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THE GREENING OF ARCHITECTURE

A Critical History and Survey of Contemporary Sustainable Architecture and Urban Design

Phillip James Tabb
A. Senem Deviren

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To the Western Black Rhino, declared extinct in 2011

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A Critical History and Survey of Contemporary Sustainable Architecture and Urban Design

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This book is an accumulation of nearly 50 years of study and a deep desire to better define sustainability and green architecture in order to contribute to further advancements in the field. This work goes beyond any single discipline and certainly is the result of many people who have contributed on so many levels. *The Greening of Architecture* is a moment in a larger process, which this book acknowledges and explains. Yet it is really a story about architecture, its changing role, the magic of its manifestation, and more miraculously, how it is truly becoming a living practice. In viewing the changes that have occurred over time, it is evident that the way in which we create architecture and cities are crucial to our survival. The works of many great projects and the people who created them supports a critical history of sustainable architecture and urban design, and this is evident with the explosion of examples worldwide.

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Phillip Tabb
College Station

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A. Senem Deviren
Istanbul

Preface

The Brundtland Commission Report in 1987 defined sustainability in intergenerational terms: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[1] This was a useful and admirable approach to sustainability and was considered the most often-quoted definition. Integral to this definition was the overriding priority to be given to the world's poor according to the Report. The definition cited two fundamental dimensions to which sustainability is to be directed: to geographical space and differing global contexts, and to evolving systems over time. It did not establish a metrics to which present needs might be defined and achieved, nor did it give any indication as to what future needs might be, especially in the context of unknown population increases, undefined levels of equity and the enormous planetary scale. Present and future needs are moving targets and seem impossible to define. Therefore, sustainability is seen as a philosophical proposition within a context of uncertainty and supports a dynamic process with thoughtful incremental adjustments to the built environment in response to changing needs. In turn, green architecture is a sub-set of global cultural sustainability and, as a consequence, architecture is the process of designing, constructing and maintaining buildings in response to these principles of sustainability. Green architecture is, of course, subject to the inherent limitations of the discipline, which generally function at the aggregate building scale.

Within the term "architecture" certain green principles are coded and can be useful for sustainable design practice. The Oxford Dictionary defines architecture as being the "art and science of building." It is seen as an art because it has beauty of form, beauty of craft, and reflects contemporary ideas with important social, political and cultural content. It is a science because it must respond to important health, safety and welfare constraints and it needs to be technically competent, functional and affordable. Both art and science aspired to similar objectives, but employ different means. This suggests that architecture is the practice of the artful composition of design elements and scientifically responsible construction of buildings, and for green architecture, this means the inclusion of sustainable principles of design, introduction of renewable resource technologies and environmentally conscious use.

One view of the term "architecture," is derived from the Greek αρχιτεκτων, "a master builder" and from αρχι- "chief, leader." Rather than a focus on an object outcome, this meaning refers to the one who leads the design process: *archê*—chief authority (archbishop, archangel,

arch-duke, or arch-enemy), *tektôn*—builder, any craftsman or worker, master in an art; and *ure*—simply a marker of function (prefecture, legislature, juncture).[2] "Architecture" then was the product of the one who leads the building work (Cicero). For green architecture this might suggest the heroic examples set by architects Frank Lloyd Wright, Le Corbusier, Ralph Erskine, Norman Foster, Richard Rogers, Renzo Piano, Zaha Hadid, as well as the influential works of Alvar Aalto, Hassan Fathy, Charles Rennie Mackintosh, and Glenn Murcutt, among others. This definition shifted its meaning from the product of the created building to the one who conducted this process. It focused on the position of superiority, authority, or simply, the powerful influence upon the discipline of architecture. These forward thinking architects were among the leaders of theoretical, aesthetic, formal and exemplar buildings that later gave impetus to the development of green architecture.

Another etymological exploration of the Greek roots of the term "architecture"[3] provided a definition revealing something more noetic, completely different than the modern heroic notions of architecture, and containing more explicit green principles of design. The root terms function as noun, verb and suffix, and provide insights and keys to its operational meaning. The ancient view suggested a hierarchical approach to the term and gave an invigorated redefinition where the word itself became a sentence. Again referring to the three prime roots to the term; *archê*, *technê*, and *ure*.[3]

> ***archê***—noun, realm of archetypes, beginnings, first principles. This originates in the dwelling of the prime or essential potential of a beginning. It is the power-activity associated with creation and has the qualities of purity, clarity, perfection and initiation. The first term, archê, means both "beginning" and "principle" and therefore, relates to the realm of archetypes or the First Principles. The archê is a going back to the beginning where the prime or essential dwells and emanates. As "beginning," archê suggests focusing on essential human needs and the pure natural context within which we dwell. The function of creation suggests the dynamic interrelationship between nature and needs. As "principle," archê suggests a truth, which is powerful, essential and universally applicable.
>
> ***technê***—verb, process of bringing something into appearance, manifestation. It is the revealing of ideas, designs or principles into manifest form and material. It is the substantial and meaningful quality obtained in making. The middle term, technê, relates to the technique or technology of manifestation or simply "building." Yet it is building with a certain consciousness and presence of mind and tectonic realization between nature and need. To the early Greek, it referred not specifically to art or handcraft, but to making something appear—revealing or letting the physically constructed "thing" appear. It was the substantial expression of higher principles, and with respect to the greening of architecture it would refer to the tectonic expression of sustainable measures.
>
> ***ure***—from Latin (ura) a morpheme or suffix added to the end of a word performing a function, process or rank making a noun out of an adjective, such as picture, culture, gesture, measure, enclosure, structure, etc. In Greek, ure or ur means well fitted and is a weaving process that binds the other two terms into a unity of beauty and fitness. The third term, ure, relates to the crafting or weaving process as explained by Marcus Vitruvius: "And first, with upright forked props and twigs put between, they wove their walls." This third term also has associations with eurhythmy, which according to Vitruvius

was "beauty and fitness in the adjustments of the members." It relates to the integrative warp and weft of sustainable measures that occur with the natural flows of a place.

Then, in applying these root terms of the word architecture to green architecture, we have a very rich and useful three-fold meaning. Architecture is the revealing through the manifestation process the First Principles. Concisely stated, architecture is "the First Principles that are well-fitted to a context or woven into a dynamic place." Also embodied in this definition are the three prime functions in grammar: the noun, verb, and descriptive figure of speech (conjunction, adverb or adjective). The First Principles (noun) are dynamic and well-fitted (verb) into manifest tectonic form (suffix). So embodied into the very word of architecture is this three-fold essence of speech also found within the simplest sentence. The accumulative meaning derived by combining concepts of these terms becomes: "Architecture" is the weaving into manifestation of the First Principles. Which begs the question, what are the First Principles that architecture seeks to manifest, especially as encoded with the now relevant function of temporal and spatial sustainability?

First Principles, according to Plato, were manifestations of goodness (commodity), truth (firmness) and beauty (delight).[4] In architecture, they are realized through the unity, generative, formative, corporeal and re-generative processes.[5] Where these principles are applied to architecture in the most general sense, they do possess inherent green connotations. Unity implies a singularity of purpose, coherence and wholeness of form and continuity of detail. The generative principle suggests connections to the earth and responses to the diverse, proliferating and multifarious local contextual conditions. The formative principle implies an internal intelligence, integrity and logic to the spatial order, structural systems, and tectonic character of built form. The corporeal realm is grounded into pragmatic realities of materiality, constructability, cost, systems' performance, and project delivery. And finally, the regenerative principle brings the temporal, mutable, transformative and evolutionary dimensions into the work. The First Principles function as an accumulative and interactive set of directives that are intended to guide and inform the sustainable planning and design processes.

The temporal dimension to sustainability defines the potential changes for green architecture to become more familiar over time and to improve accumulatively and incrementally. It assumes innovation, technological refinements, and further invention, but more importantly it suggests that the greening process can become more pervasive connecting to all scales, locals and facets of contemporary life. This also assumes that small individual changes will grow and multiple influencing inter-scaler applications through a passive process of evolution. Incremental changes toward greater levels of sustainability are initially remedial and then progressed to more complex, dynamic and systemic measures with eventual reductions in embodied energy.[6] This is typical of any innovation or infusion of new technologies. They are additive and often awkward at first, and after time they become amalgamated and fuse into the function, mainstream of use and aesthetic of the host, which in the context of this work includes the entirety of the built environment.

The spatial dimension to sustainability emphasizes geographical differences in climate, ecology, culture, land-use patterns, density, technology, and architectural traditions. It also recognizes dynamic interactions as well. What is interesting are the ways in which the greening of architecture vary and express from East to West, where differences occur due to the geo-cultural influences of form. The urban to rural contexts generate drastically different

demands upon the power, transportation and building sectors, and reflect differences in building typologies and tectonic characteristics. Industrial-world exemplifications tend to be more universal, utilizing higher technology, and project greater self-importance as compared to undeveloped regions where the architecture derives from mere survival and far less means. Low densities and high densities offer differing challenges and opportunities for addressing sustainable design strategies. New buildings afford fresh and innovative designs while the existing stock of buildings brings its own form of constraints and challenges. High technologies are prototyped, manufactured, mass-produced and exported, while low-tech sustainable technologies are often handmade utilizing local materials, labor and fabrication methods. Extreme examples of green architecture occurring with research stations in Antarctica or living sandstone wall dwellings in the Sahara Desert are compared to mainstream projects that could be found in any temperate climate zone where most people live. It is interesting to observe the degree to which these variations of approach manifest divergent architectural languages. And in the end, "green architecture" should simply be good "architecture."

