガクアジサイ	.	.	●	.	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
87		*Acer pycnanthum* K. koch ハナノキ	.	.	.	●	.	●	.	● [endemic]	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
88		*Cleisostoma scolopendrifolium* (Makino) Garay ムカデラン	.	●	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
89		*Hydrangea serrata* var. thumbergil アマチヤ	.	.	●	.	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
90		*Hydrangea serrata* f. prolifera シチダンカ	.	.	●	.	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
91		*Desmodium heterocarpon* シバハギ	●	.	●	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
92		Ougon'oni lily *Lilium lancifolium var. flaviflorum* オウゴンオニユリ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden

Makino Museum of Plants and People

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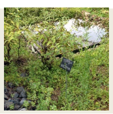
93		*Maachia tashiroi* Makino シマエンジュ			●			●		●							●		● Exhibition Hall - Courtyard Garden	
94		*Deutzia cremata* / Deutzia scabra ウツギ			●			●		●							●		● Exhibition Hall - Courtyard Garden	
95		Weeping higan cherry *Prunus pendulata Maxim.* エドヒガン				●		●		●							●		● Exhibition Hall - Courtyard Garden	
96		*Dendrobium catenatum* Lindl. キバナノセッコク	●	●			●			●							●		● Exhibition Hall - Courtyard Garden	
97		*Lycopus ramosissimus* (Makino) ヒメサルダヒコ	●				●			●							●		● Exhibition Hall - Courtyard Garden	
98		*Hamamelis japonica* var. bitchuensis アテシマンサク			●	●		●		●							●		● Exhibition Hall - Courtyard Garden	
99		Japanese winterberry *Ilex serrata* ウメモドキ			●			●		●							●		● Exhibition Hall - Courtyard Garden	
100		*Aster hispidus* ヤナギノギク	●						●	●							●		● Exhibition Hall - Courtyard Garden	
101		*Berchemia berchemiaefolia* ヨコグラノキ				●		●		●							●		● Exhibition Hall - Courtyard Garden	
102		Nakagawa River wild daisy *Chrysanthemum yoshinaganthum* ナカガワノギク	●				●			●							●		● Exhibition Hall - Courtyard Garden [Plants associated with Dr. Makino]	representative or identified species [in Makino Botanical Garden Map]

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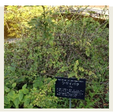
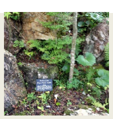
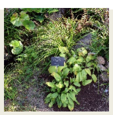
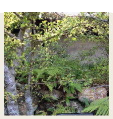
	Identification:		Strata and growth				Life span and leaf drop			Origin			Surface Integration						Location	
	[image]	designation	herb(acious)	climber	shrub	tree	evergreen	deciduous	bi/annual	native	exotic	invasive	enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	areas	
103		*Chrysanthemum shiwogiku* シオギク	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden [Plants associated with Dr. Makino]	representative or identified species [in Makino Botanical Garden Map]
104		*Tilia kiusiana* Makino & Shiras ヘラノキ	.	.	.	●	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
105		*Osbeckia chinensis* L. ヒメノボタン	●	.	●	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
106		*Rosa fujisanensis* フジイバラ	.	.	●	.	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
107		*Geranium yoshinoi* Makino ex Nakai ビッチュウフウロ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
108		*Forsythia japonica* Makino ヤマトレンギヨウ	.	.	●	.	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
109		*Rhododendron weyrichii* f. albiflorum シロバナオンシシジ	.	.	●	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
110		*Pseudolysimachion rotundum* (Nakai) var. petiolatum ヒメトラノオ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
111		*Chioranthus fortunei* キビヒトリシズカ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
112		*Tricyrtis macrantha* ジヨウロウホトトギス	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	

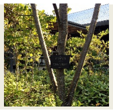
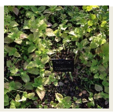
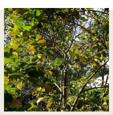
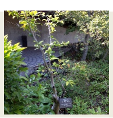
Makino Museum of Plants and People

Identification and location of flora species [abridged version]

	Identification:		Strata and growth				Life span and leaf drop			Origin			Surface Integration						Location
	[image]	designation	herb(acious)	climber	shrub	tree	evergreen	deciduous	bi/annual	native	exotic	invasive	enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	areas
113		Silky wisteria *Wisteria brachybotrys* シロカピタン	.	●	.	.	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
114		Manadzuruzakura *Prunus x affinis Makino f. manadzuruensis Sugimoto*	.	.	.	●	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
115		*Stewartia rostrata*	.	.	●	●	.	●	.	.	● [China]	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
116		Japanese Maple *Acer palmatum var. amoenum* オオモミジ	.	.	●	●	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
117		*Epimedium grandiflorum* var. thunbergianum イカリソウ	●	.	.	.	●	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
118		*Hosta montana* F. Maek. オオバギボウシ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
119		Nara Koh double cherry *Prunus verecunda* / Prunus donarium var. pubescens Makino	.	.	.	●	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
120		*Spiraea nipponica* Maxim. Var. tosaensis トサシモツケ	.	.	●	.	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
121		*Pyrrosia lingua* "Variegata" フイリヒトツバ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
122		*Malus spontanea* ノカイドウ	.	.	●	●	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden

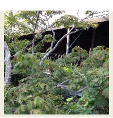
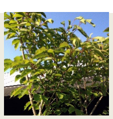
Makino Museum of Plants and People

Identification and location of flora species [abridged version]

	Identification:		Strata and growth				Life span and leaf drop			Origin			Surface Integration						Location
	[image]	designation	herb(acious)	climber	shrub	tree	evergreen	deciduous	bi/annual	native	exotic	invasive	enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	areas
123		*Rhododendron dilatatum* Miq. var. decandrum Makino トサノミツバツツジ	.	.	●	.	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
124		*Prunus x kanzakura* Makino cv. Kanzakura カンザクラ	.	.	.	●	.	●	.	● [cultivar]	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
125		*Meehania urticifolia* Makino ラシヨウモンカズラ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
126		*Dianthus superbus* var. longicalycinus カワラナデシコ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
127		*Rhododendron dilatatum* var. decandrum トサノミツバツツジ	.	.	●	.	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
128		*Camellia japonica* L. subs. Japonica f. leucantha シロバナヤブツバキ	.	.	●	●	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
129		*Salvia koyamae* Makino シナノアキギリ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
130		Goldfish Camellia *Camellia japonica 'Kingyo-tsubaki'* キンギョツバキ	.	.	●	●	●	.	.	● [cultivar]	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
131		*Rhododendron makinoi* Tagg ex Nakai ホソバシヤクナゲ	.	.	●	.	●	.	.	● [endemic]	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
132		*Rhododendron ripense* Makino キシツツジ	.	.	●	.	●	.	.	● [endemic]	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden

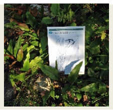
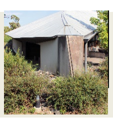
Makino Museum of Plants and People

Identification and location of flora species [abridged version]

	Identification:		Strata and growth				Life span and leaf drop			Origin			Surface Integration						Location
	[image]	designation	herb(acious)	climber	shrub	tree	evergreen	deciduous	bi/annual	native	exotic	invasive	enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	areas
133		*Leptodermis puichella* Yatabe シチョウゲ	.	.	●	.	.	●	.	● [endemic]	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
134		*Rhododendron weyrichii* Maxim. オソつつじ	.	.	●	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
135		*Hakonechloa macra* Makino ex Honda ウラハグサ	●	.	.	.	●	.	.	● [endemic]	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
136		*Hypericum ascyron* トモエソウ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
137		*Lagerstroemia indica* サルスベリ	.	.	.	●	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
138		Clove grass *Amsonia elliptica* チヨウジソウ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
139		*Aster microcephalus* var. ovatus ノコソギク	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
140		*Acer japonicum* f. parsonsii / A. japonica 'Aconitifolium マイクジヤク	.	.	.	●	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
141		*Stewartia pseudocamellia* Maxim. ナツツバキ	.	.	.	●	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden
142		*Sapium japonicum* シラキ	.	.	●	●	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden

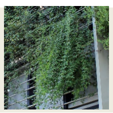
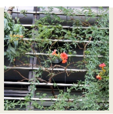
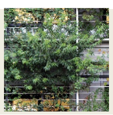
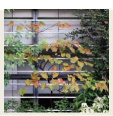
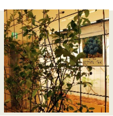
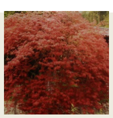
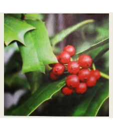
Makino Museum of Plants and People

Identification and location of flora species [abridged version]

