# Applying Systems Thinking: Geodesign Structure Provides General Models Integrating Architecture with Landscape Planning and Design to Create a Sustainable Environment

Ping XU

University of Colorado Boulder, USA · xup@colorado.edu

## Abstract

The problems and dynamic changes in the environment demand new theories and methods. This paper explores general models of the design process to integrate architecture with landscape planning and design, by applying the theory of "Systems Thinking" (by Ludwig von BERTALANFFY and Ervin LASZLO) to environmental design. According to "Systems Thinking," elaborating principles and models applying to "systems" provides an interdisciplinary approach to integration between systems. Thus, discovering general models is the key issue for developing an integrative approach. Following the geodesign concepts, the models work from large scale to small scales, from planning to design, feedback is in every step. Architecture and landscape design share common principles, particularly in the design process; thus general models would integrate the two fields. Integration would be accomplished in one mind. The two general models have been tested in design studio education for over a decade, providing a valid integrative process with the framework for practice in design studios and guiding students with systematic thinking. Furthermore, this paper proposes a new synthesis major, "Architectural and Landscape Design", that would be beneficial for creating a sustainable built environment.

## 1 Introduction

Only about a hundred and fifty years ago was "landscape architect" separated from the profession of architect. As a result, contemporary architecture is often seen in isolation from its surrounding landscape. As the products of architects, buildings are the biggest source (over 40 %) of pollutant emissions and energy consumption in the world (WILLIAMS 2007), but this fact has escaped the attention of architectural education until the recent decade. Conventional architectural education emphasizes artistic creativity and ignores design constraints and environmental issues. Thus, many architects often have difficulty integrating function with their designs, as well as working in a team environment (FISHER 2000). During the 1970's – 90's, architectural education and practice did not involve the environmental movement; they were exhilarated to pursue Post Modernism and then Deconstructionism.

In the 21st century, along with the threat on the global ecosystem, extreme climate patterns, economy problems, and the information revolution, the sustainability movement has been breaking the isolated ivory tower of architecture. Many educators, and practitioners in architecture, exploring new design applications of renewable energy, recycling, and reduced

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energy consumption, are changing the field. However, the knowledge structure of architectural education, by which most current architects were trained, lacks the integration of architecture with its surrounding landscape, ecology education, and the landscape visual analysis and site planning. It is the time for a remarriage of the fields to create a new major synthesizing architecture, landscape design and planning. For such a challenging endeavor, we need to introduce a new theory: "Systems Thinking".

Systems Thinking was first conceived by Ludwig von BERTALANFFY, an Austrian biologist. During the 1930s and 1940s he developed the idea of general systems theory (VON BERTALANFFY, 1968). In the 1970s the Hungarian philosopher Ervin LASZLO's pioneering work developed systems philosophy in both breadth and depth (BERTALANFFY in LASZLO 1972). What is general systems theory? As von BERTALANFFY defined it, it is "*an interdisciplinary doctrine elaborating principles and models that apply to systems in general, irrespective of their particular kind, elements, and 'forces' involved"* (BERTALANFFY in Laszlo 1972).

According to von BERTALANFFY, the domain of general systems theory is the correspondences or isomorphism in certain general aspects of "systems." Elaborating principles and models applying to "systems" provides an interdisciplinary approach to integration between systems. Systems Thinking has been broadly applied in natural science, social science, and business, becoming an efficient methodology and developing a new world view in the contemporary world (BERTALANFFY in Laszlo 1972 and LASZLO1996). General systems theory explores "wholes" and "wholeness" to find principles applied in the entire system. It is different from the conventional analytical method, which is to divide a system into pieces and examine their details to find the rules for the system (LASZLO 1972).