The critical history of green architecture covers the past 50 years and provides a survey of recent works throughout the seven continents illustrating the growth in the field and breadth of development along with the diversity and character of the creative works. There has been a great deal of change from the visionary and technological explorations of the 1960s to the more biophilic and infrastructural green propositions of today. Much of this effort has been to undo the unsustainable mistakes of the past and to provide sustainable models that penetrate all facets of modern life. The challenge is to create a bridge from our current modes of consumption, waste, use of resources, inventory of existing cities, infrastructures and stock of buildings, and styles of living to an evolutionary green architecture that serves as a link that truly can help ensure the ability of future generations to meet their own needs—leaving an inheritance of bountiful renewable resources, energy, intellectual capital and the inventory of a healthy living environment.

This work represents research, travel, practice and analysis of an accumulation of material on the subject of sustainability over a 50-year period. Dr Tabb began architectural practice in the late 1960s and focused on solar applications throughout the decade of the 1970s. His research on English villages during his studies at the Architectural Association in the mid-1980s contributed to informing characteristics associated with multiple buildings and community placemaking. In the 1990s his commissioned work was directed toward off-grid architectural demonstrations and sustainable site development projects, and after the millennium 12 years of design work for Serenbe Community brought together the integration of both sustainable architecture and planning agendas. This accession of familiarity led to a personal history informed by actual lived experiences in these critical phases of the development of sustainable architecture and urban design, and gave valuable insights in the writing of the first six chapters on the historic development of the greening of architecture. Dr Deviren's research into placemaking, regional context and especially the relationship between site and building, give a background for the understanding of global effects of sustainable design and a unique perspective from both the European and Asian continents. Her more recent interests in emergent green technology and her teaching and current research at Istanbul Technical University provide a common thread for her contribution to this work and the proliferation of the greening of architecture into the global landscape in distinct and diverse ways. The blend of these two dimensions of *time* (historic development) and *space* (geographic exemplifications) present a full account of an extremely complex and often contentious subject.

P.1 View from Namba Tower, Osaka, Japan Namba Park

ENDNOTES

1 World Commission on Environment and Development (WCED). *Our Common Future.* Oxford, UK: Oxford University Press, 1987: 43.

2 Oxford American Dictionary. Oxford, UK: Oxford University Press, 2010.

3 Source: http://www.perseus.tufts.edu, accessed May 2000.

4 Robert Lawlor, *Sacred Geometry—Philosophy and Practice*. London: Thames and Hudson, 1982.

5 Plato, *Timaeus*, translated by Peter Kalkavage. Newburyport, MA: Focus Publishing/R. Pullins Co., 2001.

6 Melissa Leach, Ian Scoones and Andy Stirling, *Dynamic Sustainabilities: Technology, Environment Social Justice*. London, UK: Earthscan Publications, 2010.

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Chapter 1
Origins of Green Architecture

Phillip Tabb

As from a seed the tree grows, so from a seed idea a pattern issues forth from the Center, passed on by ranks of silent angels—silent and still because that idea is too unformed and unfixed to endure any but the most exacting care.[1]

INTRODUCTION

Modern architecture, and the contemporary culture it reflected, contributed to the cause and necessity of a burgeoning *green process* that has emerged over the past half-century. Modern architecture broke from the eclectic traditions of the 18th century and focused on abstraction, standardization and serial production seeking a homogeneous international identity. As the world evolved with greater complexity and increased reliance upon technology, it was exhilarating and bewildering—and to a large extent was energy inefficient. As a result, it added unintended adverse consequences to the environment and exposed our dependence on fossil fuels. Beginning in the 1960s, works of Rachel Carson, E.F. Schumacher, Buckminster Fuller, Ian McHarg, and Stewart Brand, focused on the harmful effects to the environment and the awareness of holistic environmental thinking. Fortunately, earlier climate responsive architectural works by Le Corbusier, Frank Lloyd Wright, Ralph Erskine, Constantinos Doxiadis, Louis I. Kahn and Alvar Aalto, emerged as early modernist green precedents. The ever-closing circle of a single set of modernist universal principles was reconsidered by place-oriented intentions that initiated a diversity of environmentally conscious designs.

The Greening of architecture became an emerging process that attempted to transform modern architecture into more benign, environmentally oriented buildings. Green architecture evolved into a practice that advanced initially from rationalist, performance-based and remediating measures in response to particular unsustainable concerns, to far more encompassing ecological and systemic processes cutting deep across contemporary culture. So pervasive was the greening of architecture that, according to Julien de Smedt (JDS Architects), there was a definition problem. "'Green' and 'Sustainability,' the terms used to name the answer to the most pressing problem of our time, have become dangerously afloat in ambiguity and indeterminacy. Sustainable architecture is everywhere and nowhere."[2] Nevertheless, the green

movement grew as a global phenomenon seeking an accumulative reduction in the negative environmental effects caused by buildings, urban designs, settlements and other public works. Simultaneously, it served to explore environmentally oriented canons with new tectonic and emergent architectural languages.

The need for sustainable planning and design was not a new design consideration or determinant. Certain constructions for shelter, protection, and the need to create tolerable levels of comfort were considered in ancient designs and not surprisingly, still remain important today. The very term "shelter," meaning to provide cover, derives from the need for physical safety, to mitigate the negative effects of weather and adverse conditions of the environment, and to provide a place of dwelling. Over the centuries, various cultures developed specific architecture and planning responses to differing climatic conditions. These responses were refined progressively over time, usually from the development of single vernacular dwellings to larger urban settings. The English village, for example, grew from the rural cottage to the agglomeration of cottages into more compact settlement forms, especially during Celtic and Anglo-Saxon times (500 BC–1066 AD).[3] There were many lessons to be learned from the past's coping with climate and growing societal complexities that together with new green architectural technologies, could provide appropriate and intelligent approaches for future current and use.

The reaction to the harmful consequences of the Modern Movement—wasteful use of land and resources, inefficient and unhealthy construction practices, over-dependence upon fossil fuel-driven technologies, and reliance on the automobile for transportation to name a few—is warranted, but not entirely without a truly acceptable alternative. Yet, there seems to be an inextricable bond that still remains between modernism and the greening of architecture, which is amplified with the newest of examples in green building. This contradiction in philosophy, principles and perception of need has led to confusing and ambiguous results, which this chapter addresses. It is important to see the greening of architecture as an evolutionary process and cyclical ecology rather than simply a fixed set of strategies for a fixed period of time. A more dynamic and iterative view allows for the natural shifting of cultural values and needs to ever-increasing levels of sustainability, which in turn fosters a maturing architectural and urban response. It is a process that can affect every facet of contemporary culture toward attaining a more sustainable future. Sustainability goes far beyond the buildings and cities to include nations, continents and the planet as a whole.

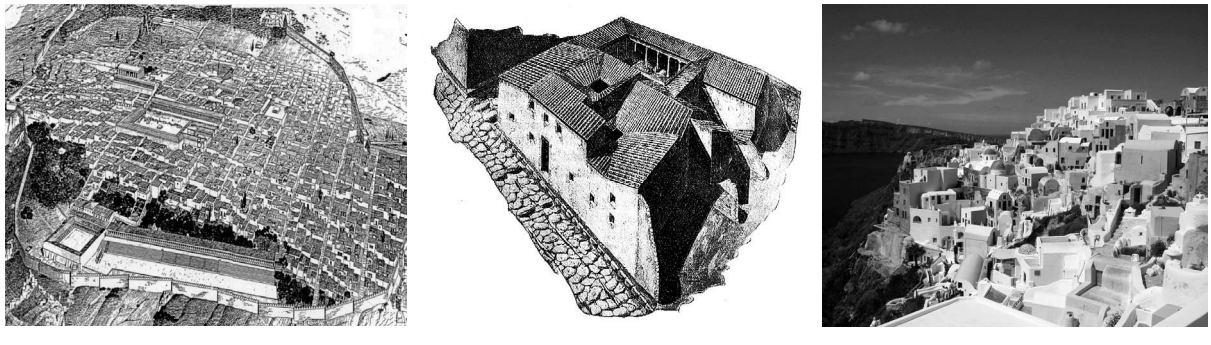
EARLY GREEN DESIGN STRATEGIES

Early examples of green architecture were by necessity climate responsive, providing shelter from inclement weather, and they also responded to other environmental concerns, such as on-site water collection, sewage removal and fuel for heating. Butti and Perlin suggested that the ancient Greeks had no artificial means of heating or cooling their homes. In winter they used mostly portable charcoal-burning braziers along with warmth they could glean from the sun during the day. However, as populated areas began to expand, surrounding forests were ravaged for wood for heating and cooking. By the 5th century BC many parts of Greece were almost totally denuded of trees.[4] Knowledge of seasonal changing of sun angles precipitated more aggressive vernacular designs that allowed the lower winter sun within the dwelling for warmth and the higher summer sun excluded to help mitigate overheating. The northern