	Identification:		Strata and growth				Life span and leaf drop			Origin			Surface Integration						Location	
	[image]	designation	herb(acious)	climber	shrub	tree	evergreen	deciduous	bi/annual	native	exotic	invasive	enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	areas	
143		*Woodwardia unigemmata* ハイコモチシダ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
144		*Pyrrosia Lingua* ヒトシバ	●	.	.	.	●	.	.	● (grey)	● (grey)	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
145		*Deparia x lobatocrenat* ヒトシバシケシダ	●	.	.	.	●	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
146		*Deparia okuboana* (Makino) M.Kato オオヒメワラビ	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
147		Asian pear *Pyrus pyrifolia* var. culta ナシ	.	.	.	●	.	●	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
148		Big Blue Lilyturf *Liriope muscari* [ヤブラン]	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	almost spontaneous in all areas: ● Research & Administration Building - Courtyard BF1 ● Kochi Ecological Garden	
149		Herbaceous [Nnon identified]	●	.	.	.	●	.	.	● (grey)	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden	
150		Japanese lily *Lilium speciosum*	●	.	.	.	●	.	.	●	.	.	.	.	.	.	●	.	● Exhibition Hall - Courtyard Garden [Plants associated with Dr. Makino]	representative or identified species [in Makino Botanical Garden Map]
151		Shrub [Non identified]	.	.	●	.	● (grey)	.	.	● (grey)	.	.	.	.	.	.	●	.	● Exhibition Hall - [around]	

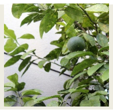
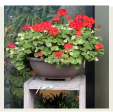
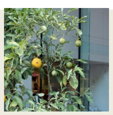
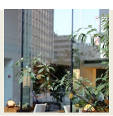
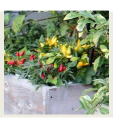
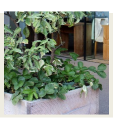
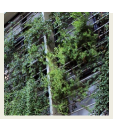
Pasona Urban Farm

Identification and location of flora species [abridged version]

Identification:			Strata and growth				Life span and leaf drop			Origin			Surface Integration						Location
	[image]	designation	herb(aceous)	climber	shrub	tree	evergreen	deciduous	bi/annual	native	exotic	invasive	enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	areas
1		Crape myrtle *Lagerstroemia indica* サルスベリ	.	.	●	●	.	●	.	●	.	.	.	.	●	.	.	.	● Green wall | Balcony
2		Rose [diverse cultivars] ツルバラ/バラ	.	●	●	.	●	.	.	●	.	.	●	.	●	●	.	.	● Green wall | Balcony ● Indoor Urban Farm 1F ● Rooftop
3		Japanese wisteria *Wisteria floribunda* フジ	.	●	.	.	.	●	.	● [endemic]	.	.	.	.	●	.	.	.	● Green wall | Balcony
4		Broom *Cytisus* エニシダ	.	.	●	.	●	●	.	.	●	.	.	.	●	.	.	.	● Green wall | Balcony
5		Chinese Trumpet Vine *Campsis grandiflora* ノウゼンカズラ	.	●	.	.	.	●	.	●	.	.	.	.	●	.	.	.	● Green wall | Balcony
6		*Callistemon speciosus* カリステモン	.	.	●	.	●	.	.	.	● [Australia]	.	.	.	●	.	.	.	● Green wall | Balcony
7		Chinese tallow tree *Triadica sebifera* ナンキンハゼ	.	.	.	●	.	●	.	.	● [Taiwan]	.	.	.	●	.	.	.	● Green wall | Balcony
8		Blueberry *Vaccinium* [diverse cultivars] ブルーベリー	.	.	●	.	●	●	.	.	● [American continent]	.	●	.	●	.	.	.	● Green wall | Balcony ● Indoor Urban Farm 2F
9		Acer モミジ	.	.	●	●	.	●	.	●	.	.	.	.	●	.	.	.	● Green wall | Balcony
10		Holly *Ilex aquifolium* ホーリー	.	.	●	.	●	.	.	.	●	.	.	.	●	.	.	.	● Green wall | Balcony

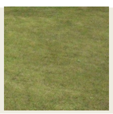
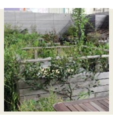
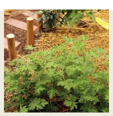
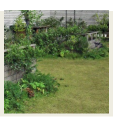
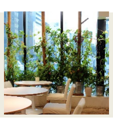
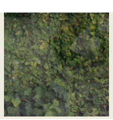
Pasona Urban Farm

Identification and location of flora species [abridged version]

	Identification:		Strata and growth				Life span and leaf drop			Origin			Surface Integration						Location
	[image]	designation	herb(aceous)	climber	shrub	tree	evergreen	deciduous	bi/annual	native	exotic	invasive	enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	areas
11		Pyracantha ピラカンサ	.	.	●	.	●	.	.	●	.	.	.	.	●	.	.	.	● Green wall | Balcony
12		*Satsuma mandarin* *Citrus unshiu* ミカン	.	.	●	●	●	.	.	●	.	.	.	.	●	.	.	.	● Green wall | Balcony
13		Guava *Psidium guajava* グアバ	.	.	●	●	●	.	.	.	●	.	.	.	●	.	.	.	● Green wall | Balcony
14		Geranium *Geranium* [diverse species]	●	.	.	.	●	.	●	.	●	.	.	.	●	.	.	.	● Green wall | Balcony
15		*Lemon tree* *Citrus limon*	.	.	●	●	●	.	.	.	● [southern Asia] [cultivar]	.	.	.	●	.	.	.	● Green wall | Balcony
16		Variegated Lemon *Citrus limon "Variegated Pink Eureka"*	.	.	●	●	●	.	.	.	. [cultivar]	.	.	.	●	.	.	.	● Green wall | Balcony
17		Peach tree *Prunus persica*	.	.	●	●	.	●	.	.	● [China] [cultivar]	.	.	.	●	.	.	.	● Green wall | Balcony
18		Peppers *Capsicum frutescens*	●	.	.	.	●	.	●	.	● [America] [cultivar]	.	.	.	●	.	.	.	● Green wall | Balcony
19		Strawberry *Fragaria × ananassa*	●	●	.	.	●	.	●	.	. [cultivar]	.	.	.	●	.	.	.	● Green wall | Balcony
20		Asparagus アスパラガス	●	.	.	.	●	.	.	●	●	.	.	.	●	.	.	.	● Green wall | Balcony

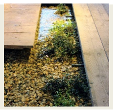
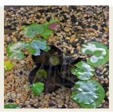
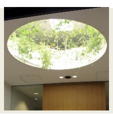
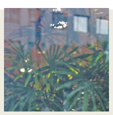
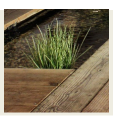
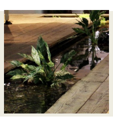
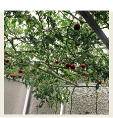
Pasona Urban Farm

Identification and location of flora species [abridged version]

	Identification:		Strata and growth				Life span and leaf drop			Origin			Surface Integration						Location
	[image]	designation	herb(aceous)	climber	shrub	tree	evergreen	deciduous	bi/annual	native	exotic	invasive	enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	areas
21		Rosemary *Rosmarinus officinalis* ローズマリー	.	.	●	.	●	.	.	.	● [Mediterranean]	.	.	.	●	.	.	.	● Green wall | Balcony ● Indoor Urban Farm 2F
22		Shrub [Non identified]	.	.	●	.	● (grey)	.	.	.	.	.	.	.	●	.	.	.	● Green wall | Balcony
23		Acer *Acer negundo 'Flamingo'* ネグンドウカエデ フラミンゴ	.	.	.	●	.	●	.	.	● [North America] [cultivar]	.	.	.	●	.	.	.	● Green wall | Balcony
24		Grass [Non identified]	●	.	.	.	●	.	.	. [cultivar]	.	.	.	.	.	●	.	.	● Rooftop
25		Evergreen Clematis *Clematis armandii* 常緑クレマチス アーマンディ	.	●	.	.	●	.	●	.	● [China, Burma]	.	.	.	.	●	.	.	● Rooftop
26		Olive *Olea europaea* オリーブ	.	.	.	●	●	.	.	.	● [Mediterranean]	.	.	.	.	●	.	.	● Rooftop
27		Rose geranium *Pelargonium graveolens* ローズゼラニウム	.	.	●	.	●	.	.	.	● [Africa] [cultivar]	.	●	.	.	●	.	.	● Rooftop ● Indoor Urban Farm 2F
28		Others spontaneous herbacious [Non identified]	●	.	.	.	●	.	●	● (grey)	● (grey)	.	.	.	.	●	.	.	● Rooftop
29		Golden pothos *Epipremnum aureum*	.	●	.	.	●	.	.	●	.	.	●	.	.	.	.	.	● Indoor Urban Farm 1F Cafeteria
30		Common Ivy *Hedera helix*	.	●	.	.	●	.	.	.	● [Eurasia]	. [can be]	●	.	.	.	.	.	● Indoor Urban Farm 1F Cafeteria

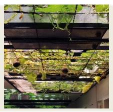
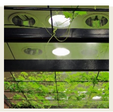
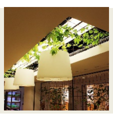
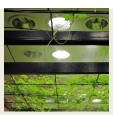
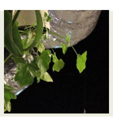
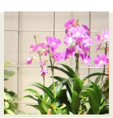
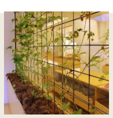
Pasona Urban Farm

