Progress and Prospects of Promoting Sustainable Architecture through Education in Nigeria

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Abstract

The world is faced with daunting issues such as the energy crisis dating back to the Arab Oil Embargo of the 1970’s, the aftermath of the Arab–Israeli war and current problems of global warming which resulted from extensive use of fossil fuels such as oil, gas, coal, et cetera. The greatest consumer of energy and a major contributor to the greenhouse effect is the building industry. Sustainable development in architecture as it relates to Nigeria is thus concerned with issues of energy conservation (water utilisation, indoor climate and use of materials).

In architectural education worldwide there is a shift of purpose towards training students in handling issues of energy conservation. The paper demonstrates how the developed world in particular and other countries including Nigeria are pioneering efforts especially through education by reassessing their priorities and shifting emphasis to matters of sustainability. It highlights methods used in the Western world to achieve this goal including case studies of teaching programmes and computer software involved in the design, construction and use of low-energy, low-CO2 emissions buildings. Rating systems for green buildings such as BREEAM in the UK, LEED in North America, Green Star in Australia, and HQE in France are also presented.

It highlights the circumstances surrounding issues of sustaining environmental resources and of sustainable architectural design. It deliberates on progress and prospects for the future and lessons for the Nigerian Development Agenda.

Keywords: architectural education, global warming, green architecture, low-energy buildings, sustainable architecture.

1. Introduction

Perhaps the major catalysts that triggered the serious awareness for sourcing alternative and appropriate forms of energy were the forces of the energy crisis (the Arab oil embargo) of 1973-74, a precipitation from the Middle East politics of the Cold War that exposed the West’s vulnerability and the present crisis of environmental pollution of the eco-system manifest in rapid global warming confronting the earth (Trumbore, 2010).

Given the enormous level of concern being expressed throughout the world over environmental problems, all stakeholders should help create a better world rather than contribute to its demise. The growing consensus now is that problems affecting the environment cannot be ignored, unlike earlier years when environmentalism was regarded as
an activity for the radical fringe of society (Encyclopaedia Britannica, 2010a). It was concluded long ago that “as a result of dramatic scientific evidence of ozone depletion, and agreement over the impending problems of global warming, a new sense of urgency has arisen” (MacKenzie, 1991). This is the era when environment performance with ethical and moral issues is at the forefront of the agenda for businesses, governments and individuals with a commitment to sustainable rather than uncontrolled development.

Global resources are being used up at an alarming rate through Man’s over exploitation and there are projections that indicate when these resources could be exhausted. The world is being threatened with diminishing energy resources and if the consumption of energy continues at this rate, life will be threatened in the future. The building industry which consumes about 50% of world energy has an important responsibility in decreasing the consumption of energy resources. For any development to be sustainable, it must not neglect the interest of the future generations. Doing anything otherwise would run contrary to the concept and resolutions of the United Nations World Commission on Environment and Development - WCED (The Free Dictionary, 2010; Encyclopaedia Britannica, 2010b). The key issues of biodiversity, global warming, sustainable development, and preservation of tropical rain forests were addressed at subsequent Earth Summits organized by UN WCED, starting with the conference held in Rio de Janeiro in 1992. This was to reconcile worldwide economic development with environmental protection. It was the largest gathering of world leaders in history, with 117 heads of state and representatives of 178 countries. The second Earth Summit was held in New York in 1997 to review progress while the last Earth Summit took place in 2004 in Johannesburg, South Africa (The Free Dictionary, 2010). The Earth Summit web portal documents global climate change problems, policies and resolutions (Earth Summit Info, 2010).

2. The Hazards of Environmental Pollution

Greenhouse Gases and Global Warming
The earth is under great ecological stress as a result of global warming and climate change. The Intergovernmental Panel on Climate Change (IPCC) has concluded that, “most of the observed temperature increases since the middle of the 20th century was very likely caused by increasing concentrations of greenhouse gases resulting from human activities such as fossil fuel burning and deforestation” (Wikipedia, 2010a). Over exploitation of natural resources and activities that promote global warming are factors that could compromise or jeopardise the future of other generations and this calls for a shift or change from the traditional way of doing things to a more progressive approach.

Climate Change
The main goals of development include economic growth, provision of basic needs and protection of rights. These goals demand industrial activities which requires the use (burning) of fossil fuels such as coal, oil and natural gas that releases additional carbon dioxide, methane and water vapour (known as the greenhouse gases) into the atmosphere. This assisted by deforestation and bush burning makes the atmosphere richer in these gases and turns it into a better insulator that retains more of the heat provided to the planet by the sun. This is the chief cause of global warming which is the increase in the average temperature of the Earth’s atmosphere, oceans and landmasses since the mid-20th century and its projected continuation. The earth is under great ecological stress as a result of this global warming and climate change (Architecture Week, 2010).

Pollutants
The lion's share of the pollutants that cause global warming are attributable to architecture. (Energy Information Administration, 2010; Smith, 2004). Building construction and
operations account for nearly half (48%) of all U.S. energy consumption. See Figure 1. Architecture is responsible for 46% of U.S. carbon dioxide (CO₂) emissions.

