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# SUSTAINABLE DESIGN IN ARCHITECTURE

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## 1. Introduction

The contemporary environment today has been undergoing many changes. Particularly the interference of the human activities with the natural environment ends up with universal changes, and thus, these changes add new dimensions to the ecological equilibrium of the world. The developments created by humankind for his comfort are threatening his own life. Never before in history have human beings had such an impact on the Earth. The resulting problems are a product of the size and growth of population, quantity of consumption and quality of technology. A general acceptance, regarding environmental crisis is reflected on both local and global levels that, the present form and degree of resource exploitation and associated consumption practices are unsustainable.

The understanding of the 20th century architecture, has a big responsibility in achieving this unsustainable result. Architecture in the 20th century, began as a celebration of the Age of Industry and Technology; but this is rapidly changing in response to a new Age of Information and Ecology. Most conventional practitioners of modern design and construction find it easier to make buildings as if nature and place did not exist. Fossil fuels make buildings in both locales inhabitable, lighting them, cooling them, heating them. However, the consumption of fossil fuels is one of the biggest environmental problems. We may think of cars and factories as the most obvious enemies of the environment, but buildings consume more than half the energy used worldwide [Wines 2000].

The aim of this presentation is to obtain a general exploration of one of the most complex and problematic issues facing the humanity over the last and current centuries – that is, how to construct a human habitat in harmony with nature. Modern Architecture tend to confuse, rather than reinforce, a progressive image of earth-friendly architecture. So, initially it is essential to rethink briefly about modern architecture.

## 2. Modern Architecture

In 1923, the great Modernist pioneer Le Corbusier hailed a “new epoch” and proclaimed: “There exists a new spirit! Industry, overwhelming us like a flood which rolls towards its destined end, has furnished us with new tools adapted to this new epoch, animated by the new spirit. Le Corbusier and the other modernists such as Walter Gropius and Mies van der Rohe pursued a rational , minimalist approach to architecture to free it from class distinctions and the nationalist ideologies of the day. They employed modern materials, new technology, and industrial forms (the building as a sleek, mass-produced machine) in the interest of replacing unsanitary, inequitable housing with clean, austere buildings for the masses.

Their theories and their glass-walled high-rises helped articulate a modernist sensibility that came to be known as the International Style. These architects, and those who followed them, designed monuments to rational form and pure function, which to a great degree achieved their end: an international aesthetic largely freed from the constraints and ideologies of particular places.

Modernist architects conceived of buildings as light, rectilinear enclosures of dynamic volumes of space. The robust mass of traditional stone and brick provided a poor representation of this modern idea of form. Instead, the modern architect turned to concrete, steel, and glass, far better materials for suggesting lightness, space, transparency, and sleek, industrial modernity.

Whereas Le Corbusier referred to the house as “a machine for living in” –acknowledging his dept to industrial sources- there is a new generation of architects who regard the earth itself as the ultimate “machine” and the human habitat as an extension of this concept. The initial triumphs of Modern Architecture were inspired by the industrial dream. From the turn of the century through the 1930’s, architects passionately believed there was a direct equation between the combustion engine and a spiritual vision for shelter.

Air-conditioning called “man-made weather”, liberated modern architecture from nature. It allowed Le Corbusier to dream of “**one single building for all nations and climates,”** the machinelike structure independent of place. With a few notable exceptions, his dream has come true. If we scan the skyline of Shanghai we see little that is much different from the skylines of Los Angeles, Manhattan, or Frankfurt. The buildings are steel-and-glass boxes, tightly sealed, short on fresh air and natural light, their internal ecosystems divorced from their surroundings [Gissen 2003].

If buildings such as these were to be a strike against nationalism, they have become as well a leveler of cultural diversity, overshadowing the very rich differences between Eastern and Western approaches to shelter and landscape. Today one only has to observe the bleak and hostile legacy of this vision in cities around the world to see how these ideals have degenerated through endless repetition in the hands of the followers of the Modern Movement. As long as buildings are conceived as isolated “big events”, as monumental statements by their designers, all the same mistakes will be compounded over and over again.

The modern architecture movement, under the name of internationalism and universality, took it for granted that architecture could be governed by architectural design indifferent to essence of place.