Identification and location of flora species [abridged version]

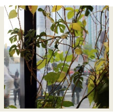
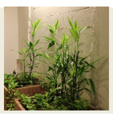
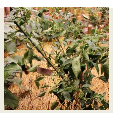
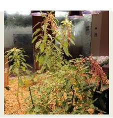
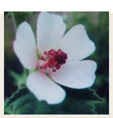
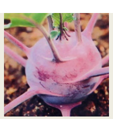
	Identification: [image]	designation	Strata and growth: herb(aceous)	climber	shrub	tree	Life span and leaf drop: evergreen	deciduous	bi/annual	Origin: native	exotic	invasive	Surface Integration: enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	Location: areas
31		Japanese Ivy *Hedera rhombea*	.	●	.	.	●	.	.	●	.	.	●	.	.	.	.	.	● Indoor Urban Farm 1F
32		Water herbacious [Not identified]	●	.	.	.	●	.	.	.	.	.	●	.	.	.	.	.	● Indoor Urban Farm 1F Lobby
33		Water herbacious [Not identified]	●	.	.	.	.	.	●	.	.	.	●	.	.	.	.	.	● Indoor Urban Farm 1F Lobby
34		Water lilies *Nymphaea* [diverse cultivars]	●	.	.	.	●	.	.	.	.	.	●	.	.	.	.	.	● Indoor Urban Farm 1F Lobby
35		Rudbeckia	●	.	.	.	●	.	●	.	● [North America]	.	●	.	.	.	.	.	● Indoor Urban Farm 1F-9F Hall Ceiling
36		Bamboo Palm *Chamaedorea sefritzii*	●	.	.	●	●	.	.	.	● [Central America]	.	●	.	.	.	.	.	● Indoor Urban Farm 1F Lobby
37		Spider plant *Chlorophytum comosum* オリヅルラン	●	.	.	.	●	.	.	.	● [Africa]	.	●	.	.	.	.	.	● Indoor Urban Farm 1F Lobby
38		Chinese evergreen *Aglaonema*	●	.	.	.	●	.	.	.	● [southeast Asia]	.	●	.	.	.	.	.	● Indoor Urban Farm 1F Lobby
39		Tomato *Solanum lycopersicum*	.	●	.	.	●	.	●	.	● [America] [cultivar]	.	●	.	.	.	.	.	● Indoor Urban Farm 1F Meeting room ceiling
40		Lettuce *Lactuca sativa*	●	.	.	.	.	.	●	.	● [Eurasia] [cultivar]	.	●	.	.	.	.	.	● Indoor Urban Farm 1F-2F

Pasona Urban Farm

Identification and location of flora species [abridged version]

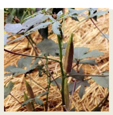
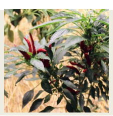
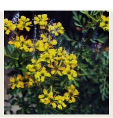
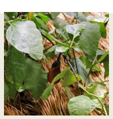
	Identification:		Strata and growth				Life span and leaf drop			Origin			Surface Integration						Location
	[image]	designation	herb(aceous)	climber	shrub	tree	evergreen	deciduous	bi/annual	native	exotic	invasive	enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	areas
41		Herbaceous [Not identified]	●	.	.	.	●	.	.	.	.	.	●	.	.	.	.	.	● Indoor Urban Farm 1F-9F Hall Ceiling
42		*Philodendron xanadu*	●	.	.	.	●	.	.	.	●	.	●	.	.	.	.	.	● Indoor Urban Farm 1F-9F Hall Ceiling
43		Japanese pumpkin *Cucurbita maxima* [jap. var.] カボチャ	.	●	.	.	.	.	●	. [cultivar]	● [America]	.	●	.	.	.	.	.	● Indoor Urban Farm 1F-2F, 9F
44		Cucumber キョウリ *Cucumis sativus*	.	●	.	.	.	.	●	.	● [South Asia] [cultivar]	.	●	.	.	.	.	.	● Indoor Urban Farm 1F-2F
45		Bitter gourd / Goya *Momordica charantia* ゴーヤー	.	●	.	.	.	.	●	. [cultivar]	● [India] [cultivar]	.	●	.	.	.	.	.	● Indoor Urban Farm 1F-9F Hall Ceiling
46		キョウリ *Cucumis sativus* [other variety]	.	●	.	.	.	.	●	.	● [South Asia] [cultivar]	.	●	.	.	.	.	.	● Indoor Urban Farm 1F-2F
47		Passion fruit *Passiflora edulis*	.	●	●	.	●	.	.	.	● [South America] [cultivar]	.	●	.	.	.	.	.	● Indoor Urban Farm 2F-9F Partition
48		Syngonium *Syngonium podophyllum*	●	●	.	.	●	.	.	.	● [South and Central America]	.	●	.	.	.	.	.	● Indoor Urban Farm 1F-9F Hall Ceiling
49		Dendrobium Orchids [diverse species]	●	.	.	.	●	.	.	●	.	.	●	.	.	.	.	.	● Indoor Urban Farm 1F Lobby
50		Raspberry *Rubus idaeus* ラズベリー	.	●	.	.	●	.	.	● [some var.]	● [cultivar]	.	●	.	.	.	.	.	● Indoor Urban Farm 2F-9F Partition

Identification and location of flora species [abridged version]

	Identification: [image]	designation	Strata and growth: herb(aceous)	climber	shrub	tree	Life span and leaf drop: evergreen	deciduous	bi/annual	Origin: native	exotic	invasive	Surface Integration: enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	Location: areas
51		Chili peppers *Capsicum annuum* トウガラシ	●	.	●	.	●	.	.	.	● [American continent] [cultivar]	.	●	.	.	.	.	.	● Indoor Urban Farm 2F
52		Malabar spinach *Basella Alba* ツルムラサキ	.	●	.	.	●	.	.	.	●	.	●	.	.	.	.	.	● Indoor Urban Farm 2F
53		*Monstera deliciosa* / or Philodendron pertusum	.	●	.	.	●	.	.	.	● [American continent]	.	●	.	.	.	.	.	● Indoor Urban Farm 1F Cafeteria
54		"Lucky bamboo" *Dracaena braunii*	●	.	.	.	●	.	.	.	● [Africa]	.	●	.	.	.	.	.	● Indoor Urban Farm 2F-9F Hall
55		Bell pepper *Capsicum annuum 'grossum'* ピーマン	●	.	●	.	.	.	●	.	● [American continent] [cultivar]	.	●	.	.	.	.	.	● Indoor Urban Farm 1F-2F
56		Rice *Oryza sativa* 米	●	.	.	.	.	.	●	● [cultivar]	.	.	●	.	.	.	.	.	● Indoor Urban Farm 1F
57		Corn *Zea mays subsp. mays*	●	.	.	.	.	.	●	.	● [Africa] [cultivar]	.	●	.	.	.	.	.	● Indoor Urban Farm 1F
58		Amaranth *Amaranthus* アマランサス	●	.	.	.	.	.	●	.	●	.	●	.	.	.	.	.	● Indoor Urban Farm 1F
59		Marshmallow *Althaea officinalis* マーシュマロウ	●	.	.	.	●	.	.	.	● [Africa]	.	●	.	.	.	.	.	● Indoor Urban Farm 2F
60		Kohlrabi *Brassica oleracea var. gongylodes* コールラビ	●	.	.	.	.	.	●	.	●	.	●	.	.	.	.	.	● Indoor Urban Farm 2F

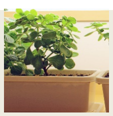
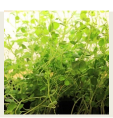
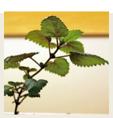
Pasona Urban Farm

Identification and location of flora species [abridged version]

	Identification:		Strata and growth				Life span and leaf drop			Origin			Surface Integration						Location
	[image]	designation	herb(aceous)	climber	shrub	tree	evergreen	deciduous	bi/annual	native	exotic	invasive	enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	areas
61		Common yarrow *Achillea millefolium* ヤロウ　（オワイト）	●	.	.	.	●	.	.	.	● [Europe]	.	●	.	.	.	.	.	● Indoor Urban Farm 2F
62		Common mallow Malva sylvestris コモンマロウ	●	.	.	.	●	.	●	.	●	.	●	.	.	.	.	.	● Indoor Urban Farm 2F
63		Shell ginger Alpinia zerumbet 月桃 [ゲットウ]	●	.	.	.	●	.	.	●	.	.	●	.	.	.	.	.	● Indoor Urban Farm 2F
64		Wormwood *Artemisia indica Willd. var. orientalis* ニシヨモギ	●	.	.	.	●	.	.	●	.	.	●	.	.	.	.	.	● Indoor Urban Farm 2F
65		Physalis *Physalis alkekengi* ホオズキ	●	.	.	.	●	.	.	●	.	. [can be invasive]	●	.	.	.	.	.	● Indoor Urban Farm 2F
66		Okra/ Ladies fingers *Abelmoschus esculentus* オクラレッドサン	●	.	.	.	●	.	●	.	● [cultivar]	.	●	.	.	.	.	.	● Indoor Urban Farm 2F
67		Chilli pepper [japanese var. "Claws of a hawk"] タカノツメ	●	.	●	.	●	.	.	● [cultivar]	●	.	●	.	.	.	.	.	● Indoor Urban Farm 2F
68		Rue *Ruta graveolens* ルー	●	.	●	.	●	.	.	.	● [Europe]	.	●	.	.	.	.	.	● Indoor Urban Farm 2F
69		Fennel Foeniculum vulgare フェンネル	●	.	.	.	●	.	.	.	● [Mediterranean]	.	●	.	.	.	.	.	● Indoor Urban Farm 2F
70		[Kamo] Eggplant *Solanum melongena* 賀茂ナス	●	.	.	.	●	.	●	● [cultivar]	● [origin: India]	.	●	.	.	.	.	.	● Indoor Urban Farm 2F