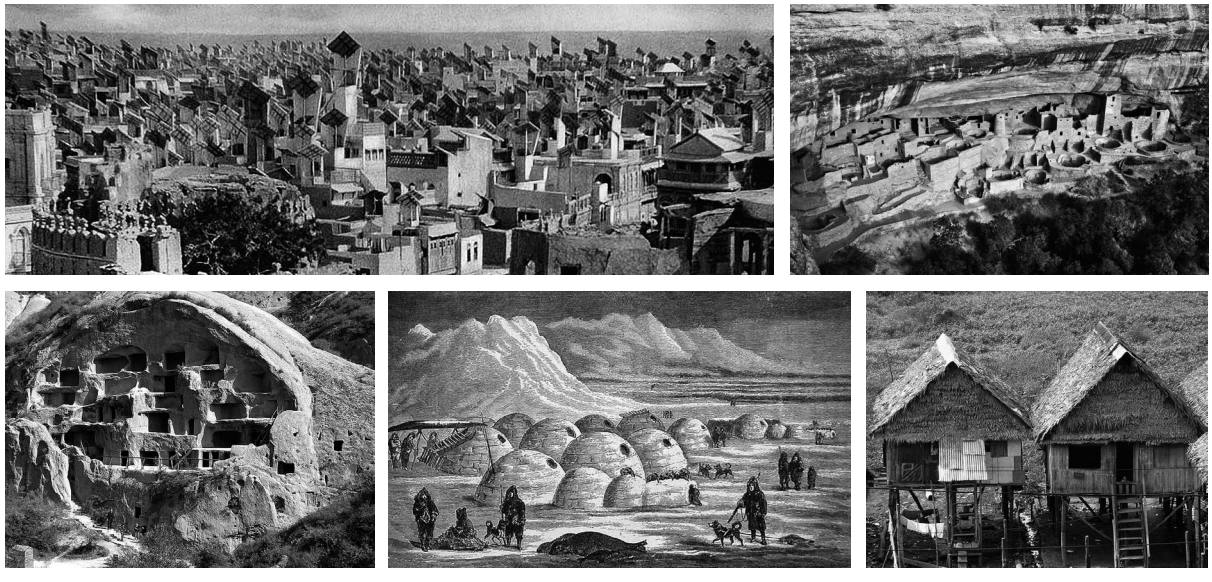
façades, with few or no windows at all, were constructed of thick masonry walls to keep out the cold winds in winter. These ingenious design measures crossed class lines from temple or palace to commoner's dwelling, which resulted in a cultural proliferating effect.

The Olynthian house, for example, was typically organized around a south-facing exterior portico and court that served as a private outdoor room and provided light and solar heat to the adjacent indoor spaces. The portico and roof eaves served to shade the sun in summer. The house designed with an integrated courtyard was the general scheme. The entrance to the dwelling was from the street and led directly to the courtyard. Surrounding the courtyard were all the other rooms, which opened into it. A portico with colonnade was built on the north side of the courtyard, which faced south for maximum sunlight. At ground level was a living room with a central hearth surrounded by a kitchen and bathroom. A men's room was fitted with typically seven couches around the perimeter for dining. The remaining rooms on the ground floor were for storage. The women's quarters and bedrooms were built above the northern half of the house. Slaves and family lived together as one big family. The significance of this work was in both the development of single building sustainable strategies in conjunction with urban design schemes, which provided the context for a compact sun-oriented settlement plan. Figures 1.1a and b illustrate the predominant cardinal grid pattern for Priene and a reconstructive drawing of a typical early Roman urban residence with interior court.

Modern excavations of many Classical Greek cities reveal the principles that generated these effective vernacular designs, which carried over into urban planning where street widths and orientations considered this solar phenomenon giving equal access to the sun for all structures. The Ionian city of Priene (1000 BC), located on the southwestern coast of Turkey, was a good example of urban design for challenging topography and excellent solar access. The region of between 4,000 and 5,000 residents was relocated because its original site was plagued with constant flooding, and therefore Priene was planned on higher ground beneath the escarpment of Mount Mycale. The six main avenues were placed on terraces paralleling contours and running east and west including the central avenue that was fed by the main west gate entrance. The avenues were wider providing solar access to south-facing building façades. Secondary streets ran up the north–south slopes and tended to be narrower. The agora occupied the center of the plan was situated on a widened contour to accommodate the larger open space.



1.1 Ancient Green Predecessors a) Priene Reconstruction Image (image courtesy of the German Archaeological Institute) b) Drawing for Early Roman Domus (image courtesy of the VRoma Project (www.vroma.org)) c) Oia, Santorini Today



1.2 Climate Responsive Examples a) Hyderabad, Pakistan Wind-catchers (Mangh) (1928) b) Mesa Verde, Colorado (image courtesy "Shutterstock") c) Yanqing Guyaju, China d) Oopungnewing Village (1865) e) Stilt House of Myanmar

The city was divided into four districts—political (Bouleterion), cultural (Theater), commercial (Agora), and religious (Temple of Athena). According to city planner Edmund Bacon, "the most remarkable thing about Priene is the total harmony of architecture and planning, extending from the over-all form of the city down to the last detail."[5] The photograph of Oia, Santorini in Figure 1.1c shows the earth sheltered solar-oriented residential forms cascading along the island's interior. These same principles were practiced in ancient China with important streets aligned along cardinal directions and the design for solar-oriented houses. In other climate zones and geographic locations, architectural and planning measures have responded to climatic conditions. For example, the powerful image of the city of Hyderabad, Pakistan demonstrates the pervasive use of hundreds of wind catchers used in many Persian cities as seen in Figure 1.2a. These examples are a good illustration of multiplicity of form, land-based design, and the Generative Principle.

Certainly, climate-responsive architecture and planning were not only confined to Ancient Greece and Asia Minor. Other locations worldwide indicated architectural designs for varying climate zones, extreme weather and natural hazards, and according to architectural historian Paul Oliver, these buildings did not "control" climate, but rather "modified" climate by affecting internal conditions toward greater levels of acceptable comfort.[6] Oliver suggested that, "arguments have been powerfully made for a physical and environmental determinism that considers that advantageous climates and temperatures, soils and seasons give shape to man's culture." These examples cross both time and geography representing varied design responses to differing environmental conditions. For example, the Swiss alpine house, the English cottage, the igloo of the Inuit, raised platform dwellings of the Amazon Basin, the adobe dwellings in southwest North America, the underground dwellings in China, and the wind towers of Pakistan, all have formal characteristics unique to the environments within which they respond.

The Long House at Mesa Verde, Colorado, shown in Figure 1.2b, utilized the concave rock formation for the advantage of solar energy exposure in winter and solar shading in summer. Typical, among the climatic design strategies were direct form and material responses to the prevailing climatic and environmental conditions, such as, the use of insulating and heat retaining materials and solar energy in colder climates or use of stilts, raised platforms for flood-prone tropical areas, and extended roofs for capturing breezes and for solar shading.

Roman architect, Marcus Vitruvius, in the 1st century BC, developed a set of architectural principles, known today as *The Ten Books on Architecture*,[7] which included planning and design guides and patterns on different aspects of building. In Book VI, Vitruvius described the importance of climate in siting and design, recognizing that different climates required different design approaches. He also addressed the proper exposure of different rooms to qualities of light and exposure to the sun for warmth. In Book VIII he described the finding of water, its differing qualities, collecting and exporting it and uses for it—showering, drinking and cooking. He felt that rainwater was wholesome and that the vaporous properties of different waters should be considered. He describes the many innovations made in building design to improve the living conditions of the inhabitants. Foremost among them was the development of the hypocaust; a type of central heating where hot air generated by a fire was channeled under the floor and inside the walls of public baths and villas. Vitruvius also recommended that in hot climates the north facades should be open away from the sun. In *A Green Vitruvius,* J. Owen Lewis suggested that the sustainable principles put forward by Vitruvius could be distilled into relevant design patterns, which are applicable today.[8]

The shelter with protective roof, thick walls and openings became the archetype for refuge and early climatic designs. The roof provided protection directly above from rain, sleet, snow, winds and the high hot sun in summer, and was also a symbolic element mediating between heaven and earth. Heat naturally rises, so roofs in cold climates tended to be lighter with higher insulation values for containing it. Thatch, straw and mud were used in early roof construction, and later clay tiles were used for greater fire protection and the protective outer layer exposed to the elements. Walls emerged from the ground and support the roof. Generally made from local materials of a site, they tended to be load-bearing masonry or earthen and quite thick, dividing domains of inside and outside. Mass walls served the function for defensive protection, heat retention as well as protection from climate. Stonewalling, for example, used a wet process of bonding stones with mortar made from lime and cement as early as 300 BC. These ancient walls had two thermal characteristics—the thicker the wall, the greater the insulative value, and the increase of thermal lag or flywheel effect.

Primitive windows were merely small holes placed in walls, and later were covered with animal hides, cloths, or wood. Shutters, that could be opened and closed, evolved next and enabled inhabitants to respond to diurnal (day–night) cycles. Over time, windows were made from natural translucent materials, such as mica and alabaster that gave protection from the elements while simultaneously letting in light. The Romans were the first to use glass for windows as they discovered the transparent optical qualities of amorphous materials. In Alexandria around 100 AD, cast glass windows, with poor optical properties, began to appear. Mullioned glass windows were the windows of choice among European elite, whereas paper windows were economical and widely used in ancient China, Korea and Japan. Double-glazing, with a resistance value of around R-2 ($ft^2 \cdot °F \cdot h/Btu$), was introduced in the 1930s and was designed to increase the insulative value of glass especially in colder climates.