The design or visual forms of architecture tend to be swiftly disseminated via magazines and quickly and indiscriminately reproduced and copied all over the world, irrespective of whether it be in a middle eastern desert or a monsoon region, that is dissociated from the climatic and cultural context of the place which increases the energy consumption [Nagashima 1999].

It is not only in the realm of information that the earth is a village. The issues of environment and ecology are also significant. We have to recognize that phenomena which used to be regarded as somebody else’s problems are now inevitably ours too. Literally everyone has became everyone’s neighbor.

Until modern architecture conquered the world, architecture was mostly rational, functional, hence resource conserving and energy saving in the regional/local climatic context. Architecture embodied the local characteristics or a place. Therefore, vernacular architecture, by its nature, had built-in sustainability, both physical and cultural. In that sense, we ought to have a meek attitude to learn from the vernacular.

For the professionals who are involved in the creation of cities and architecture, it is becoming more and more important to be interested in and be involved in the process of development in the local community of actual residence for being able to attain sustainable designs.

## 3. Sustainability

Sustainability is most certainly concerned about excessive use of finite resources and the efficient management of the ecosystem, greenhouse gases, storm water pollution, efficient food production as well as fundamental concerns for social equity and social justice. The idea of sustainable development helps to base the human standard of living on the carrying capacity of nature.

Sustainability, in essence, is a way of thinking about one’s relationship to the natural world in the context of time. The word “sustainable”, according to the Dictionary of Webster’s New collegiate, is defined as follows:

“Of , relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged” [Onal 1997].”

Nature conservation has been the most deep-seated root of sustainable development thinking. Indeed, sustainable development was put forward as a concept partly as a means of promoting nature preservation and conservation [Adams 2001]. A generally accepted definition of sustainable development can be found in the Brundtland Report: (UN, World Commission on Environment and Development, 1987)

“Sustainable development is the kind of development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs.”

The concept of ‘sustainability’ has progressed with ‘Agenda 21’ which was developed after the Rio Summit by the European Union in 1995. According to it, valuing resources includes valuing existing building stock as physical materials, and embodied energy, but also the cultural resources and heritage of people. Part of the process involves requiring local and regional authorities to carry out audits of ‘present conditions’. This includes the social, economic and cultural context. The thrust of Agenda 21 is that sustainability should be incorporated into all regional plans, and community participation is a key activity to ensure that those ultimately affected by proposals are fully represented [Farmer 1999].

Sustainability represents a balance that accommodates human needs without diminishing the health and productivity of natural systems. The American Institute of Architects defines sustainability as: [Mendler, Odell 2000]

> “the ability of society to continue functioning into the future without being forced into decline through exhaustion or overloading of the key resources on which that system depends.”

Although sustainability is one of the most significant concepts of this decade, influencing the design of global government policy, economics, energy resources, technology, manufacturing, community planning and **architecture**; the idea of sustainability is not new. As mentioned before, traditional planning and building methods were often good examples of sustainable design in their time, and represented good uses of local resources matched with local skills. In combination, they produced a built environment which met people’s needs. However, factors such as demographic growth, and shifts from rural to urban areas create an imbalanced population distribution, natural and man-made resource depletion, and significant changes in expectations and life-styles, all of which combine, in their various ways, to erode the viability of traditional approaches to shelter provision. A building method that worked well in the past in its given context may have now become difficult to afford, build and maintain, and it may no longer meet the desired requirements of the family or community [Oktay 2001]. But it is essential to look to buildings in the distant past for ideas about how to build in the future. Indeed, before the advent of air-conditioning and other technologies that is now taken for granted, architects and builders had no choice but to create sustainable structures. In the late nineteenth century – before electrical heating, cooling and illumination – architects used a combination of mechanical devices and “passive” techniques (which worked without electrical or mechanical equipment) to illuminate and ventilate the interior spaces of even high-rise and long-span buildings.

There are roughly two meanings in the notion of Sustainable Architecture. The one is buildings which physically last long, require little maintenance, and save in energy, utility and disposal costs. These are the aspects of gentleness to nature and that of small load to the environment, hence contribute to the sustainability of cities and consequently contribute to the sustainability of the whole earth. This is the aspect of what sort of impact the human deed of constructing buildings renders to natural environment and ecology. These are largely engineering aspects.