Pasona Urban Farm

Identification and location of flora species [abridged version]

	Identification: [image]	designation	Strata and growth: herb(aceous)	climber	shrub	tree	Life span and leaf drop: evergreen	deciduous	bi/annual	Origin: native	exotic	invasive	Surface Integration: enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	Location areas
71		Spearmint *Mentha spicata* スペアミント	●	.	.	.	●	.	.	●	.	.	●	.	.	.	.	.	● Indoor Urban Farm 2F
72		Long eggplant *Solanum melongena* 長ナス	●	.	.	.	●	.	●	● [cultivar]	● [origin: India]	.	●	.	.	.	.	.	● Indoor Urban Farm 2F
73		Pineapple Mint *Mentha suaveolens 'Variegata'* パイナップルミント	●	.	.	.	●	.	.	.	● [Mediterranean]	.	●	.	.	.	.	.	● Indoor Urban Farm 2F
74		Ground ivy *Glechoma hederacea* グレコマ	.	●	.	.	●	.	.	●	.	.	●	.	.	.	.	.	● Indoor Urban Farm 2F
75		Lemon myrtle *Backhousia citriodora* レモンマートル	.	.	●	.	●	.	.	.	● [Australia]	.	●	.	.	.	.	.	● Indoor Urban Farm 2F
76		Curry plant *Helichrysum italicum* カレープランツ	.	.	●	.	●	.	.	.	● [Mediterranean]	.	●	.	.	.	.	.	● Indoor Urban Farm 2F
77		Cuban oregano *Plectranthus amboinicus* アロマティカス	●	.	.	.	●	.	.	.	● [Africa]	.	●	.	.	.	.	.	● Indoor Urban Farm 2F
78		Common sage *Salvia officinalis* セージ	.	.	●	.	●	.	.	● [naturalized]	● [Mediterranean]	.	●	.	.	.	.	.	● Indoor Urban Farm 2F
79		Pea sprout *Pisum sativum* スプラウト　（豆苗）	.	●	.	.	.	.	●	.	● [China] [cultivar]	.	●	.	.	.	.	.	● Indoor Urban Farm 2F
80		Lemon balm *Melissa officinalis* レモンバーム	●	.	.	.	●	.	.	.	● [cultivar]	.	●	.	.	.	.	.	● Indoor Urban Farm 2F

Pasona Urban Farm

Identification and location of flora species [abridged version]

	Identification:		Strata and growth				Life span and leaf drop			Origin			Surface Integration						Location
	[image]	designation	herb(aceous)	climber	shrub	tree	evergreen	deciduous	bi/annual	native	exotic	invasive	enclosure	base envelope	lateral envelope	top envelope	on-site landscape	off-site	areas
81		Oregano *Origanum vulgare* オレガノ	●	.	.	.	●	.	.	.	● [Eurasia] [cultivar]	.	●	.	.	.	.	.	● Indoor Urban Farm 2F

Appendix IV. Qualitative Data Surveys Script and Information Materials

RESEARCH QUESTIONNAIRE [number:

[on local ecosystem regeneration strategies within architectural design: support tool for project analysis and design solutions] [date: : : 2013

Description and purpose:

The following questions are addressed to professionals and future professionals in the field of architecture: students, architects, researchers and consultants.

The resulting data will be treated anonymously, for the use in Research in Architecture conducted under the PhD Program of the Faculty of Architecture, University of Tokyo. The purpose of the present research focus on the integration of micro-local ecosystem regeneration within architectural design process (design solutions and strategies for architectural quality and local ecology), object of thesis dissertation.

Section 1. Background information and control data

1. Please indicate:

a. Your current age: ________ (in completed years)
b. Your nationality: ________

c. Current occupation: ________ [ex: student, practice professional, researcher, professor, consultant]
d. Work experience: ________ (in years)
e. Academic level: ________ completed/attending [ex: undergraduate, bachelor, graduate diploma, masters, PhD, postdoc]
f. Area of study: ________ [please refer to your latest or more accurate field of specialization]

2. Did you knew previously the SPECIFIC PROJECT, prior to this questionnaire? Yes No

a. If Yes, please specify all apliccable:	From magazines, books, online sources or lectures	Yes	No
	From case study technical sheets, monographies, design or consultancy materials	Yes	No
	From direct observation [exterior of the project]	Yes	No
	From direct observation [interior of the project]	Yes	No

Section 2. Application of support tool: analysis of project and design solutions [Please fill in the table in the next page] ➔

Section 3. Validation and assessment of support tool

1. How would you define your interest/knowledge in the fields of sustainability, bioclimatic architecture, green design and ecology?
[Please use a scale from 0 to 5 [being 0 = not important, 1 = almost not important, 2 = somewhat important, 3 = important, 4 = very important, 5 = extremely important]

0 1 2 3 4 5

2. According to the indicators in previous section, what areas do you consider more important to define architectural design quality?
[Please use a scale from 0 to 5 [being 0 = not important, 1 = almost not important, 2 = somewhat important, 3 = important, 4 = very important, 5 = extremely important]

MACRO-LOCAL RELATIONS	0	1	2	3	4	5
ENVIRONMENTAL BALANCE	0	1	2	3	4	5
BUILDING CONSTRUCTION	0	1	2	3	4	5
COMFORT	0	1	2	3	4	5
CONCEPTUAL-PERCEPTIVE QUALITY	0	1	2	3	4	5
FUNCTIONALITY	0	1	2	3	4	5
SOCIO-ECONOMIC RELEVANCE	0	1	2	3	4	5

3. What areas of architecture design quality would you consider to have a stronger correlation with local ecology?
[Please use a scale from 0 to 5 [being 0 = not important, 1 = almost not important, 2 = somewhat important, 3 = important, 4 = very important, 5 = extremely important]

MACRO-LOCAL RELATIONS	0	1	2	3	4	5
ENVIRONMENTAL BALANCE	0	1	2	3	4	5
BUILDING CONSTRUCTION	0	1	2	3	4	5
COMFORT	0	1	2	3	4	5
CONCEPTUAL-PERCEPTIVE QUALITY	0	1	2	3	4	5
FUNCTIONALITY	0	1	2	3	4	5
SOCIO-ECONOMIC RELEVANCE	0	1	2	3	4	5

4. Do you consider that the integration of local ecology regeneration strategies can beneficiate overall architecture design quality? Yes No

5. Do you consider that a design support tool for local ecology integration could be useful during design process? Yes No

6. Do you consider that the reasoning raised by the application of the support tool, in Section 2, enhanced your perception of ecosystem regeneration potentialities within architectural design?

Yes No

THANK YOU for your time and cooperation to complete the questionnaire!

(If you have further comments and suggestions, please write them here:)

Section 2. Application of support tool: analysis of project and design solutions [cont.]

1. Based on your knowledge and on the data provided, how would you consider that the following aspects influence positively* each other, in the SPECIFIC PROJECT?