1.3 Rural Village Cottage Designs a) Selborne Street Façade b) Rear Garden Façade c) Brittany Solar Vernacular

Using a "float glass" process developed in the early 1950s, larger continuous sheets of glass were produced and used in greenhouses and other larger-scaled applications. Heat Mirror glazing (R-4) and Low-E glass (R-3) were developed in the 1980s to further increase transmission of light and resistance to heat flow. Critical to the function of passive solar technologies was the use of improved glazing systems necessary to enhance the greenhouse effect and increase the efficiency of the system. Figures 1.3a and b illustrate vernacular cottages located in Selborne, Hampshire with more formal "eyes to the street," front façades and manicured landscapes, thatch roofs and informal rear garden in the back. Primary ridgelines run parallel to the street for good solar access into the streets, and hip and half-hip roof forms provide sunshine to rear gardens. Figure 1.3c is a typical rural house in Brittany, France, constructed using a simple gable roof form, masonry walls with integral fireplaces, and both south-facing windows and dormers that employed operable shutters.

Many of the conditions for planning and design that existed thousands of years ago still remain today, particularly the needs for shelter, climatic design and environmental modulation. However, the magnitude of the contemporary global culture has created a more complicated and far reaching set of sustainable problems. The initiating sustainable principles practiced before have tremendous obstacles to overcome in order to re-emerge as effective measures for today's labyrinthian complexity. If modernism was considered the cause of the present environmental problems, then it too was responsible for many of the solutions. Most of the green designs maintained close connections to modernism, especially using modernist structural, HVAC and material systems, and the tendencies of economy and functionality. Modernism's pervasive nature was a welcome consequence of the greening process. Key leaders in the Modern Movement provided valuable architectural works that embodied sustainable principles and design measures, which inspired a generation of greening of architecture.

MODERN GREEN ANTECEDENTS

While the effects of the Modern Movement became a worldwide phenomenon, it produced a relatively unified architectural language. A few architects and their works provided welcome examples of more environmentally oriented approaches to design that later had significant effects on the development of green architecture. These works tended to integrate climatic design principles with modernist forms, technologies and materials. Critical to this process

was the matching of the more extreme climatic conditions, such as overheating or underheating, with appropriate building forms that became sculpted through intentional climatic determinants. Historian William Curtis explained that nature was a growing source of inspiration, and that "several major 20th-century architects, notably Frank Lloyd Wright, Le Corbusier, and Alvar Aalto who, far from being just 'materialists,' had a lofty vision of 'nature' as a counterforce to banal mechanization."[9] Philip Johnson's Geier House (1968) located in Indian Hills, Ohio, was one of the first modern underground buildings. Daylight spilled through reflectors in the cycloid geometric vaults in Louis Kahn's Kimbell Art Museum (1972) in Fort Worth, Texas. In some instances the International Style had undergone a process of naturalization with rural vernaculars as continuing references and sources of inspiration.

Le Corbusier, who was considered to be one of the most influential architects of the 20th century, invigorated the modern movement with new shape grammars with universal implications. Although he had regionalist beginnings, most of his works had traces of salient and discriminating extractions from traditional and eclectic examples of the 19th century, but mainly forged new geometries, spatial orders and materials that were transformed for contemporary purposes. His search for a set of ideal principles led to a process of prototyping, which in turn advised his proposition of architecture as machine and his interest in mass-production. According to architectural historian Charles Jencks, Le Corbusier did not see the machine as a fetish, but rather it was being celebrated as an expression of evolution toward "higher states of organization."[10] He developed a means by which he could apply several levels of significance to single configurations. He was fascinated with light that created bold fenestration and light producing schemes, such as the monumental works in Chandigarh, the courtyard scheme at Sante Marie de La Tourette and the renown Virgo constellation window-wall at Notre Dame du Haut Chapel at Ronchamp, to name a few. Climate became an important consideration as his commissions had taken him to difficult climatic regions—the Mediterranean, Africa, Argentina, Brazil, Chili, Iraq, India and Russia.

Le Corbusier's plan for the Chandigarth capital (1953) was organized with shifted axis, asymmetrical symmetry, divisions of urban functions and institutional hierarchies, grand boulevards and focal points, and monumental buildings. The High Court of Punjab and Haryana in Chandigarh (1956) exemplified the bold phototropic form with large upturned parasol for sun and rain protection and the functional separation and articulation of the four principal operations of the window, and according to Jencks, was accomplished with "the various *brises-soleil* shade the glass wall from the sun; vertical, pivoting ventilators of sheet metal allow fresh air in—otherwise ventilation is achieved by fans; finally, the fixed glass wall, obscured at points for indirect light and open at other points for view." These formal characteristics were suffused in elemental sunlight, breezes, and rain and in many ways derived from the earlier Mogul traditions of Muslim India in the 16th century. Le Corbusier's architecture had far reaching impact because it communicated something profound and had a seemingly transferable language. It was not surprising that his works and ideas influenced both modern and green architecture alike.

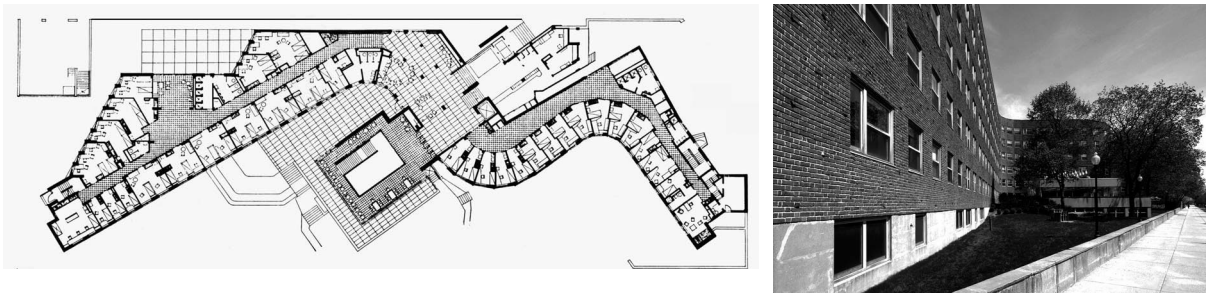
The more modest works of Egyptian architect Hassan Fathy were quite different than the heroic works of Le Corbusier. Fathy was disillusioned with the modern movement and with the environments created by it. Rather, he felt missing was the need for socially-oriented architecture and planning. New technology was supposed to change the quality of life, but for Fathy this was a failing of modern architecture. Nevertheless, his work aimed to be a part of the modern movement with focus on improving human living conditions, especially the poor.[11]

1.4 Le Corbusier and Hassan Fathy a) Chandigarth High Courts (1956) (image courtesy Eduardo Guiot) b) Ronchamp Chapel (1960) c) New Gourna Village (1948) (© Aga Khan Trust for Culture)

Key to his belief system was the idea that cultural authenticity was an essential non-interchangeability of cultures and that climate played an important role in this. New Gourna Village, located in West Luxor, was constructed in 1948 and was one of the most renowned and successful examples of Egyptian public projects. Construction began with the most public buildings—the mosque, market, village hall, theater, crafts exhibition hall and boy's school. Both the master plan and individual buildings within it responded to climate-oriented considerations with the close packing of buildings, narrow streets, thick adobe walls and courtyard dwelling designs. Two important observations can be made. First is that modern architecture and urban planning are inextricably wed. Second, is that climatic design determinants of form, rather than high technology, can produce effective green designs. Figures 1.4 a, b and c show photographs of the boldly formed sun-shaded façade for the Chandigarth High Courts Building, the daylit Chapel Notre Dame du Haut at Ronchamp, France by Le Corbusier, and the close-packing city blocks composed of courtyard dwellings in Fathy's New Gourna Village.

The works of Alvar Aalto expressed the mood of a new regionalism where the principles of vernacular architecture were crossbred with the languages of modern design. This suggested the adoption of local traditions, climate and construction methods and materials that were more place-adapted. While teaching at MIT in the late 1940s, Aalto acquired the commission to design new student dormitories for a site located to the south of the campus that overlooked Memorial Drive and the Charles River. The program was broken down into two different space types: first was the served or more livable functions, such as the sleeping quarters and dining hall, and second was the service functions, such as circulation, bathrooms, stairs, storage and laundry facilities. A serpentine double-loaded spine and spatial organization was employed with the service functions to the north and the dorm room functions to the south, which maximized the views and solar orientation from the more livable areas of the building. The architectural language of the north and south façades differ with planer walls and the cantilevered stair on the north in contrast to the undulating wall with regularly punctuated fenestrations on the south, which were only interrupted by the public functions of the program including the lounge and dining hall on the ground level. Figures 1.5a and b indicates the Baker House ground floor plan with the double-loaded serpentine shape and separation of the space types, and a photograph of the south façade.

This eccentric functional and serpentine plan organization was used in other projects as well, most notably the Neue Vahr housing project in Bremen, Germany (1959) that also employed the expressive fanning of the livable activities. It also echoed his New York World's Fair design of 1938–9.