The second aspect is the way architecture and environment ought to be, in fostering man’s spirit and soul, and make man as a spiritual being sustainable. That is to say that, architecture should not only be justified for giving little negative impact to global ecological systems by being resource conserving and energy saving, but also it should have beauty and something metaphysical which could work on human soul [Wines 2000].

So, ecological design has to struggle with ways to integrate environmental technology, resource conservation, and aesthetic content. Without all thee components in place, there is little chance for a truly enduring architecture. A major factor contributing to the longevity of buildings that have survived from the past, is their fusion of nature and art. They had to be both earth friendly and beautiful to be worthy of preservation in the first place.

## 4. Sustainable Architectural Design

Over the past two decades, sustainable design has been in the process of being defined world-wide. Sustainable architectural design, is the kind of design which respects natural resources, and embraces, human, cultural, and historical distinctions.

Architecture is an intervention upon Nature. It protects human beings from the intensities of solar exposure, climate and other humans [Crowther 1992]. Besides, architecture is a reflection of the contemporary society in attitude, customs, desires, needs and technology; and in present society, the natural coherence and sustainability become important priorities in the process of design. Sustainability in architecture, requires efficient and healthful interior solar and climatic space planning. Besides, the relationships of the interior spaces with the exterior spaces have to be strong and the coherence of nature has to be provided.

Modern technology and methods of construction have sadly degraded natural resources- agricultural land, forests, air, and water. There has been a loss of energy on the Earth because of misuse. Sustainable design assumes that this misuse can no longer be sustained, because the world's population is expected to be more than double in the next fifty years. One of the defining features of the machine-age twentieth century, has been how separated and sealed off from the environment people have become. Whether in air-conditioned buildings, the shopping centers or the theme park, technology has been used to construct a world that removes people from nature [Farmer 1999]. So sustainable design, focuses on optimizing and using the environment. It requires a fundamental change in mind set and a change in values towards less consumption and environmental awareness.

In the context of sustainability, architecture seems to act as a container of changing circumstances, where individuals and groups play an important role in the creation of their habitats, and at the same time it provides opportunities for long term flexibility and adaptability. So, architecture must be capable of sustaining changes and be based on long user needs. Architecture does not end with its foundation and outer walls. But the complete design infrastructure of urban planning, interior, landscape, product and systems design are part of the sustainable architecture [Crowther 1992].

Many factors account for the shift toward a more human and contexual design approach. These factors can be grouped under the heading of "criteria for sustainable achitecture".

### 4.1 Main Criteria For Sustainable Architecture

#### *4.1.1 Energy*

Energy is the precondition of any civilization. First wave societies drew their energies from human and animal muscle power; or from the sun, wind and water. Second wave industrial societies began to draw their energy from irreplaceable fossil fuels-oil, coal and natural gas. This revolutionary shift meant that for the first time a civilization was eating into nature's capital rather than merely living off the interest it provided. Third wave civilization must and will draw on an amazing variety of energy sources-hydrogen, solar, geotermal, perhaps advanced fusion power, as well as other energy sources not yet imagined [Onal 1997].

After World War II, the architects explored the potential of air-conditioning and they developed a new form for high-rise, mid-rise and long-span spaces, also for residences, that reflected the moving away from passive strategies. These buildings featured an entirely new language of smooth-skinned glass-and-steel boxes without operable windows, ventilators or external sunshades. And with the development of low-wattage fluorescent lights that didn't emit much heat, the floor area of these structures widened to the point where natural illumination was replaced completely with artificial.

The affordability of these new buildings and the fossil fuels used to drive the generators that powered them explains, in large part, why passive environmental control was phased out. The consumption of fossil fuels is one of the biggest environmental problems. Drilling in ecologically sensitive areas, oil spills, air pollution and the destruction of the atmosphere all result from the incredible demand for fossil fuels. Mechanical systems that supply air-conditioning and heating, lighting systems, and other building technologies have to be redesigned to consume less energy – and alternate sources of energy have to be developed. Building owners can purchase energy made from renewable or clean sources (solar, wind or hydroelectiric), architects can design buildings that generate their own clean and renewable energy [Gissen 2003].