[Please fill in the cells of the table in this page, using the following scale:

● Mutual positive influence
● Positive influence on local ecology parameters
● Positive influence on architecture quality parameters
○ No positive influence/ not relevant
/ Not enough information/ no available data

	LOCAL ECOSYSTEM SERVICES AND FUNCTIONS	01. SUPPORTING					02. REGULATING						03. PROVISIONING					04. CULTURAL			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	ARCHITECTURE QUALITY PARAMETERS	Soil formation and fertility	Photosynthesis and primary production	Nutrient cycling and waste treatment	Water cycling and regulation	Biodiversity refugium and nursery habitats	Air quality regulation	Climatic regulation	Water purification	Erosion control and hazard protection	Biological control & pollination	Perceptive environmental modulation	Food supply	Fresh water supply	Fibers and raw materials	Fuel and energy sources	Ornamental and medicinal resources	Sense of place and local identity	Cultural and artistic and scientific resources	Landscape aesthetic fruition	Leisure, recreation and psychophysical health
	01. MACRO-LOCAL RELATIONS																				
1	Adaption to eco-physical values and restraints																				
2	Sense of place and cultural identity																				
3	Transports and functional articulation with the context																				
	02. ENVIRONMENTAL BALANCE																				
4	Biodiversity and ecosystem																				
5	Energy [and atmospheric emissions]																				
6	Water [and effluents]																				
7	Materials [and solid waste]																				
8	Other sources of local pollution																				
9	Sustainable life-style support systems																				
	03. SOCIO-ECONOMIC RELEVANCE																				
10	Customization possibilities and operation																				
11	Community participation and user's satisfaction																				
12	Social responsible construction practices																				
13	Economic dynamics and lifecycle costs																				
14	Human health and well being																				
	04. CONCEPTUAL-PERCEPTIVE QUALITY																				
15	Concept originality, innovation and creativity																				
16	Visual																				
17	Acoustics																				
18	Tactility and motion perception																				
19	Olfactory																				
	05. COMFORT																				
20	Acoustics																				
21	Lighting																				
22	Indoor air quality																				
23	Humidity and temperature																				
24	Exterior areas																				
	06. FUNCTIONALITY																				
25	Ergonomy, accessibility and universal design																				
26	Adequacy to function, occupancy and circulation																				
	03. BUILDING CONSTRUCTION																				
27	Details and finishes																				
28	Execution quality and process management																				
29	Structure quality and stability																				
30	Durability and maintenance of systems and materials																				
31	Safety and emergency systems																				

Section 2. Application of support tool: **[Indicators description]**

ECOSYSTEM SERVICES AND FUNCTIONS:

[indicator]	[description]
01. SUPPORTING	
Soil formation and fertility	Weathering of rock and accumulation of organic matter, for natural productive soils
Photosynthesis and primary production	Production of oxygen by plants, and assimilation and accumulation of energy and nutrients by organisms
Nutrient cycling and waste treatment	Role of biota in storage and cycling of 20 life-essential nutrients, remove/breakdown compounds and control their concentration in air, soil, and water
Water cycling and regulation	Water cycling and concentration in the ecosystem, land cover regulating role in timing and magnitude of runoff, flooding, and aquifer recharge
Biodiversity and nursery habitats	Protection of endangered and native species, provision of habitats [food, water, shelter...] and conditions for reproduction and breeding
02. REGULATING	
Air quality regulation	Bio-chemical balance and particle filter/removal of the atmosphere performed by vegetation
Climatic regulation	Land cover and vegetation influence at local scale, on temperature, humidity, precipitation and wind
Water purification	Filter and decomposing of nutrient and compounds in inland and marine waters
Erosion control and hazard protection	Soil retention and landslide prevention, natural buffers [soil, vegetation, etc.] role in moderation of extreme wind, water and waves
Biological control & pollination	Biological control of pests and diseases vectors, pollinator conditions for plants reproduction and production of seeds and fruits
Perceptive environmental modulation	Perceptive moderation and environmental comfort modulation of light, noise, etc.
03. PROVISIONING	
Food supply	Provision of edible habitats: crops, livestock, fisheries, aquaculture, wild food sources
Fresh water supply	Provision to fresh water resource [filtering, retention and storage]
Fibers and raw materials	Provision and renewability of raw material sources: wood, cotton, hemp, bamboo, sand, stone, fodder, etc.
Fuel and energy sources	Provision and renewability of energy sources: wood, biomass and [solar, eolic, tidal and geothermal]
Ornamental and medicinal resources	Provision and renewability of animal, vegetal and mineral ornamental and medicinal sources
04. CULTURAL	
Sense of place and local identity	Identity features of the ecosystem, significant species, historical cultural landscapes, valuation of sacred landscape areas and elements
Cultural and artistic and scientific resources	Inspirational sources for literature, cinema, architecture, arts & crafts, formal and informal educational, scientific research and knowledge systems
Landscape aesthetic fruition	Fruition of landscape features, scenery valuation, belvederes and nature observation points
Leisure, recreation and psychophysical health	Landscapes with potential recreational use, outdoor sports and leisure, healthy environment and food, and psychological balance

ARCHITECTURE QUALITY PARAMETERS:

01. MACRO-LOCAL RELATIONS	
Adaption to eco-physical values and restraints	Site selection, hydrography and topography adequacy
Sense of place and cultural identity	Socio-cultural context references, identity attributes, landscape marks, system of views, behavioral and cultural adequacy and relevance
Transports and functional articulation w/ context	Relations with local infrastructures and volumes, proximity to daily life functions, materials, energy and water sources and low impact mobility
02. ENVIRONMENTAL BALANCE	
Biodiversity and ecosystem	Local impact on soil, water and nutrient cycle, biodiversity and other ecological processes
Energy cycle & atmospheric emissions	Passive performance, renewable energy use, energy consumption in construction and occupancy, greenhouse gases emissions and control
Water cycle & effluents	Interior and exterior water consumption, rain water harvest, waste water management, local waste water treatment, waste water reuse
Materials cycle & solid waste	Locally sourced, recycled, renewable and low impact materials, design for deconstruction and biodegrability, local waste treatment and hazardous waste management
Other sources of local pollution	Light pollution, noise, heat island effects and glare
Sustainable life-style support systems	Provision and encouragement for kitchen gardens, compost, low mobility transport, laundry natural dry , etc.
03. SOCIO-ECONOMIC RELEVANCE AND OCCUPANCY	
Customization possibilities and operation	Interior space and envelope control, extension and modification possibilities, ease of operation of comfort mechanisms
Community participation and user's satisfaction	Participatory processes, engagement with local communities and stakeholders, user targeting, social relevance
Social responsible construction practices	Multifunctional uses and typologies, intergenerational mix, construction work security and responsible material sourcing
Economic dynamics and lifecycle costs	Economic impact and distribution, balance of initial investment, operation and end use costs
Human health and well being	Human health and well-being, socio-psychological comfort aspects, qualitative occupancy comfort
04. CONCEPTUAL-PERCEPTIVE QUALITY	
Concept originality, innovation and creativity	Artistic and conceptual valuation, contemporaneity, innovation, logic and intention
Visual	Scale, rhythm and volume, material colors, texture, transparency/opaqueness, light/shadow, framing and views
Acoustics	Interior acoustic properties [sound reflection, propagation, and absorption], sounds from uses and materials
Tactility and motion perception	Surfaces texture and motion perception [pavement regularity, steepness and height level]
Olfactory	Scents from materials and uses
05. COMFORT	
Acoustics	Internal and external noise control, sound propagation
Lighting	Natural maximization and artificial minimization, function adapted to comfort levels, glare avoidance
Indoor air quality	Air renovation, VOC's, humidity condensations
Humidity and temperature	Hygrothermal comfort through daily and annual cycles
Exterior areas	Heat island effect, amenities, landscape, wind, shadows, safety
06. FUNCTIONALITY	
Ergonomy, accessibility and universal design	Spatial adequacy to human movements and dimensions, access and easiness of use by handicapped or elderly people
Adequacy to function, occupancy & circulation	Spatial, material and organizational adequacy to functions, occupancy capacity and circulation flows fitness
07. BUILDING CONSTRUCTION	
Details and finishes	Durability, coherence, and rigor of finishing materials
Execution quality and process management	Rigor of construction methods, on-site management, quality control processes and project management during life cycle
Structure quality and stability	Resistance to regular loads, structure design and hazard preparedness
Durability & maintenance of systems and materials	Long life cycles of systems and materials, resistance to regular use and hazard, ease of substitution or repair, local maintenance
Safety and emergency systems	Fire, earthquake, flood, intrusion and hazard prevention, mitigation and evacuation systems

Indicators

Scale of Analysis

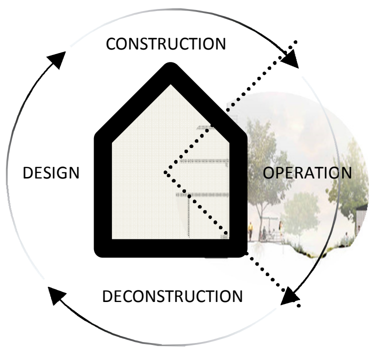
In this survey, Ecosystem Integration is expressed by positive interactions between Architecture decisions and solutions with Local Ecology, creating opportunities to increase at the same time the quality of design and the environment.

THE ANALYSIS OF POSITIVE INTERACTIONS BETWEEN ECOSYSTEM AND ARCHITECTURE INDICATORS, **FOCUS AT**:

ECOSYSTEM CRITERIA:

LOCAL SCALE:
within project site limits and immediate environs

ARCHITECTURE QUALITY CRITERIA:



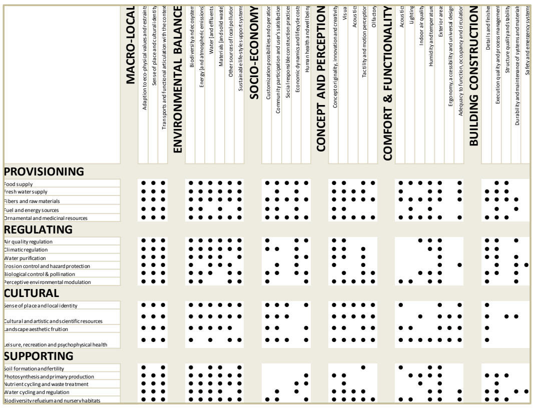
WHOLE LIFE CYCLE:
within the most relevant stage(s) to each parameter

Collaborative Interactions

Positive interactions - towards local ecology, architectural quality, or both - between 2 Indicators of Ecosystem and Architecture Criteria are designated as COLLABORATIVE INTERACTIONS.