1.5 MIT's Baker House (1946) by Alvar Aalto a) Ground Level Plan b) Serpentine South Façade (courtesy Yan Da, novatrio3.com)

Aalto's works certainly were inspired by metaphors of nature and served as a basis for regional abstractions for design and principles for architecture and urbanism. Architectural historian Malcolm Quantrill observed, "To many the Baker Dormitory remains as an American anomaly in Aalto's *oeuvre*; but in its bold use of apparently conflicting geometries and an equally confident handling of the fenestrations, both towards the river and Memorial Drive, it clearly outlines the programme for Aalto's direction in the next two decades."[12] The differentiated front and back façade treatment was reminiscent of earlier Greek architecture and later played an important role in the development of modern-day phototropic solar architecture common in the 1970s.

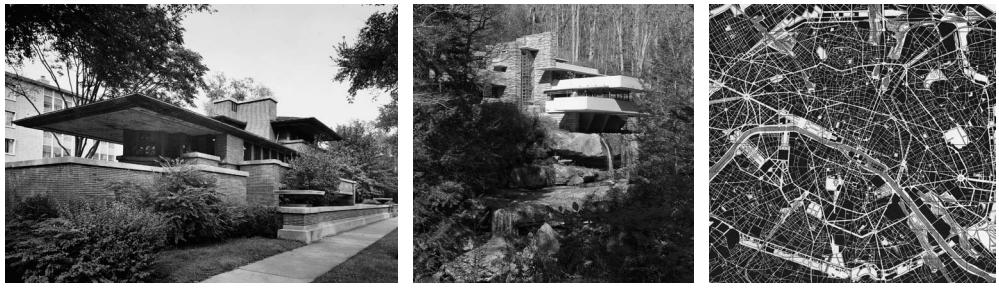
The early works of Frank Lloyd Wright generally focused on domestic architecture, in particular the Prairie houses, Usonian houses and a myriad of private commissions, but also included a range of other building typologies that included the Larkin Building, Unity Church and the Guggenheim Museum. Wright's early domestic works demonstrated sensitivity to nature, site, climate and context. Wright's works were considered to have green elements, which included a sensitive and often evocative relationship to the land, topography and surrounding site. His organic architecture possessed new spatial ordering systems, adaptable forms and innovative building materials, and were inclusive of the careful and integrated design and geometric control of all buildings elements from overall form to door handle creating an aesthetic continuity and unity. His Prairie Style works, with open living areas, low horizontal roofs, the use of natural materials, and the central hearth, were responsive to local climatic conditions. The Kaufmann Residence (1939) in Bear Run, Pennsylvania was certainly an expression of intense engagement between architecture and its immediate site, especially with the topography and adjacent waterfalls. It was given the "best all-time work of American architecture" by the American Institute of Architects in 1991.

The Robie house built in 1908 in Hyde Park, Illinois was probably the most celebrated example of his Prairie house typology, which was masterfully crafted into striations and asymmetrical unity within the urban setting. Figure 1.6a shows the strong horizontal roof planes that are cantilevered to cover integrated outdoor patios and circulation. Some of the principles derived from the Prairie house designs contributed to the concept of an organic architecture, and included extending the building form into the site for more participation, placing living spaces on raised foundations or platforms, organizing spaces with axial control and horizontality, creating open spatial connections for increased light, natural ventilation and view, mono-materiality where possible to contribute to a more harmonious whole, and incorporation of environmental control systems (heating, lighting and plumbing) into the constituent parts of the architecture. These principles were certainly important in generating a green agenda for architectural design a half-century later.

And of course, his Usonian houses were created to moderate cost single-family homes in response to the Depression in the 1930s. Concurrently, the designs resulted in reductions in energy loads because of their smaller size and the utilization of their sun tempering and passive solar heating schemes. They were extremely practical and were constructed from a kit of parts that included modular floor plans, standardized natural materials, unit wall systems, service cores, built-in components, zoned living areas with open living, dining and kitchen, and a central hearth. The insulated flat roofs extended beyond the walls to provide sun shading and throw water clear of the house. With these design principles there was an emphasis on "spaciousness" rather than "space," and simplicity above all. Simplicity was not merely reduction without complexity, especially in regards to organic elaboration. Rather, it dissolved its diversity of parts into an integrated whole.

The Jacobs' house was the first of the Usonian houses to be built and was located near Madison, Wisconsin. This project was organized by an orthogonal grid and an "L-shaped" plan, which accommodated 1,340 square feet (180 square meters), and in 1936 had a construction cost of $5,500. The plan shape served to separate public and private zones of the house with entrance at the right angle. These design strategies were later re-iterated in E.F. Schumacher's *Small is Beautiful* (1973).[13] Nature-embodied principles served as inspiration for Wright's organic architecture, which provided similar cannons for Biometrics and to some degree Landscape Urbanism nearly a century later. In Wright's own words, "Nature is my manifestation of God. I go to nature every day for inspiration in the day's work. I follow in building the principles which nature has used in its domain."[14] The contrasting climatic design approaches to Taliesin East in Spring Green, Wisconsin (1911) and Taliesin West in Scottsdale, Arizona (1937) clearly demonstrated Wright's knowledge and mastery of seasonal and climate-oriented architecture. Fallingwater or the Kaufmann House, completed in 1939, was designed for 2885 finished square feet (268 square meters), and was an extraordinary expression of the intense cantilevered patios interacting between dwelling and the 30-foot (nine meters) waterfall (Figure 1.6b).

Constantinos Doxiadis proposed the concept and intellectual framework for Ekistics, which was defined as the science of human settlements. By encompassing all scales of human habitation along with archeological, historical and morphological patterns of growth, Ekistics models were organized by five distinct and hierarchical elements—nature, anthropos (human beings), society, shells and networks. The coordination of scales inherent to settlement structure was a major objective of the Ekistics model as container (form) and content (function) formed a dynamic unity, as pictured in Figure 1.6c with the plan of Paris.



1.6 Frank Lloyd Wright and Constantinos Doxiadis a) The Robie House (1909) (Library of Congress, Prints & Photographs Division, ILL,16-CHIG, 33-1) b) Kaufman House (1939) (courtesy Jeffrey Howe) c) Ekistics Nodes and Networks (courtesy Random House)

Ekistics approached the problem through the interactions among these various elements. Importance was gained in the inclusive and relational functions of these elements, which later became influential in the development of emergent green urban philosophies and ecological design strategies. After his death in 1975, the Ekistics movement fell into obscurity. Yet, important concepts were exposed that today are integral to sustainable urban thinking. Doxiadis boldly stated that: "Human settlements are no longer satisfactory for their inhabitants. This is true everywhere in the world, in under-developed as well as developed countries."[15]

CONTRADICTIONS WITH MODERNISM AND SUSTAINABILITY

Modernism was a general set of cultural tendencies considered to have begun in the late 19th and early 20th centuries. In its initial reaction to the tradition and the ambiguity of enlightenment, modernism grew as a simplifying agent that later provided sympathetic resonance for advancing and changing technology and form. According to William Curtis, "modern architecture" was an invention conceived to oppose earlier chaotic, eclectic and historic forms, and sought to generate its own authenticity for an emerging modern industrial society.[16] He argued that modernism was a break to rediscover the true and genuine path of architecture, which was led by the Modern Movement of the Congres Internationaux d'Architecture Moderne (CIAM), the Bauhaus and Le Corbusier's *Vers une Architecture*. The modernist polemic of aesthetic reduction and abstraction and the secularization of development as a tool of everyday economic practice were aspects that critics have attacked. Architectural theorist Kate Nesbitt suggested that, "Abstraction, atonality, and atemporality, however, are merely stylistic manifestations of modernism, not its essential nature."[17] It was, therefore, important to see the framework of the motivations as well as the formulations to which the greening of architecture needed to relate and against which it was charged to rebel.

Current environmental problems can be traced to several general phenomena—rapid increase in world population, dependence upon fossil fuels for nearly every aspect of contemporary life, and the increasing addiction of use of the automobile for transportation. Confronting these phenomena according to Carl Stein, "Renewable resources are limited by the rate at which they are received and by the environmental disruption caused by their capture and use."[18] This includes fossil fuels, timber, arable land, and fresh water. Stein further went on to say that the waste from this process was another untenable consequence. The shifting of wealth and emergent modernity in large-population, developing countries has posed further environmental concern. The blame cannot be entirely laid on modernism as the evolution of our immense global culture, with its insatiable appetite for consumption, dominates the current placemaking process. Much of green architecture, while designed with renewable technologies, utilized the same construction methods, conventional building equipment, and materials, as was commonplace in modern architecture it sought to improve. A massive large-scale shift in city and building making could only occur with ubiquitous change in engineering, energy production, manufacturing, transportation, and construction methods.