## 2 Two Waves: Ecological Approach and Sustainability

The greatest accomplishments in the environmental movement are marked by two waves: 1) Ecological Approach and 2) Sustainability Design. The first wave was led by Professor Ian MCHARG, one of the most influential professors of landscape and regional planning of the 20th century. MCHARG's book, *Design with Nature*, had a great impact on academia and the general public in a global scale for over three decades. Dealing with the environment as a whole, Ian's model emphasizes ecological balance, integrating landscape planning with environmental sciences. Ian's model presents a vertical overlay analysis, called by his students as "Ian's cake" (see Figure 1).

The second wave of the environmental movement is sustainability design, synthesizing the concerns of ecological balance, cultural values and human needs. Professor Carl STEINITZ is the leader and pioneer to generate the second wave and make it wider and higher. Carl STEINITZ is the Alexander and Victoria Wiley Research Professor at the Harvard Graduate School of Design. STEINITZ is a pioneer in applying Geographic Information System (GIS) in landscape design analysis and modeling, in which he emphasizes and incorporates visual quality and cultural values to design in addition to ecological concerns. STEINITZ is one of a few scholars, during the peak of the first wave, who challenged Ian's method due to its weak points on cultural analysis and dealing with dynamic societal issues. At the same time, STEINITZ's method shares Ian's ecological concepts. STEINITZ's model presents a

synthesis approach. His book, "*A Framework for Geodesign: Changing Geography by Design,*" provides a structure of sustainability design (see Figure 2).

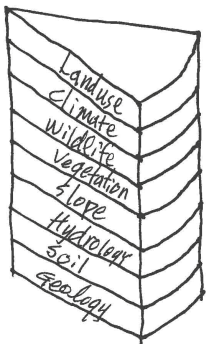


**Fig. 1:** "Ian's cake" (MCHARG 1971)

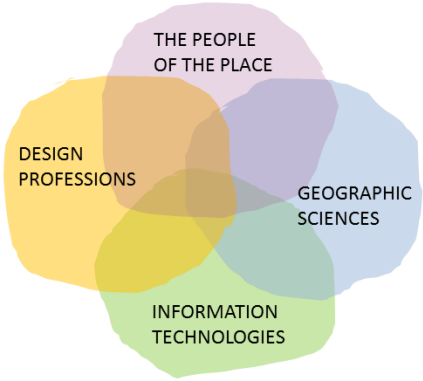


**Fig. 2:** STEINITZ model (STEINITZ 2012)

As a graduate student of both MCHARG and STEINITZ, the author feels extremely lucky and grateful for their education and straight-forward debates between each other, which highly inspired her scholar thinking, including the thought of the design process models in this paper. Although MCHARG and STEINITZ created two different schools of geodesign, they are common in the following aspects: 1) they are great thinkers and pioneers in geodesign, applying Systems Thinking with general models; 2) they are charismatic teachers who inspired and cared for their students; 3) they emphasize practice and field investigations; and 4) they have the great vision of environmental design. Both of them encouraged the author to teach architecture, although both were not happy with some architects and the stylish-ism architectural education.

Geodesign is applied in multiple design professions. As STEINITZ states, "*Geodesign is a set of concepts and methods that are derived from both geography and other spatially oriented sciences, as well as from several of the design professions, including architecture, landscape architecture, urban and regional planning, and civil engineering, among others"* (STEINITZ 2012). Geodesign framework provides the general model of the structure of environmental design. Its every step requires professionals to develop detailed models, guided by geodesign concepts and methods. In this paper, the general models of design process demonstrate such an example, that belongs to the second step in the STEINITZ's geodesign framework.

The built environment centers on buildings that are surrounded with gardens, urban landscape, city, and natural landscape, fitting one inside another and forming nesting spaces; every larger one includes all the smaller ones. The boundaries of these spaces are ambiguous. Built by and for people, the environment stands up on the earth and under the sky. In this system, social and environmental sciences are relevant fields. Operating in the same space, influencing and relying on each other's design and studies, architects, landscape architects, urban designers, city and regional planners, work together to create a functional and meaningful space for the users. Research and design on isomorphism or correspond-

ences in these sub-systems of the built environment would create a sustainable environment. In this endeavor, the geodesign collaborates with multiple design professions. Architectural involvement is significant otherwise the geodesign structure of environmental design is not complete (see Figure 3).