COLLABORATIVE INTERACTIONS FORM THE STRUCTURE OF THE PROPOSED **DESIGN ASSISTANCE RESOURCES:**

DESIGN ASSISTANCE TOOL
Assessment and communication of Ecosystem Integration in a single project



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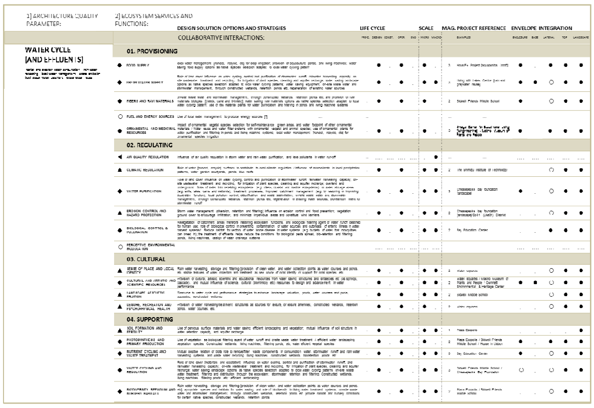
REFERENCE DATABASE
Catalogue of multiple project references for Ecosystem Integration



Local Ecosystem

In this research, Local Ecosystem Criteria is based on ECOSYSTEM FUNCTIONS AND SERVICES [the essential ecological processes and tangible and intangible benefits derived to human well-being].

ECOSYSTEM SERVICES AND FUNCTIONS
ARE ORGANIZED INTO **4 AREAS**:

SUPPORTING

REGULATING

PROVISIONING

CULTURAL

Local Ecosystem: Services and Functions

SUPPORTING

E1 SOIL FORMATION AND FERTILITY Weathering of rock and accumulation of organic matter for productive soils

E2 PHOTOSYNTHESIS AND PRIMARY PRODUCTION Oxygen production and accumulation of energy by plants

E3 NUTRIENT CYCLING AND POLLUTION TREATMENT Storage, cycling and balance of chemical elements in air, soil, and water by organisms

E4 WATER CYCLING AND REGULATION Concentration and cycle of water through the ecosystem, runoff regulation and aquifer recharge

E5 BIODIVERSITY AND HABITATS Provision of food, water, shelter and reproduction conditions to endangered and native species

REGULATING

E6 CLIMATIC REGULATION Land cover and vegetation influence on local temperature, humidity, precipitation and wind

E7 EROSION CONTROL AND HAZARD PROTECTION Mitigation of extreme wind, flood, landslide and soil dispersion by vegetation and topography

E8 BIOLOGICAL CONTROL & POLLINATION Biota role to control pests and diseases and assure plants pollination and reproduction

E9 PERCEPTIVE ENVIRONMENT MODULATION Moderation, filter and modulation of light and sound through natural elements

PROVISIONING

E10 FOOD SUPPLY Production of edible goods (agriculture, livestock, fisheries or wild food sources)

E11 FRESH WATER SUPPLY AND PURIFICATION Filtering, retention and storage of water for consumption

E12 RAW MATERIALS, ORNAMENTAL & MEDICINAL RESOURCES Provision of raw materials, medicinal sources and ornamental elements

CULTURAL

E13 SIGNIFICANT ECOSYSTEM VALUES AND SPECIES Local significant species, historic-cultural landscapes, sacred areas and elements

E14 LANDSCAPE AESTHETIC FRUITION Landscape and scenery valuation and nature observation points

E15 LEISURE, RECREATION AND PSYCHOPHYSICAL HEALTH Sports, recreation and leisure areas, and psychophysical healing environments

Architecture Design Quality

In this research, Architecture Quality Criteria is expressed through DESIGN ASSESSMENT INDICATORS [which comprise both intrinsic and extrinsic design quality indicators and sustainability assessment factors].

DESIGN ASSESSMENT INDICATORS
ARE ORGANIZED INTO **6 AREAS:**

MACRO-LOCAL RELATIONS

ENVIRONMENTAL BALANCE

SOCIO-ECONOMIC RELEVANCE

CONCEPT & PERCEPTIVE QUALITY

COMFORT AND FUNCTIONALITY

BUILDING CONSTRUCTION

Architecture Design Quality: Assessment Indicators I

MACRO-LOCAL RELATIONS

A1 ADAPTATION TO ECO-PHYSICAL VALUES & RESTRAINTS Site selection and project adequacy to hydrography and topography

A2 SENSE OF PLACE AND CULTURAL IDENTITY Local context references, landscape integration, socio-cultural adequacy and relevance

A3 FUNCTIONAL ARTICULATION W/ CONTEXT Relation with infrastructures & volumes, access to daily functions, & low impact mobility

ENVIRONMENTAL BALANCE

A4 ENERGY CYCLE [AND ATMOSPHERIC EMISSIONS] Energy consumption through life cycle, passive performance and renewable energy use

A5 WATER CYCLE [AND EFFLUENTS] Consumption of water, rain water harvest, waste water management, treatment and reuse

A6 MATERIALS CYCLE [AND WASTE] Local, renewable and low impact materials, deconstruction, recycling and biodegradability

A7 EXTERIOR AREAS AND LOCAL POLLUTION Landscape and amenities, control of light pollution, noise, heat island effect and glare

A8 SUSTAINABLE LIFE-STYLE SUPPORT Provision of kitchen gardens, compost, bicycle parking, laundry dry

SOCIO-ECONOMIC RELEVANCE

A9 CUSTOMIZATION AND OPERATION Interior space, comfort and envelope control, possibilities of extension and modification

A10 COMMUNITY PARTICIPATION AND USER SATISFACTION Participatory processes, engagement with local communities & stakeholders and user targeting

A11 ECONOMIC DYNAMICS AND LIFECYCLE COSTS Economic impact and distribution, balance of initial investment, operation and end use costs

A12 HUMAN HEALTH AND WELL BEING Human health and well-being and other psycho-sociological aspects

Architecture Design Quality: Assessment Indicators II

CONCEPT & PERCEPTIVE QUALITY

A13 CONCEPT ORIGINALITY AND INNOVATION Artistic and conceptual valuation, contemporaneity, innovation, logic and intention

A14 VISUAL Scale, rhythm and volume, colours and texture, transparency-opaqueness, light-shadow, and view framing

A15 ACOUSTICS Sound reflection, insulation and absorption, sounds from uses and materials

A16 OLFACTION, TACTILITY & MOTION PERCEPTION Surfaces texture, pavement regularity and steepness and height levels, scents from materials & uses

COMFORT AND FUNCTIONALITY

A17 LIGHTING Optimization of natural light sources, and luminance adapted to function and comfort levels

A18 INDOOR AIR QUALITY Air renovation, elimination of VOCs (volatile organic compounds), dust particles and humidity condensations

A19 HUMIDITY AND TEMPERATURE Hygrothermal comfort through daily and annual cycles

A20 ADEQUACY TO FUNCTION, OCCUPANCY & CIRCULATION Functional and program organization, and circulation flows

BUILDING CONSTRUCTION

A21 DETAILS AND FINISHES Coherence, quality and attributes of details and finishing materials

A22 EXECUTION QUALITY & PROCESS MANAGEMENT Rigor of construction methods, on-site management during life cycle and quality control

A23 STRUCTURE STABILITY AND DESIGN Resistance to use and regular loads and structure design quality

A24 DURABILITY & MAINTENANCE Long life cycles of systems and materials, ease of substitution or repair, and local maintenance

Dancing Trees, Singing Birds

Project Data

1] PROJECT DATA

Designation:	**Dancing Trees, Singing Birds**	
Year [of completion]:	2007	
Author:	Hiroshi Nakamura & NAP Architects	
Function:	**Housing**	
Structure:	Reinforced Concrete + Steel	
Number of floors:	3	[above ground]
Owner:	Private	
Environmental Assessment:	.	
Rating:	.	