3. Emergence of Sustainable/Green Architecture

The green building movement began as a result of the need and desire for more energy efficient and environmentally friendly construction practices by taking advantage of renewable resources and energy like solar, geothermal, wave and wind. Green buildings often include measures to reduce energy use and increase the efficiency of the building envelope. The strategy is through passive solar building design in low energy homes. Daylighting can provide more natural light and lessen the need for electric lighting during the day and solar water heating further reduces energy loads. On site generation of renewable energy through solar power, wind power, hydro power or biomass can significantly reduce the environmental impact of buildings (Waldrep, 2008; Wisegeek, 2010).

Sustainable/Green architecture

Sustainable/Green architecture is a general term that describes environmentally-conscious design techniques in the field of architecture and it is framed within the larger context of the discussion of sustainability. It results in green, sustainable, earth-friendly, and high-performance design and involves the responsible recycling of existing resources along with the efficient use of environmentally friendly systems to provide water and power services to buildings that are created using a sustainable design (SMARTe.org, 2009). As more people have become concerned about the wise use of the planet’s resources, the concept of green architecture has gained in both acceptability and interest, especially because it does not pose a threat to the surrounding environment and makes the best use of available resources for heating, cooling, cooking and water supply. Sustainable architecture did not just evolve but rather was a demand by the society. Sustainable design is gradually emerging as the new cutting edge in science, a basis for innovative technologies and design approaches. Some common features of green architecture are the use of solar panels, water collection vats, wind turbines, solar water heating, heat pumps, recycled materials, waste management, water management and building placement and the strategic placement of windows around the elevations of the building. Renewable resources are used to create energy to meet the demands of modern life. Green building techniques use designing, constructing and operating buildings and landscapes to incorporate energy efficiency, water conservation, waste minimization, pollution prevention, resource-efficient materials, and indoor environmental quality in all phases of a building's life (SMARTe.org, 2009).
**Sustainability**
Sustainability is the ongoing process of achieving development or redevelopment that does not undermine its physical or social systems of support.

**Sustainable Development**
This is a process of change in which the resources consumed (both social and ecological) are not depleted to the extent that they cannot be replicated. The concept also emphasizes that the creation of wealth within the community considers the wellbeing of both the human and natural environments, and is focused on the more complex processes of development rather than on simple growth or accumulation.

**4. Teaching Sustainable/Green Architecture**
Ecological design is an approach to teaching sustainable/green architecture. The goal of introducing sustainable architecture into any school curriculum should be to teach designers to become environmentalists. Sustainable architecture does not form any rigorous part of architecture as a discipline in any Nigerian school of Architecture as many are still ignorant of this concept and therefore are yet to integrate it into their curricula. Numerous other schools of Architecture worldwide equally exclude sustainable architecture from their curricula, but it is gradually being considered a fashionable subject at the moment. Sustainability is a global concern and the body of knowledge is increasing on the international scene. As the profession is quickly recognising its importance, more schools are developing courses in sustainability or determining ways that their degree programmes can incorporate this hot topic. An example of a green architecture school committed to sustainability is the Arizona State University School of Sustainability.

Meaningful change for a more functional, just and equitable world is only possible if better, more meaningful education takes place. In architectural education eLearning is emphasised (Prucnal-Ogunsote *et al* 2007; Ogunsote *et al* 2007).

Education is the primary tool for raising awareness of environmental issues. If architectural education is to have any relevance, it must be seen to be environmentally sensitive, socially responsible and economically viable and must teach architecture that will sustain the natural environment. Architectural education should have an obligation to the society at large. An architect should be trained as a service provider to the society with the interest of the community in view. In addition, the architect should be trained as an environmentalist, a resource manager, a community advocate and a social reformer. Education for sustainable development should therefore emphasize the importance of education in shaping future development options and choices and learning about new value orientations. According to the 2005 Ahmedabad Declaration (Docstoc.com, 2010):

> Education for Sustainable Development (ESD) must happen in the villages and cities, schools and universities, corporate offices and assembly lines and in the offices of ministers and civil servants. All must struggle with how to live and work in a way that protects the environment, advances social justice and promotes economic fairness for present and future generations.

What would sustainable architectural education look like? Brown (2001) believes that it takes a whole curriculum redesign from the ground up and not for architecture schools to tack on sustainable courses as electives. The core concept would be to take a whole-systems approach that focuses on healthy environments. The focus should be on all of the project’s potential impacts, both environmental and social and on the community and the biosphere.

Teamwork is vital to enable the students contribute their solutions to the programme. Inviting renowned practitioners with outstanding design reputations and commitment to sustainable design may constitute another important aspect of the programme. Apart from projects and
visiting architects, lectures and presentations on topics such as environmental economics, ecopsychology, global change and form and pattern in nature should be introduced. Field trips to sites are essential too.

A comprehensive course list at the School of Architecture, University of Arizona, reveals some elective courses on sustainability as presented in Table 1. The curriculum demonstrates sensitivity to climate change related problems.

Table 1: Elective courses on sustainability at the School of Architecture, University of Arizona.