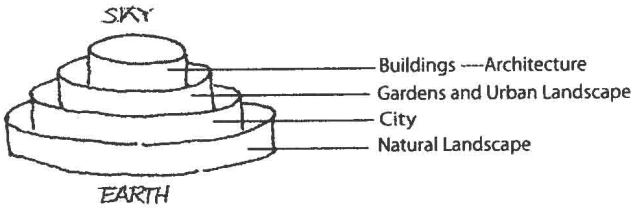


**Fig. 3:** The nesting spaces

# 3 General Models: Integrate Architecture with Landscape Design

To understand systems, as LASZLO suggests, we should find out what is meant by "system" and how systems are realized at the various levels (LASZLO 1972). The hierarchical system of environment involves many aspects including the natural and social, and the physical and spiritual. In such a complex system, subsystems conflict, compromise, and coexist. These aspects of environment do not simply overlap, but join with each other by compromise.

Architecture and landscape design are hardly separated. Not only is landscape design relevant to architecture, but architecture often plays a significant role in cultural landscape. By considering the impacts on the environment, an elaborated suitability analysis and site selection can protect natural resources on a large scale. Site planning definitely plays an important role in integrating the architecture with the landscape. Moreover, architectural design would benefit from a landscape study of visual qualities that emphasize the horizontal and spatial analyses of landscapes.

Architecture and landscape design share common principles, particularly in the design process; thus general models would integrate the two fields**.** Applying "Systems Thinking", synthesizing the methods applied in both studios of architecture and landscape design, the author developed two general models of the design process to integrate the two fields. The first general model deals with large-scale landscape design and the super system's master plan, serving as the bridge connecting architecture and landscape design. The second general model emphasizes architectural and landscape design, dealing with the subsystems. The second general model is a part of the first, and should be controlled by the first general model. Architectural and landscape design receives information from the first general model, then the output feeds back into the first general model. The two models provide an approach to the integration of architecture with landscape design.