2] LOCAL CONTEXT

Country:	Japan
Location:	Tokyo, Meguro
Context:	**Urban** [medium to high density city districts]
Site [characteristics]	located on the edge of arborized slope (to South), and in the vicinity of steep gradient streets towards Meguro river valley (to South West)

3] PROJECT AREAS

Site area:	770	m2	
Total floor area:	685	m2	
Constructed area:	424	m2	55% [of site area]
Number of users:	~ 14	tenants	

Ecosystem interpretation options [digest]

1 Preservation and proximity to the existent tree grove [with more than 20m high], inside and outside the site area

2 Allocation of 6 birdhouses [for *parus major*] on the wooden façade

3 Structure and circulation design attending to roots of trees and to branch movement in case of strong winds

4 Landscape influence on volume shape [interplay with trees], visual mimic between birdhouses and huts

5 Immersion in nature, for users: protruding "huts" close to the trees, semi-outdoor spaces, and landscape views from the interior

6 Knowledge and environmental education opportunities

7 Architecture concept of cohabitation of habitat species [trees, humans, birds]

8 Water features [outdoor pool and pond] on ground and first floor: reflections and cooling breeze to apartments

9 Patch of balcony greenery on rooftop

10 Semi-pervious pavement on access areas

...

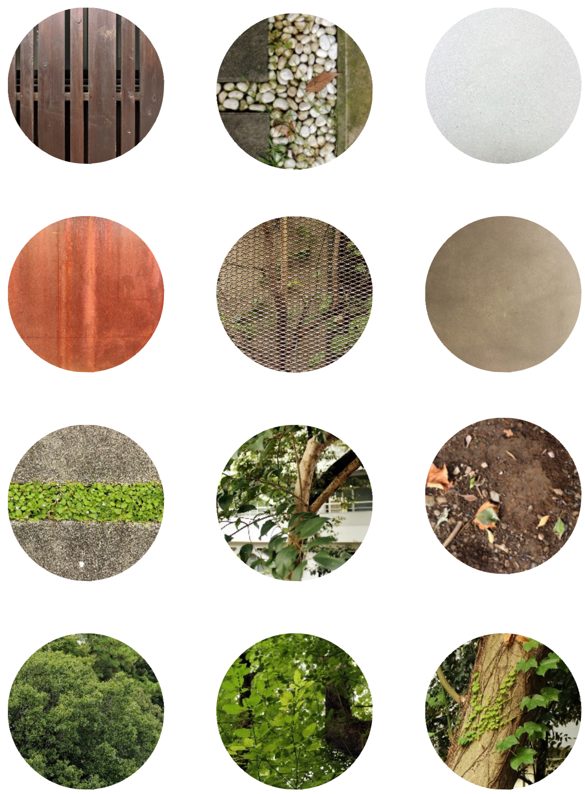


image credits and sources: ©Catarina.Vitorino

ECOSYSTEM INTEGRATION: RESEARCH QUESTIONNAIRE. Information Materials: SPECIFIC PROJECT.

Pasona Urban Farm

[Pasona HQ Tokyo]

Project Data

1] PROJECT DATA

Designation:	**Pasona Group Urban Farm**
Year [of completion]:	2010
Author:	KONO Designs
Function:	**Office + Urban Farm**
Structure:	Reinforced Concrete + Steel [existing envelope and superstructure]
Number of floors:	9[above ground]
Owner:	Private
Environmental Assessment:	.
Rating:	.

2] LOCAL CONTEXT

Country:	Japan
Location:	Tokyo, Otemachi
Context:	**Urban** [high density central city districts]
Site [characteristics]	flat area, in the vicinity of the Imperial Palace Gardens, and adjacent to an artificialized water canal and express way

4] PROJECT AREAS

Site area:	~ 2700 m2
Total floor area:	20000 m2
Constructed area:	~ 2250 m2 83% [of Site Area]
Number of users:	~ 2000 employees

ECOSYSTEM INTEGRATION: RESEARCH QUESTIONNAIRE. Information Materials: SPECIFIC PROJECT.

Ecosystem interpretation options [digest]

1 Preservation and renovation of existing building structure

2 Green rooftop with leisure areas

3 Promotion of traditional and urban farming, knowledge and environmental education opportunities

4 Local food supply provision within the building with ~200 diverse vegetal species, for consumption on cafeterias for employees and general public

5 Green wall balconies with seasonal flowering climbing plants, towards South, providing microclimate and environmental modulation

6 Indoor vegetation improvement on working environment, quality of space and air quality

7 Iconic urban design and influence on corporate identity

8 User participation in the maintenance and harvesting of crops, and envelope control through operable windows

9 Interaction of urban population with farming activities and boost of agriculture economic dynamics

…

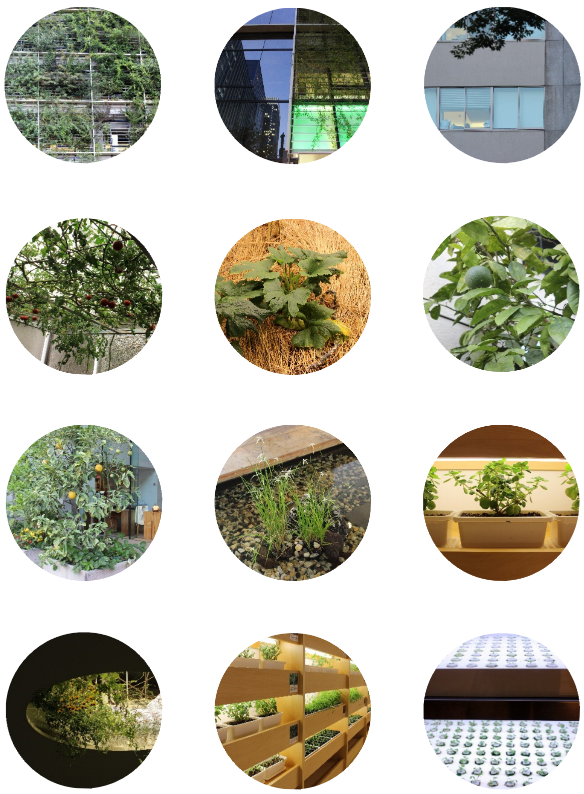


image credits and sources: ©Catarina.Vitorino

Makino Museum of Plants and People

Project Data

1] PROJECT DATA

Designation:	Makino Museum of Plants and People
Year [of completion]:	1999
Author:	Naito Architects and Associates
Function:	Museum + Botanical Garden
Structure:	Reinforced Concrete + Steel + Laminated Wood (Roof frames)
Number of floors:	2[above ground]
Owner:	Public [Kochi Prefecture]
Environmental Assessment:	CASBEE [New Construction, 2004 edition]
Rating:	2.9

2] LOCAL CONTEXT

Country:	Japan
Location:	Kochi
Context:	Natural Park [habitat conservation and green field site]
Site [characteristics]	gentle slope area, on the ridge of forested mountain, in the vicinity of sea coast, outskirts of Kochi city

4] PROJECT AREAS

Site area:	44600m2	
Total floor area:	7360m2	
Constructed area:	5700m2	13% [of Site Area]
Number of users:	~ 70 visitors/day	

Ecosystem interpretation options [digest]

1 Landscape design exclusively with diverse native plant species, and introduction of more than 500 trees

2 Transplantation of trees and plants in order to avoid construction impacts

3 Form design [setting, circulation, volume and height] in order to blend in with the landscape and alter as less as possible the topography

4 Creation of biotope courtyards and microclimate control through vegetation, wind flows and water surfaces

5 External air cooling system for energy efficiency using deciduous trees shade

6 Reuse and filtering of rain water for roof sprinklers and water circulation in the Exhibition building courtyard

7 Reuse of rubble excavated from the site as building material

8 Reuse of rainwater and filtering through ponds for water species exhibition on the Musem Building

9 Iconic design, visual form and varied views of landscape/nature from the interior and courtyards

10 Scientific-educational learning opportunities and outdoor recreation leisure amenities

11 Roof structure design, in alliance with trees and rock mounds, in order to minimize wind patterns alteration, and preparedness for typhoon

12 Bioclimatic design with deep eaves, vegetation and reflective roof materials

13 Use of locally (municipality) produced cedar and cypress wood

...






image credits and sources: ©Catarina.Vitorino

Ecosystem Integration: Research Questionnaire

Ecosystem Integration can be defined as the promotion and collaboration with Local Ecology in Architectural Design. In this research, focus is set on the positive interactions between Local Ecosystem Criteria and Architecture Quality Parameters, developing design assistance resources for Ecosystem Integration.

HOW TO PARTICIPATE:

In this survey, you will be asked to answer about a SPECIFIC PROJECT, according to a set of INDICATORS.
1. Before starting to reply, please read the following INDICATORS [pdf file].
2. And choose one of the PROJECTS:
> DANCING TREES, SINGING BIRDS [pdf file]
> PASONA URBAN FARM [pdf file]
> MAKINO MUSEUM OF PLANTS AND PEOPLE [pdf file]

•

The following questions are addressed to professionals in the field of architecture and environmental design, students, researchers and consultants.
The survey targets Ecosystem Integration within specific design projects, as way to observe individual perception and use of the proposed methods. The resulting data is subject of Thesis Dissertation, in the PhD Program of the Architecture Department of Tokyo University.

[Participants in the survey will be acknowledged with further information materials on the research.]

* Required

BACKGROUND INFORMATION

Please fill in with your personal information.