Buildings consume at least 40% of the world's energy. They thus account for about a third of the emissions of heat-trapping carbon dioxide from fossil fuel burning and two-fifths of acid-rain-causing sulfur dioxide and nitrogen oxides. So, in building designs, the reliance on fossil fuels have to be reduced and the use of cleaner sources of power have to be explored. Fuel cells, photovoltaics, solar hot water, and other renewable energy sources have to be considered in building designs.

#### *4.1.2 Climate*

The architecture itself as a fixed state construction has to contend with the dynamics of people and the dynamics of the sun and climate. Within its "fixity" adaptive ecologic attributes can be given to architecture by design [Crowther 1992]. Architecture must be a response to climate. In colder climates, comfort depended on shelter from prevailing winds by sitting, land form, and vegetation, together with low ceilings, thick walls, and windows on the exposed side. In the extreme cold (as in the extreme heat), buildings were buried in earth or covered [Onal 1997]. The northern facades usually have only a few openings, whereas the southern facades contain the main openings, thus maximizing the benefit of the limited sunshine. The ideal orientation for buildings in such a climate is with their long axis running along east-west.

In wet areas, houses were raised above the ground or had raised floors, with a steep pitched roof and overhanging eaves. Each region has its own climatic conditions and cultural patterns, which must be the basis for the solutions in each individual case.

The use of solar energy in building forms has challenged designers from ancient times and continues to do so today. There is a broad range of use for solar systems, from space and hot-water heating, to natural lighting and electricity production. An enormous benefit of a solar system is in the use of a pollution-free, renewable energy source – the sun. The solar trajectory affects the amount of radiation received on vertical surfaces: in winter, a southerly-oriented surface receives a lot of radiation, because the sun is low, but any other orientation would receive much less solar energy. In summer, on the other hand, when the sun is higher at noon, a southerly-oriented surface receives less direct radiation, while a westerly-or easterly-orientation is heavily impacted during the evening or the morning hours [Arvanitis 2002].

Climate and the need to heat or cool a building plays a major role in the design of the external envelope – transparent elements like windows and sunspaces, walls, roofs and floors – of a building. By improving the building envelope, passive solar strategies can be developed to improve comfort and reduce energy demands [Mendler, Odell 2000]. There are various factors for the climatic considerations, which affect heating, cooling, etc. in a building [Onal 1997]. The thermal inertia or mass of walls, floors, partitions and roof (influences the rate of temperature change inside the building); external colors and surfaces (influence heat absorption and reflection); insulation of the external envelope (can reduce heat loss); reduction of infiltration (can reduce heat loss); contact with ground (good for helping to keep a building cool in summer, and moderating heat loss in winter); contact with external air (cross-ventilation / useful for cooling).

The density and the heights of the buildings are significant in reducing the effects of the most annoying weather conditions. Wind tends to bypass low in densely built areas, but it is caught, directed downward, and intensified by tall free-standing buildings. The natural forces that exist in terms of radiation, air movement or wind, and gravity, can be used to find form in the architecture so that architecture isn't only about art, it's actually about a physical response to its environment.

#### *4.1.3 Building Materials*

The building materials can also change, enhance or negate climatic advantage. Besides, the sensual perception of an interior space is largely determined by the materials which line its surfaces; as light is transmitted and refracted through materials, or reflected by the texture and color of the internal surfaces, its quality, delight and utility are established. Thermal sensation is influenced by the interaction of the materials with heat. Thus, for an input of energy into a material, either from direct insulation or by transfer from the air, the amount the temperature of its surface increases depends upon the combination of its thermal capacity, its thickness and how readily the heat is conducted into its depth. Additionally, the materials on the ground of exterior spaces will also affect the microclimate [Onal 1997].

So, the environmental impacts and resource use of proposed building materials have to be evaluated. Raw material sources, production, and transport to the site, installation and use, and finally disposal or reuse should be questioned and evaluated prior to making a selection.

A report by the World Resources Institute, projects a 300 percent rise in energy and material use as world population and economic activity increase over the next 50 years. The report continues as, if industry can become more efficient, using less material to provide the goods and services people want, economic growth can be sustained, thus decoupled from resource extraction and environmental harm. This idea is often called eco-efficiency and influenced architecture as well. "Reduce, reuse, recycle" is eco-efficiency's popular mantra. Recycling building materials is one of the techniques being employed to reduce the environmental impact of buildings.