Where modernism reacted to history and the traditions of the Enlightenment, it created a culture of consumerism and a vocabulary of a reductionist architectural language. New technologies and the use of modern materials, components and construction methods gave new expression to design. The curtain wall, first used by Skidmore Owings and Merrill (SOM) in the Lever House in New York City (1952), featured a 24-story, blue-green heat-resistant

fixed glazing system with a stainless steel frame curtain wall. Later, the Inland Steel Building (Figure 1.7a) in Chicago (1956) featured a totally open plan with separate service core and curtain wall of brushed stainless steel. The Seagram Building (1958) by Ludwig Mies van der Rohe was another example of the curtain-wall technology. The elevator, central HVAC systems and innovations in structure, glazing materials and telecommunication systems helped enable an expanding modern urban architecture. Also pictured in Figures 1.7b and c are the Northland Shopping Center in Detroit, Michigan and Levittown, New York. Taken together, the proliferation of steel and glass buildings, suburban shopping centers and low-density suburban housing developments contributed to a rapidly expanding and automobile-dependent post World War Two settlement pattern.

Modernism did not only inform building design, but influenced land use planning as well, especially within the suburban landscape, which in large part was a manifestation of it. Access to abundant and seemingly endless supplies of petroleum and mass production of automobiles opened a floodgate for a low density, single use settlement form. Numerous single-family housing developments followed with development of large shopping malls expanded into bordering agriculture land. Northland Shopping Center (1954) in Southland, Michigan was designed by Victor Gruen and was one of the first suburban malls. Schools and office parks followed in turn. This new suburban phenomenon was replete with all the modern facilities and services as long as there were inexhaustible supplies of gasoline nearby. Necessary life-support functions were separated by use, or what Leon Krier called "functional zoning," and required and elaborate automobile systems to connect all the disparate parts. Levittown, New York (1947–51), for example, spawned a generation of postwar suburban growth tied to this model. Interestingly, Levittown began with 2,000 small rental houses, and in time the development expanded to include larger homes with populuxe aesthetic that Levitt called "ranch houses," which spawned a total of 17,747 homes by 1951. Regional planner Marcial Echenique (1976) observed the inextricable relationship among the type and abundance of the source of energy, the kind of transport system and settlement form. If energy was cheap and the prevailing transport method was the automobile, then according to Echenique's formula, that naturally translated into a dispersed, low-density settlement form.

1.7 Expressions of American Modernism a) Inland Steel Building (courtesy K. Devyn-Caldwell -24gotham.com b) Northland Shopping Center (courtesy Walter P. Reuther Library, Wayne State University) c) Levittown, New York (Special Collections/Long Island Studies Institute)

It is important to present a discussion on modernism as it was not only the precursor to the contemporary architecture that followed, but embodied the ideals and constructions that exist at the core of many of the environmental problems in which green architecture attempts to correct. This included both the architectural and planning manifestations of it. The reaction to modernism fell into two overarching greening theories offering covalent alternatives, either future-oriented strategies promoting neo-avant-garde forms and innovative technologies, or backward-looking solutions with revivals of traditional pre-modern forms, vernaculars and methods. To summarize, modernism in cultural terms enabled a global society to evolve, expand and consume vast resources. As long as the predominant means of growth maintained the use of fossil fuels in energy production, manufacturing, transport and construction of buildings and cities, green architecture would have difficulty truly distancing from its co-dependent relationship to modernism and thus, effecting an independent developmental approach in large measure. An inherent contradiction remains—the greening of architecture requires the use of modernist construction and manufacturing, by which to realize the sustainable design measures and systems.

GREENING ARCHITECTURE

"Greening" is a *verb*, not a noun or adjective. Coincidently, the greening of architecture is not a finite set of conditions or simple application of design measures, but rather it is a dynamic process. Definitions for sustainability, fixing unsustainability, self-sufficiency, renewability, green building, bio-climatic and environmental design vary, and generally are interchangeable references to a greening process applicable to architecture and urban design. Some definitions, such as the Brundtland Report, referred to meeting the needs of the present without compromising the ability of future generations to meet their own needs. Green architecture, or green design, was also seen as an approach to building that minimized harmful effects on human health and the environment. Other definitions focused more on conservation and preservation of resources, especially non-renewable ones, and the enormous inventory of existing buildings worldwide. Generally, sustainable architecture intended to minimize the negative environmental impact of buildings by enhancing efficiency and moderation in the use of materials, energy, and development space. There were also concerns about diminishing the toxicity caused by the built environment. At the urban scale, sustainable communities were places planned, built, or modified to promote sustainable living. This included sustainability aspects relating to reproduction, water, transportation, energy, and waste and materials.

Issues of technology, scale, health, embodied resources, existing inventory, and energy conscious-behavior have also been considered and add to the difficulty of any single comprehensive and useful definition. Disagreement exists about the precise meaning of "*sustainability*." The term was used in many contexts, including development, cities, agriculture, economy, technology, environment, and buildings. Confusion existed about the meaning of the term, since it was used in so many different connotations and often was defined differently. Julien de Smedt's observation has growing relevance, that "*sustainability*" has become an ineffective term to explain either the complexity of the problem or an appropriate course of action. To better understand an effective working definition for the greening of architecture, it might be useful to discuss the problems to which it seeks to address. Vivienne Brophy and J. Owen Lewis observed that, "since the industrial revolution, but particularly in the past

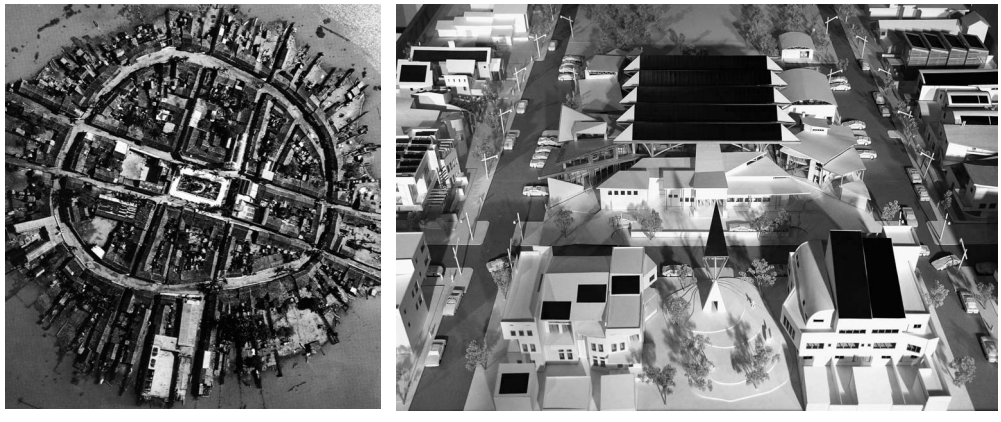
100 years, the twin phenomena of more widely-diffused wealth and relatively cheaper energy have resulted in widespread increases in energy use."[8] Carl Stein argued for a focus on two areas: the use of sustainable principles applied to all new buildings and the need to upgrade the environmental performance of most of the existing stock of buildings worldwide. And finally, Abdel-Hadi, Tolda and Soliman saw the relationships between the environment and human health, in addition to well-being and behavior as a necessity for sustainable design.[19]

Sustainability and green architecture must address design, building-making and consumer use patterns looking at issues of efficiency, health and longevity for both new and existing buildings. At the architectural scale it was both the construction and maintenance of buildings that green architecture broadly needed to improve. This implied the need to address the embodied energy of building materials, products and construction methods, thermal comfort, along with the maintenance and use of the building over time. Modernism produced buildings with shorter lives, built with lighter mass, and heavy reliance on HVAC systems that required large amounts of fossil fuel energy, approaching one-third of the useful energy produced. Thermal efficiency meant equal attention to building skin losses and gains, and the effects of climate, as well as internally generated heat gains from equipment, artificial lighting and people. James Marston Fitch published *American Building* (1966) where he discussed what he called the environmental impacts of the wall, both inside and out.[20] These environmental conditions were organized into four categories: atmospheric, luminous, sonic and biological impacts, in which the wall must ideally respond in multi-functional ways. These studies were important because they directed attention to the wall as a mediating system responding to dynamic internal and external influences.

Unlike the Modern Movement in architecture, green architecture did not express a single set of formal principles, manifest through an explicit pallet of materials or technologies, and did not have a strict and identifiable architectural form language. In the long run this was most likely a blessing in disguise, as sustainability issues were not going to disappear, but rather increase in importance and magnitude as competition for non-renewable resources increases. Dating sustainability with a particular language of form would confine it to a determinant period of time and would not allow for a natural evolution in design, function, technology and use. A new paradigm seemed necessary that has embedded in its DNA an evolutionary sustainable function and continuing reinterpretation of contemporary needs and corresponding forms.

GREENING URBANISM

Two planning forms organized by a central place have two drastically different architectural languages and approaches to sustainability. The first example, Mexcaltitan, was presumed to be a birthplace of the Aztecs and is today a living fishing community of 818 inhabitants (2010 census) that specializes in dried shrimp. It was a sustaining cruciform and circular island-city more than a thousand years old and less than a mile (1.6 kilometers) in diameter located in an estuary along the Pacific coast of Mexico. Its sustainability takes the form of a living place inextricably connected to its place for shelter, commerce, religion and community (Figure 1.8a). The second example was the proposal for a sustainable neighborhood in the Babcock Ranch Development in southwest Florida by Texas A&M University students (Figure 1.8b).[21] The orthogonal grids supported a density gradient and mix of neighborhood-scale commercial and residential uses.