## 3.1 First General Model of the Design Process for the Master Plan

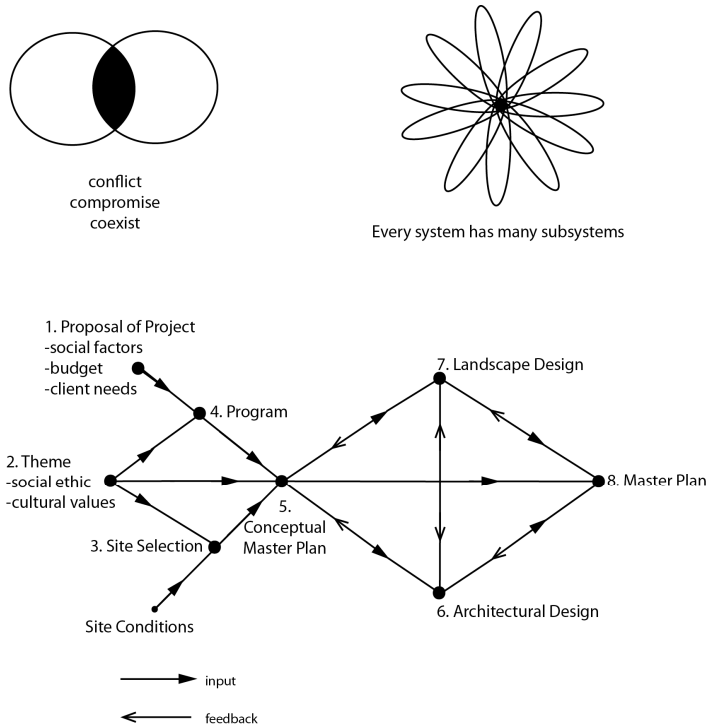


**Fig. 4:** The framework of the first general model of the design process for the master plan

Figure 4 shows the first general model of the design process of the master plan, which is divided into eight steps: 1. establish a proposal of project; 2. create a social and culture theme; 3. select a site; 4. create the program of the design; 5. develop a conceptual master plan; 6. create the architectural design, a step with many overlays including complex input and feedback; 7. create the landscape design, which is complemented by the architecture; and 8. develop a final master plan. In the design process, the inputs include the goals, a proposal and theme with social ethic and cultural values, and information concerning site conditions and ecological impacts, requirements of function, technique and structural engineering, spatial experience, user behavior, sanitary systems, and so on. The output is expected to be a master plan, integrating architecture and landscape design with respect for cultural values, human needs and environmental impacts (see Figure 4).

## 3.2 Second General Model of Architectural and Landscape Design Process

Figure 5 shows the framework of the second general model of the architectural and landscape design process, which corresponds to the step 6 and 7 in the first general model. This model deals with open subsystems of architecture and landscape design. It receives information, as input, from the conceptual master plan that is created by using the first general model. The output of this model is the architectural and landscape design that feeds back into the first general model to complete the final master plan.

The second general model of architectural and landscape design includes eleven steps: (1) Create a theme with social ethic and cultural values; (2) conduct site analysis; (3) create spatial composition; (4) integrate function design; (5) integrate conceptual engineering design; (6) develop spatial sequence design and conduct a working model; (7) merge the architecture with the landscape; (8) conduct conceptual design; (9) integrate with engineering and technique design; (10) integrate with tectonic design; and (11) conduct final work and output the final master plan. In every step a new value is inputted into the design process system. Towards the end of the process, the higher level design work is produced. Also, as the design process progresses, the possible number of feedback loops increases − that is, as the design is refined, one reaches a point where each new change involves reconsidering more factors (see figure 5).

This second general model of the design process can be applied to both architecture and landscape design. When they start to create spatial composition, the designer should consider architecture and surrounding landscape as a whole. With regards to adaptation to climate challenges, the engineering design is significant in determining the spatial composition. Guiding designers step by step, this model would serve to decrease their frustration, since the designer's frustration does not often come from lack of specialization knowledge but from lack of the skills to handle the design process.

The progression of design involves continuous compromise as more detailed concerns cycle through the loop. Feedback is the key point of the design process, and it is also the most difficult for students, who are used to thinking in terms of "yes" or "no", but not "maybe". Actually, the concept of "maybe" creates opportunities for compromise that allows many values to coexist in the architectural system. The basis of compromise is conflict. Compromise occurs through feedback. When two concerns conflict, there is an opportunity to create something new.

Architectural and landscape design is a decision-making process. Criteria used to make design decisions should reflect many concerns, including social and cultural values, environmental impact, adaptation to climate challenges, engineering structure system, function requirements and spatial sequence, and tectonic solutions. These criteria are also used to evaluate a design work.