FIELD OF STUDY *

ACADEMIC DEGREE *

YEARS OF WORK EXPERIENCE *

COUNTRY *

PRESENT OCCUPATION *

- Graduate Student
- Researcher
- Architect
- Consultant
- Professor
- Other:

PROJECT DATA

SPECIFIC PROJECT *

Please indicate the project you are answering about in this questionnaire.

Did you knew this PROJECT, before? *

- Yes, from magazines, books or online sources.
- Yes, from technical design materials or case study sheets.
- Yes, from direct observation on site.
- No, not until now.

Continue »

20% completed

I. Introduction

ARCHITECTURE AND LOCAL ECOLOGY

Based on your own perspective and provided INDICATORS, please reply to the following questions, using a scale from 0 to 3 to define relevance: [0 = not relevant, 1 = low, 2 = medium, 3 = high].

What AREAS are more RELEVANT to define ARCHITECTURE QUALITY? *

	0	1	2	3
MACRO-LOCAL RELATIONS	○	○	○	○
ENVIRONMENTAL BALANCE	○	○	○	○
SOCIO-ECONOMIC RELEVANCE	○	○	○	○
CONCEPT & PERCEPTIVE QUALITY	○	○	○	○
COMFORT AND FUNCTIONALITY	○	○	○	○
BUILDING CONSTRUCTION	○	○	○	○

What AREAS have a more relevant potential CONNECTION with LOCAL ECOSYSTEM? *

	0	1	2	3
MACRO-LOCAL RELATIONS	○	○	○	○
ENVIRONMENTAL BALANCE	○	○	○	○
SOCIO-ECONOMIC RELEVANCE	○	○	○	○
CONCEPT & PERCEPTIVE QUALITY	○	○	○	○
COMFORT AND FUNCTIONALITY	○	○	○	○
BUILDING CONSTRUCTION	○	○	○	○

How relevant is the promotion of LOCAL ECOSYSTEM SERVICES AND FUNCTIONS within ARCHITECTURE PROJECTS? *

	0	1	2	3
	○	○	○	○

« Back | Continue »

40% completed

II. Specific Project

ARCHITECTURE QUALITY CRITERIA

Based on the SPECIFIC PROJECT and provided INDICATORS, please answer the following questions as objectively as possible. If you consider that you don't have enough information or data about a specific topic, please answer "Not enough information".

In this PROJECT, do the following ARCHITECTURE INDICATORS promote or benefit from LOCAL ECOSYSTEM SERVICES AND FUNCTIONS? *

	Yes	No	Not enough information
A1 Adaptation to eco-physical values and restraints	○	○	○
A2 Sense of place and cultural identity	○	○	○
A3 Functional articulation w/ context	○	○	○
A4 Energy cycle [and atmospheric emissions]	○	○	○
A5 Water cycle [and effluents]	○	○	○
A6 Materials cycle [and waste]	○	○	○
A7 Exterior areas and local pollution	○	○	○
A8 Sustainable life-style support systems	○	○	○
A9 Customization and operation	○	○	○
A10 Community participation and user's satisfaction	○	○	○
A11 Economic dynamics and lifecycle costs	○	○	○
A12 Human health and well being	○	○	○
A13 Concept originality, innovation and creativity	○	○	○
A14 Visual	○	○	○
A15 Acoustics	○	○	○
A16 Other senses: olfaction, tactility, motion perception	○	○	○
A17 Lighting	○	○	○
A18 Indoor air quality	○	○	○
A19 Humidity and temperature	○	○	○
A20 Adequacy to function, occupancy & circulation	○	○	○
A21 Details and finishes	○	○	○
A22 Execution quality and process management	○	○	○
A23 Structure stability and design	○	○	○
A24 Durability & maintenance of systems and materials	○	○	○

« Back   Continue »

60% completed

II. Specific Project

LOCAL ECOSYSTEM CRITERIA

Based on the SPECIFIC PROJECT and provided INDICATORS, please answer the following question as objectively as possible. If you consider that you don't have enough information or data about a specific topic, please answer "Not enough information".

In this PROJECT, is there a promotion or collaboration with the following ECOSYSTEM SERVICES AND FUNCTIONS? *

	Yes	No	Not enough information
E1 Soil formation and fertility	○	○	○
E2 Photosynthesis and primary production	○	○	○
E3 Nutrient cycling and pollution treatment	○	○	○
E4 Water cycling and regulation	○	○	○
E5 Biodiversity and habitats	○	○	○
E6 Climatic regulation	○	○	○
E7 Erosion control and hazard protection	○	○	○
E8 Biological control & pollination	○	○	○
E9 Perceptive environmental modulation	○	○	○
E10 Food supply	○	○	○
E11 Fresh water supply and purification	○	○	○
E12 Raw materials, ornamental and medicinal resources	○	○	○
E13 Significant ecosystem values and species	○	○	○
E14 Landscape aesthetic fruition	○	○	○
E15 Leisure, recreation and psychophysical health	○	○	○

COLLABORATIVE INTERACTIONS

Based on the SPECIFIC PROJECT, please identify positive interactions between ECOSYSTEM and ARCHITECTURE CRITERIA. Indicate as many as you consider relevant.

Between what pairs of INDICATORS is there a POSITIVE INTERACTION, in this PROJECT? *

- ☐ A1 Adaption to eco-physical values and restraints + E6 Climatic regulation
- ☐ A2 Sense of place and cultural identity + E15 Leisure, recreation and psychophysical health
- ☐ A3 Functional articulation w/ context and mobility + E4 Water cycling and regulation
- ☐ A4 Energy cycle [and atmospheric emissions] + E2 Photosynthesis and primary production
- ☐ A5 Water cycle [and effluents] + E5 Biodiversity and habitats
- ☐ A6 Materials cycle [and waste] + E7 Erosion control and hazard protection
- ☐ A7 Exterior areas and local pollution + E12 Raw materials, ornamental and medicinal resources
- ☐ A8 Sustainable life-style support systems + E10 Food supply
- ☐ A9 Customization possibilities and operation + E14 Landscape aesthetic fruition
- ☐ A10 Community participation and user's satisfaction + E12 Raw materials, ornamental and medicinal resources
- ☐ A11 Economic dynamics and lifecycle costs + E11 Fresh water supply and purification
- ☐ A12 Human health and well being + E5 Biodiversity and habitats
- ☐ A13 Concept originality, innovation and creativity + E9 Perceptive environmental modulation
- ☐ A14 Visual + E11 Fresh water supply and purification
- ☐ A15 Acoustics + E7 Erosion control and hazard protection
- ☐ A16 Other senses: olfaction, tactility, motion perception + E14 Landscape aesthetic fruition
- ☐ A17 Lighting + E9 Perceptive environmental modulation
- ☐ A18 Indoor air quality + E3 Nutrient cycling and pollution treatment
- ☐ A19 Humidity and temperature + E2 Photosynthesis and primary production
- ☐ A20 Adequacy to function, occupancy and circulation + E3 Nutrient cycling and pollution treatment
- ☐ A21 Details and finishes + E6 Climatic regulation
- ☐ A22 Execution quality and process management + E1 Soil formation and fertility
- ☐ A23 Structure stability and design + E13 Significant ecosytem values and species
- ☐ A24 Durability & maintenance of systems and materials + E8 Biological control & pollination
- ☐ Other: ____________

« Back | Continue »

80% completed

III. Conclusion

PROJECT REVIEW

Based on your own perspective about the SPECIFIC PROJECT, please reply to the following questions, using a scale from 0 to 3 to define relevance: [0 = not relevant, 1 = low, 2 = medium, 3 = high].

How relevant is the PROMOTION of LOCAL ECOSYSTEM FUNCTIONS AND SERVICES in this PROJECT? *

	0	1	2	3
	○	○	○	○

How relevant is ARCHITECTURE DESIGN QUALITY in this PROJECT? *

	0	1	2	3
	○	○	○	○

RESOURCES FOR ECOSYSTEM INTEGRATION

Do you consider relevant the development of Design Assistance Resources for Ecosystem Integration? *

Please reply to the following question, using a scale from 0 to 3 to define relevance: [0 = not relevant, 1 = low, 2 = medium, 3 = high].

	0	1	2	3
	○	○	○	○

What do you consider to be the possible USES and QUALITIES of the proposed ASSISTANCE METHODS and INDICATORS for Ecosystem Integration? *

- ☐ COMMUNICATION TOOL
- ☐ DECISION MAKING TOOL
- ☐ INSPIRATION TOOL
- ☐ INFORMATION TOOL
- ☐ CHECKLIST MANAGEMENT TOOL
- ☐ CONSIDERATION OF OBJECTIVE PARAMETERS
- ☐ CONSIDERATION OF QUALITATIVE VALUES
- ☐ CONSIDERATION OF DETAIL AND COMPREHENSIVENESS
- ☐ IMPROVEMENT OF LOCAL ECOLOGY
- ☐ IMPROVEMENT OF ARCHITECTURE QUALITY
- ☐ Other: ____________

THANK YOU VERY MUCH FOR YOUR REPLY.

If you want to receive more information about the research project, please enter below your e-mail address.

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