1.8 Differing Approaches to Sustainable Urbanism a) Mexcaltitan, Mexico (© Yann Arthus-Bertrand / Altitude) b) Renewable Technology Neighborhood Center (© Phillip Tabb)

A central plaza was designed as a pedestrian-gathering place and was structured with saw-tooth photovoltaic collector arrays, which provided electricity for community uses, sun-shading and daylight behind the arrays. Both places relied on the spatial order, characteristics of centrality and Unity Principle. Mexcaltitan was a sustainable island plan that evolved organically over time using circumferential geometry, while the Babcock neighborhood was a new proposal featuring renewable systems and an orthogonal grid—design versus technology.

The issues of scale and context for sustainable measures enter the discussion when larger ecological principles are related to the complexity of the urban environment and the myriad of interrelated systems that are required to maintain it. Geographer Susan Owens argued that different sustainable measures or structural variables are applicable to different scales of development from single plots, buildings and neighborhoods to individual settlements and regions.[22] This is to imply, for example, that dealing with regional movement of energy and resources required different sustainable interventions than reducing thermal loads to separate dwellings. Patrick Condon argued for a set of rules or what he calls "simple steps to recovery" for sustainable communities.[23] His measures were fairly specific and covered the needs to restore the streetcar, re-establish the interconnected street system, create pedestrian zones with integral commercial, schools and transit stops, locate jobs close to homes, provide a diversity of housing types, create linked greenway systems, and invest in more sustainable infrastructure. Splintering Urbanism has promoted an infrastructurally mediated network as an emerging pattern.

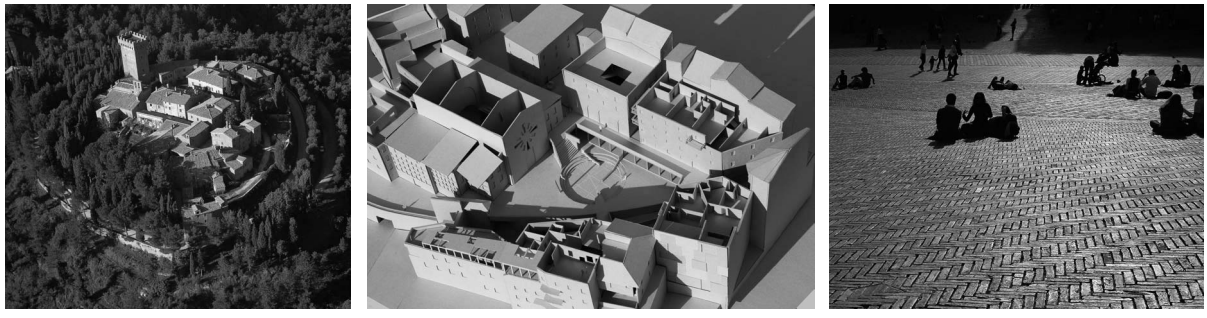
Planner Nan Ellin echoed these steps with a more abstract manifesto of urban design that she called "*qualities of an integral urbanism*." They included hybridity and connectivity, porosity, authenticity and vulnerability.[24] What was interesting with these urban measures for sustainability was the shift from isolated technological or specific design solutions to broader issues addressing integration and inter-connectedness. Analysis of Ellin's manifesto reveals relational rather than fixed qualities. Architectural historian David Grahame Shane's *Recombinant Urbanism* put forward the idea of a mutable process of self-correction through recombination of urban attributes that in the case of a fossil fuel based settings could in fact be sustainability altered and re-formed genetically.[25] This suggests a heterotopic urban

environment of fragments and patches grafted together, such as theme parks, mega shopping malls, automobile dealership campuses, and entertainment districts that especially occur in larger multicultural cities. A common thread to these emergent theories was the more complex systemic nature of the issues that exist at the urban scale and the necessity for transformable and tractable sustainable measures.

These correspond to Ken Yeang's notions of the dynamic qualities of a region's ecosystems and their changing interactions with the built environment.[26] He suggested that with "the ecological approach, there is no single '*technological fix*' or universal design approach that will solve all the environmental problems or eliminate all the negative effects." Furthermore, Yeang promoted the idea of an ecological context within which to reinvent the built environment as a greater part of the organic system that formed a dynamic and interactive involvement with the environment and the changes it undergoes. The artificial environment, according to Yeang, was like a set of circuits that should systematically process incoming natural resource inputs (energy and materials), utilize them efficiently, and discharge the outputs cleanly. This view was about relating the diversity of contemporary human activity to ecological flows. This ecological model, while ambitious in concept, was in direct conflict with the indiscriminate piecemeal urban growth that typically continues worldwide.

By the nature of their scale, sustainable planning measures require larger systems of consideration, including reforms with land use, density, infrastructure and transportation planning along with urban architecture. Expanding human populations, especially in developing countries, continues to increase the inventory of buildings and urban environments, which brings remediation rather than innovation to the forefront of sustainable planning and design agendas. Timothy Beatley states that variety and extent of greening initiatives and activities were impressive, and ranged from promotion of compact urban forms, commitment to public transit and pedestrian design, to efforts to operationalize more circular or ecological approaches to existing cities.[27] The *New Urbanism*, with examples like Seaside, Florida and Pounbury, England, attempted to develop a more compact, pedestrian friendly environment, but has drawn criticism because of the rigid and formal nature of the prescriptive work. Additionally, the apparent lack of serious sustainable planning and architecture measures were apparent especially in the early examples. With the emergence and appropriation of *Agricultural Urbanism*, the gap between the New Urbanism and sustainability has decreased. The notion of, "*placemaking as a sustainable strategy*," had promise, as it could become an integrative adhesive for both the planning and architectural scales with focused attention to the quality of dwelling and stewardship instead of technology.[28] The Generative Principle seemed to be a driving force in the beginning with strong reactive tendencies and a direct focus on developing architecture and urbanism. The Re-generative Principle emerged later with a more integrative, dynamic and holistic focus.

Meanwhile, the prevailing tendencies remain toward "business-as-usual," albeit some stiffening of energy and environmental standards and certification programs, and the development of heroic and monumental versions of green architecture. A sustainable future is faced with overcoming the context of an incredibly complex existing built environment that was generally developed unsustainably. The life expectancy of buildings varies with age, quality of materials, use, location, weather, degree of maintenance, and quality of architectural design. Factors that determine durability include moisture, UV radiation, temperature, chemicals, decay and corrosion, insects, fungi, natural hazards and wear and tear. For example, the lifespan of an office building is around 70 years. Therefore, office buildings constructed in the mid-1960s are due to be replaced in 2025.



1.9 Placemaking and Spaces Contained a) Castello di Gargonza b) Model of Piazza della Collegio c) Placemaking in the Siena Compo

The explosion of building worldwide over the past half-century has created a confusing context within which there have been places of relief and a few moments of sanity. Figure 1.9a illustrated an aerial photograph of Castello di Gargonza located in the hills overlooking the Val di Chiana with its clear boundary, internal grid system and place-marking tower. Figure 1.9b was a model of the Piazza della Collegio that formed a portal entry into the medieval center of Castiglion Fiorentino, Italy. And Figure 1.9c illustrated several social pockets or intimate places formed within the context of the Piazza del Compo in the center of Siena, Italy. Placemaking was a sustainable strategy that could also be found with Central Park in New York City, Golden Gate Park in San Francisco, Hyde Park in London, Tiergarten in Berlin and Jardin de Luxembourg in Paris all offer connections back to nature with incredible health and economic benefits. Placemaking offered tremendous opportunities in addressing sustainability on multiple levels including both building energy and transportation energy needs.

The Greening of Architecture, including urbanism, becomes a progressive and accumulative process for remediation and repurposing within the context of the tremendous inventory of the existing built environment, and innovation directed at the relationship between evolving cultural needs and new models of green architectural and urban design responses to them. Rather than merely adding sustainable measures externally, green architecture emerges through its authentic and internally generative nature and original purpose. Critical to the development of a sustainable future is the creation of inclusive intellectual capital applicable to all scales of development, existing and new. The greening architecture has many dimensions and scales of consideration, much like the earlier pioneering Ekistics' elements developed by Doxiadis—nature, anthropos, society, shells, and networks, and the qualities of Ellin's Integral Urbanism and Shane's Recombinant Urbanism. The greening of architecture is posited by the following 12 objectives and defining characteristics:

1. The greening of architecture must address resource and energy use *conservation*, *preservation* and *efficiency*, reducing loads and demands. This also includes saving energy and resources through efficient consumption and re-use.
2. The greening of architecture must address both *skin-dominated* energy flows (gains and losses) and *load-dominated* energy sources (solar gain, lights, equipment, people and outside make-up air) and employ efficient control systems.

3. The greening of architecture is *climate responsive* and seeks to utilize the beneficial qualities of local and *natural resources*, especially sun, light, wind, and water, and it needs to protect from negative environmental extremes and damaging effects.
4. The greening of architecture incorporates *low-embodied* building materials, equipment, products and construction methods. Measures should be *obtainable* and *affordable*.
5. The greening of architecture must address the *health issues* associated with site geology and outgassing from building materials, finishes, products, equipment and construction methods.
6. The greening of architecture acknowledges the need for *preservation* and the need to *recycle*, continuously *repurpose* and *up-grade* the existing building stock.
7. The greening of architecture must address the differences in single and multiple building contexts and variable *building typologies*, that have different needs, functions, and environmental conditions.
8. The greening of architecture responds interactively to *natural ecological flows* of a particular site, microclimate, region and eco-system.
9. The greening of architecture is a nested part of a larger *planning and design* process and context within which it exists, participates and contributes. Appropriate sustainable strategies need to be targeted the specific scales of application.
10. The greening of architecture seeks advanced, clean, hybrid and efficient *sources of energy* for buildings, transportation and power production.
11. The greening of architecture is a *mutable* and *iterative process* that occurs, changes, builds intelligence, and evolves over time. In the context of this work is defined by generalized measures, technologies and planning schemes found within increments of decades.
12. The greening of architecture is a *global phenomenon* that expresses both regionally and transnationally, in urban and rural contexts, with new and existing structures, and in industrialized and developing countries.