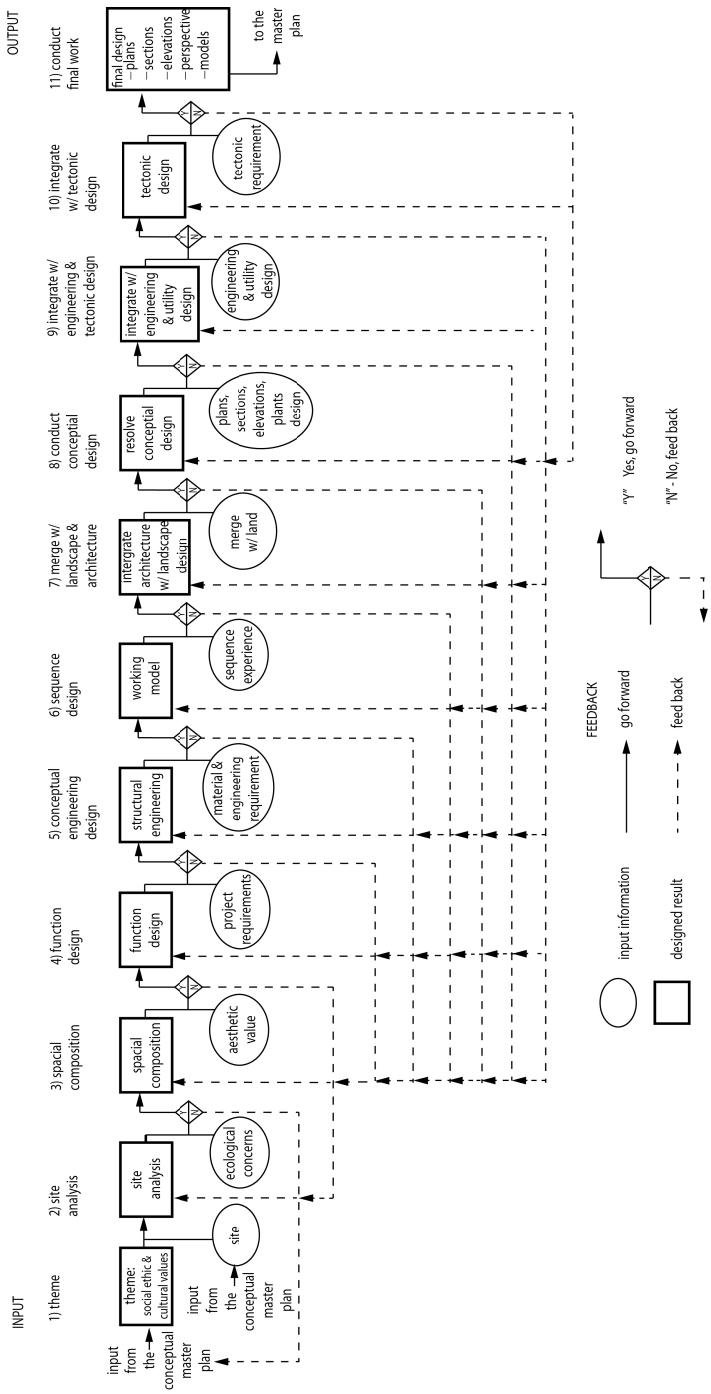


**Fig. 5:** The framework of the second general model for architectural and landscape design process

### 3.3 Practice in Studio

The two general models have been put into practice by the author over a decade in the senior undergraduate architectural studio courses in the Environmental Design Program at the University of Colorado Boulder. Particularly, the recent projects were designed with the theme: Adapting to Climate Challenges. By integrating the geographic information of local climate and hazards into the site analysis and architectural design, this studio explored the solutions for new types of architecture that adapt to climate challenges. This studio education seeks to demystify the design process. Following the general models, the studio process emphasizes the need to "do one thing at a time", without necessarily assuming that this one decision is final and unalterable. In every step there is a single focus for architectural and landscape design education as well as for the design process. Studio practice has shown that this model can direct students, step by step, to create their work independently and more fruitfully.

### 3.4 A New Synthesis Major: Architectural and Landscape Design

The success in testing these two general models for integrating architecture and landscape design has inspired the author to propose a new synthesis major: Architectural and Landscape Design. This new major would be offered both at the graduate and undergraduate level. The cadre of faculty would be required to have their education, research and practice in both majors. The structure of the proposed program includes interdisciplinary design guided by the general models and Systems Thinking. The concepts and methods of geodesign should be incorporated into the curriculums. Students would learn architectural design, ecology, landscape analysis and planning, computer applications of GIS (Geographic Information Systems), and other digital technologies, visual and aesthetic analysis, and landscapes design. In the theory and methods courses, architecture and landscape design would be discussed as a whole. In the upper-level studios, students would work on a geodesign project, generating integrative studies based on the master plan down to architectural and landscape design. This new synthesized major would train students to gain the capability of teaching an integrative approach to design, as well as becoming a practitioner in charge of both the master plan and architectural and landscape design, in order to create an integrative and sustainable built environment.