#### *4.1.4 Flexible Design*

Flexible design, provides ease of expansion and reconfiguration when needed. Design in flexibility have to be considered, to accommodate future needs through the use of modular planning and flexible building infrastructures for power, and communications. The use of fixed cabling and chases that are embedded into the building structure can be difficult and costly to change [Mendler, Odell 2000].

Buildings should be adaptable as well. They shouldn't just be a static object that sets itself for one season – it should be a compromise between all seasons, so the skin design of a building is very important. It would have to regulate energy flow through itself and store any excess energy that it doesn't need immediately.

#### *4.1.5 Indoor Air Quality*

Air is an essential resource for supporting life, a unifying substance for mankind. Every molecule of air we breathe has a 99 percent chance of having been breathed before. Air knows no boundaries or borders, and it is not recognized as a finite resource, and a sense of responsibility for it has not yet been developed. The attitude toward air fails to recognize the responsibility for maintaining air quality and cleaning the polluted air. And as trees and other plant life – the planet's natural systems for cleaning air – are destroyed, the problem becomes more acute.

An analysis of global carbon emissions reveals that between 40 and 50 percent are generated by buildings, 25 percent are from transport, and 25 percent come from industrial sources. This places a heavy responsibility on the shoulders of the construction industry. Designers need to address not only the issue of providing clean air for the occupants of buildings, but also the problem of making sure that buildings don't pollute their surrounding environments. This challenge is key to the development of a sustainable future.

### 4.2 A Sample for Sustainable Architecture

Many examples can be shown for sustainable architecture. But, for this work I chose the Avax office building in Athens which is completed in 1998. Its architect is Alexandros Tombazis. It has sheaves of glass which open and close automatically, depending on the intensity and angle of the sunshine, to provide sunlight while preventing the building from overheating. These technical facilities are made possible by computer modelling. It is located on a narrower street and it is in between the existing buildings. Although the street houses an intense built-up environment, the Avax building has a wider frontage and entrance, which makes it to be easily perceived. Architect provided this by locating the building slightly backwards from the other existing buildings. A little portion of greenery is also provided which gives a nice and friendly atmosphere to the entrance.

## 5. Conclusion

As a conclusion, what is expected of architects in the coming century is, wherever they work, they are to understand and digest the nature of climate, history and culture, that is to say, obtain inspiration from the essence of place and render contribution to create relevant architecture and city.

The images and forms of technology are often deceptive. Although 'intelligent buildings' have been anticipated for some twenty years, the prohibitive costs of many of the technologies involved have limited their realization. The possibilities of technology could transform buildings into automatic, self-regulating systems which could produce a subtly changing and modifying environment at apparently little energy cost. However, sustainable design is more than a technological add-on. The social, political and economic structures which underlie the making of buildings will have to be reformed to enable designers to use their skills to provide naturally sound environments in the broadest sense.

For the sustainable architectural design, the factors of durability, maintenance needs and embodied energy costs (including that needed to transport materials or components site and put them together) have to be evaluated. Studies can be done as to the effects of resource extraction and depletion on the natural habitat and which materials degrade biologically. Qualitative assessment can be made of the energy required for further processing, if materials can be recycled. The model for sustainable design is nature itself. Nature is efficient and effective by design, essentially producing no waste. Sustainable architectural design, guides an openness and attention on fitting materials, fitting forms and fitting systems, so that human habitation supports the life of a locale. Combining the local knowledge with an understanding of sustaining materials and energy systems, architects can create buildings that encourage healthy interaction with the natural environment.

Architectural design based on environmental preservation is the only option for maintaining quality of life and preventing lasting environmental damage. Pollution reduction, waste minimisation and energy conservation can be furthered through environmentally friendly aechitectural design and construction. The environmental community has promoted the slogans of reduce, recycle, and reuse. Recently it has been suggested that a fourth one: Recover added. The remediation of environmental pollution and damaged natural resources is vital to the support of future sustainable development. So, a new kind of architecture has to be created that actively treats its waste products and cleans the air of the cities.

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