TEMPORAL LANDSCAPE FOR SUSTAINABILITY

The development of a particular movement in architecture matriculates through cycles—reaction, development, refinement, innovation, re-invention and re-generation. The greening of architecture has moved from simple process of remediation to holistic models of design. In the 1960s the term for sustainability would address bio-climatic design features of single buildings and would promote the diversity of formal design approaches in response to varying climatic conditions. Issues of form complexity, orientation, plan aspect ratios and degrees of transparency were considered. The conditions surrounding comfort were examined and the architectural means to achieve appropriate comfort levels were explored. The broader term "*environmentalism*" was used to describe the larger effects of our modern world on the environment, especially the elemental and biological systems. Beginning in the 1960s, works of Rachel Carson, E.F. Schumacher, Buckminster Fuller, and Stewart Brand, focused on the harmful effects to the environment and the awareness of holistic and environmental thinking. The work of the Metabolists in Japan and the emergence of the megastructure provided alternative paradigms of urban design with the bio-technical notion of the city as an organic process. Team Ten, beginning in the early 1950s, provided continuity with CIAM, but broke away to promote

further ideas of an urbanism and socially transformative architecture and planning. Their theoretical framework had a profound influence on the development of architectural thinking in the second half of the 20th century, especially in Europe.

In the 1970s the focus was more on emergent solar technologies that were coupled with more aggressive energy conservation measures. Sustainability was directed to reducing energy demand and utilization of on-site resources, especially solar energy. The profound effect of the 1973 Oil Embargo spawned a change from a "form-function" architectural preoccupation to one of "form-performance." At this time a building's value was measured in its ability to save energy. As a consequence, many scientific ideas and energy technologies were developed, including solar optics, thermal storage and control systems. Passive solar designs emerged that transformed single buildings into highly insulated solar collectors. Architects Michael Reynolds, James Lambeth, Malcolm Wells, and Ralph Knowles, were influential with radical, playful and dramatic designs. The optical and thermal dynamic characteristics of energy collection and storage were explored and folded into an expanding definition of green architecture. The more rigid orientation constraints of these solar systems began to impinge upon and create the need for the necessity of more flexible and varied site responses, and the collector tilt angle requirements affected south façade designs.

In the 1980s green architecture looked to more historic-driven and vernacular forms and to de-emphasized the tectonic characteristic of the decade before. Issues of preservation, conservation and historic formalism were in part driven by postmodern theory. Postmodernism in the 1980s had an interesting gentrifying effect over these works that over-emphasized the energy function of a building. The contextual and vernacular-sensitive works of Sam Mockbee, Brian MacKay-Lyons, Glenn Murcutt and Lake Flato exemplify this re-direction with local socially conscious designs. The New Urbanism was a form of postmodern planning aimed at providing an alternative to functionally zoned, single use residential developments that proliferated suburban planning practices. It promoted place-oriented development that was inspired by traditional town planning methods and forms replete with city blocks, boulevards, more densely packed and varying housing typologies, mixes of use and formal public buildings and spaces. In his essay, *Towards a Critical Regionalism* (1983), architectural historian Kenneth Frampton called for an architecture that would strive to overcome placelessness and lack of identity by utilizing a building's geographical context.[29]

The 1990s brought Green Architecture fully into the mainstream with larger and differentiated building typologies and eco-technologies, as evidenced in the works of Arup, Calatrava, Grimshaw, Piano and Rogers. The structural and environmental control system technologies were carefully integrated into the architecture and boldly expressed. Minimalist building skins were being replaced with more complex and functional layers, and eco-technologies. Many of these new technologies were not merely fixed responses to environmental forces, but rather were dynamic and moved with them. Additionally, this time spawned the literal greening of buildings with the vegetated architectural examples of Yeang and Ambasz. These works ostensibly represented a host of similar projects that took on the literal greening of a building including green roofs, green walls, greenhouses, and sky gardens. *Cradle to Cradle* by William McDonough brought attention to the negative health effects of building materials, products and construction practices.[30] There was also a growing concern to address the embodied energy associated with imports of foreign materials and products, many of which were in themselves deemed "sustainable," but required vast amounts of energy to transport them to local sites.

This past decade beginning at the millennium has seen the ever-expanding diversity of sustainable thinking in architecture, which evolved beyond the greening of single buildings to focus on larger urban, suburban and exurban contexts. Village Homes in the 1970s, New Urbanism in the 1980s, Kronsberg in the late 1990s, Serenbe Community in the 2000s, and Masdar City projected to be completed in 2015, featured climate responsiveness, land preservation, renewable technologies, densification, active living, aging in place, mixes of use, and integral agriculture at the urban scale. Green urbanism has emerged with less to do with building technology and greater focus on shifting cultural values toward reforms in land use, density, modes of transport, and the development of community-scale clean energy systems. There was increasing recognition that the worldwide building stock was an important focus for green design interventions as they represent such a large value of embodied energy. Environmental entrepreneur Paul Hawken stated, "Modern buildings are temporal in every sense."[31] This means they have a life cycle and increasingly they are not made to last. Especially in housing, where durability of building components and materials has been reduced with increased economic demands for lower initial capital costs for construction and reduced time in project delivery. In contrast, sustainable solutions need greater attention to quality and detail. The Greening of Architecture evolved to a global phenomenon incrementally moving toward a climax planetary environmentalism. James Wines began his book, *Green Architecture* (2000), by writing; "Architecture in the 20th century began as a celebration of the Age of Industry and Technology; but today this is rapidly changing in response to a new Age of Information and Ecology."[32] The combination of these tendencies has moved the greening process to greater depth, feedback and connectedness.

Global themes in green architecture occur within a diverse international geographic landscape. The themes identify important trends and realizations of contemporary and postcolonial seminal architecture and urbanism with accompanying sustainable measures. The geographic dispositions give a more complete picture of the pervasiveness of the greening process and the diversity of design approaches worldwide. Earlier green development reveals contrast between critically derived indigenous practices that rely strongly on local building cultures, materials and methods and low technology, and the more refined and bold works characterized by high technology, hybrid systems and varying building typologies. Approaches to higher densities and urban design are a logical developmental synthesis that can be seen throughout the world.

The *Greening of Architecture* from a global perspective presents a diversity of place and geo-centered exemplifications driven by cultural, ideological, climatic, economic and tectonic determinants creating a varied landscape of geographic, oppositional divisions (Industrialized–Developing, East–West, Urban–Rural, High Tech–Low Tech, Large–Small, New–Existing, and Extreme–Conventional). Regional diversity, global congruity, and hybridization characterize green architectural approaches worldwide and tend to be distributed by building typology and urban location. The phrase "think global, act local" was attributed to Scottish town planner Patrick Geddes (1915) and captured a common sentiment connecting global issues and concerns with local sensitivity and action. The regional "modifiers" gave emerging global green architecture particular authenticity, relevance and sustainable utility, while universal tendencies presented continuity and contemporaneous global parity.

This landscape of time represented the development of an incremental response to the need for higher levels of sustainable design. Abraham Maslow's "*hierarchy of needs*" was an echo that articulated the psychology of the whole and its constituent parts in the form of a cascading order

of importance.[33] In the field of sustainability, it gave a sorted account of the critical needs and evolving circumstances that had corresponding design responses to them. Yet, the *Greening of Architecture* was not a fixed prescription, as it tended to be more transient, contingent, resilient and nonlinear. Therefore, it was the principal objective of this work to delineate the complexity of approaches and the underlying nature of developments in green architecture over time and to describe the diverse approaches to it. This work has been divided into three parts: this chapter, which is a brief overview of the environmental issues and the nature of earlier green architecture in response to them. Second is a historic perspective of the pioneering evolution of green technology and architectural integration over the past 50 years. Third is a survey that is intended to show the intransigent and culturally pervasive exemplifications *au courant* by a wide range of geographic territories and cultural contexts.

The Greening of Architecture is seen as an evolutionary process that is informed by significant world affairs, a response to climate change, intelligent management of available natural resources, emerging environmental theories, movements in architecture, technological innovations, and seminal works in architecture and planning throughout each decade over the past 50 years. The developmental effects of influential works are not always obvious as change is often a result of many parallel and seemingly unrelated events. A benefit of looking back in time is the ability to see the patterns and connections that may not have been originally visible. Nevertheless, both intended and unintended efforts have contributed to the positive change. Similar to the objectives of the Brundtand Commission Report, this understanding of sustainability, and likewise the greening of architecture, is a phenomenal process of improving, over time, the quality of human life while simultaneously living responsively within the carrying capacity of supporting ecosystems.

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