## 4 Conclusions

The greatest accomplishments in the environmental movement came in two waves: 1) Ecological Approach and 2) Sustainability Design. The leader of the first wave is Ian MCHARG and the leader of the second wave is Carl STEINITZ. Both of them apply Systems Thinking with general models (By Ludwig Von BERTALANFFY and Ervin LASZLO). The MCHARG model is the overlay analysis for ecological approach, while the STEINITZ model is a synthesis approach to environmental design. Geodesign has been applied and developed in both waves. The concepts, methods and structure of geodesign provide an integrative approach to sustainability design synthesizing concerns of ecological balance, cultural values and human needs.

STEINITZ's geodesign framework presents the general model of the structure of environmental design; its every step requests professionals to develop detailed models. In this paper, the general models of design process demonstrate such example. The concept and methods of geodesign have been applied in multiple professions, much beyond planning majors. Architecture, with its capability to deal with spatial subjects, could have great contribution to create a new built environment embodying sustainability. As a movement, geodesign would benefit and develop in a way that is inclusive but not exclusive.

Architectural design can instill social and cultural attributes into people's perceptions of the landscape. The landscape, serving as a matrix, imbues architecture with meanings of time and space. The two design fields share common principles, particularly in the design process. Therefore, general models would integrate the two fields**.** Inspired by the methods of STEINITZ and MCHARG, the author has applied "Systems Thinking" and developed two general models of the design process to integrate architecture and landscape design.

The first general model deals with large-scale design and programs a super-system's master plan, serving as the bridge for connecting architecture and landscape design. The second general model emphasizes architecture and landscape design, dealing with subsystems. The second general model is a part of the first and is controlled by the first. The architectural and landscape designs receive information from the first general model, and the resulting output feeds back into the first general model. Emphasizing the similarities rather than differences between architecture and landscape design, the two general models would structure a new interdisciplinary endeavor.

According to "Systems Thinking," elaborating principles and models applying to "systems" provides an interdisciplinary approach to integration between systems. Thus discovering general models is the key issue for developing an integrative approach. Following the geodesign concepts, the models work from large scale to small scales, from planning to design, feedback is in every step. Integration would be accomplished in a single mindset.

Challenging the conventional architectural education which evaluates design work with the emphasis of creating "cool" forms, this new integrative approach provides the evaluation model with the following criteria: (1) the design should display the theme with social and cultural values, and an adaptation to climate challenges; (2) the site selection and architectural design should have minimal impact on the environment; (3) the spatial design should provide reasonable functions with concerns to adapting to climate challenges and balance a rich experience of spatial sequence with an attractive composition; (4) the design should incorporate the application of renewable energy; (5) the design should have a reasonable engineering structure system; and (6) the design presents the integration of architecture with surrounding landscape. These criteria would also meet the requirements of sustainability.

Tested in the design studio education for over a decade, the two models have increased the students' independence, motivation, and confidence and decreased their frustrations. The integration of architecture and landscape design not only increases the breadth of the students' knowledge, but also strengthens the depth of their architectural designs. Moreover, this approach has promoted "Systems Thinking" which is a fundamental philosophy in the contemporary world.

The success in testing the two general models encourages the author to propose a new synthesis major: Architectural and Landscape Design, which will provide education with interdisciplinary and general models applied in both fields. The concepts, structure and methods of geodesign will be incorporated in the curriculums. Information technologies would make this challenging endeavor feasible.

Adopting and adapting to the geodesign concepts and methods, architectural education is beginning to join the geodesign movement in order to create a sustainable environment.

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