<table>
<thead>
<tr>
<th>Year</th>
<th>Type of Course</th>
<th>Course Number</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Elective</td>
<td>ARC 461a/561a</td>
<td>Solar Utilization in the Built Environment</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Elective</td>
<td>ARC461d/561d</td>
<td>Computer Energy Analysis</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Elective</td>
<td>ARC461e/561e</td>
<td>Sustainable Design and the LEED Initiative</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Elective</td>
<td>ARC461g/561g</td>
<td>Technology of Ecological Building</td>
<td>3</td>
</tr>
</tbody>
</table>


A list of courses in a few selected Nigerian Universities shows courses related to sustainability (Table 2). The list demonstrates that the energy saving trend is not emphasized in the Nigerian university system and there is urgent need for improvement.

Table 2: Courses related to sustainability at selected Nigerian universities.

<table>
<thead>
<tr>
<th>University</th>
<th>Year/Level</th>
<th>Course code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal University of Technology, Akure</td>
<td>100 Level</td>
<td>ARC 105</td>
<td>Nature of Environmental Science</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>300 Level</td>
<td>ARC 309</td>
<td>Environmental Control I: Climate</td>
<td>2</td>
</tr>
<tr>
<td>Federal University of Technology, Minna</td>
<td>200 Level</td>
<td>ARC 224</td>
<td>Building Climatology</td>
<td>2</td>
</tr>
<tr>
<td>Imo State University, Owerri</td>
<td>100 Level</td>
<td>ARC 151</td>
<td>Nature of Environmental Science</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>200 Level</td>
<td>ARC 243</td>
<td>Environmental Science I</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>400 Level</td>
<td>ARC 455</td>
<td>Building Climatology</td>
<td>1</td>
</tr>
<tr>
<td>University of Jos, Jos</td>
<td>100 Level</td>
<td>ARC 161</td>
<td>Introduction to Environmental Science</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>200 Level</td>
<td>ARC 261</td>
<td>Building Climatology</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>300 Level</td>
<td>ARC 364</td>
<td>Climate and Design</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>400 Level</td>
<td>ARC 464</td>
<td>Environmental Impact Analysis</td>
<td>2</td>
</tr>
</tbody>
</table>

Source: Authors’ survey.

The goals of academic and professional partnership are to equip architecture students with the knowledge and tools necessary for delivering beautiful, high-performance, low-energy buildings, and to demonstrate the economic and environmental potential of new methods, systems and materials for creating the next generation of high performance learning environments. Some of the tools that can be used to attain these goals are reviewed below. The findings can be incorporated into teaching of environmental science courses and into studio work.
5. Rating Systems for Green Architecture and Sustainable Design around the World

**The Building Research Establishment Environmental Assessment Method (BREEAM)**
BREEAM is a voluntary measurement rating for green buildings that was established in the UK by the Building Research Establishment (BRE). Since its inception it has grown in scope and geographically, being exported in various guises across the globe. It sets the standard for best practice in sustainable design and has become the *de facto* measure used to describe a building's environmental performance. BREEAM addresses wide-ranging environmental and sustainability issues and enables developers and designers to prove the environmental credentials of their buildings to planners and clients. It:

- uses a straightforward scoring system that is transparent, easy to understand and supported by evidence-based research,
- has a positive influence on the design, construction and management of buildings,

**The Leadership in Energy and Environmental Design (LEED)**
This is a green building rating system developed by the United States Green Building Council, USGBC. It provides a suite of standards for the environmentally sustainable design, construction and operation of buildings and neighbourhoods. The hallmark of LEED is that it is an open and transparent process where the technical criteria proposed by the LEED committees are publicly reviewed for approval by the more than 10,000 membership organizations that currently constitute the USGBC (United States Green Building Council, 2010). Individuals recognized for their knowledge of the LEED rating system are permitted to use the LEED Accredited Professional (AP) acronym after their name, indicating they have passed the accreditation exam given by the Green Building Certification Institute - a third-party organization that handles accreditation for the USGBC (Green Building Council Australia - GBCA, 2010 & Wikipedia, 2010c).

**Green Star**
Green Star is a voluntary environmental rating system for buildings in Australia. It was launched in 2003 by the Green Building Council of Australia.

The system considers a broad range of practices for reducing the environmental impact of buildings and to showcase innovation in sustainable building practices, while also considering occupant health and productivity and cost savings (Green Building Council Australia - GBCA, 2010 & Wikipedia, 2010d).

**Haute Qualité Environnementale (HQE)**
The *Haute Qualité Environnementale* (High Quality Environmental standard) is a standard for green building in France, based on the principles of sustainable development first set out at the 1992 Earth Summit. The standard is controlled by the Paris based *Association pour la Haute Qualité Environnementale* - ASSOHQE (Wikipedia, 2010e).

**In Nigeria**
The introduction of education on green architecture and the existing rating systems on an international level will create a more informed approach towards designing buildings based on the principles of sustainable architecture at a national level.

**CarbonLite program**

The CarbonLite program is an AECB (Association for Environment Conscious Building) initiative providing the tools and knowledge to create low-energy buildings in line with existing and future legislation covering both domestic and non-domestic buildings in the UK (Figure 2).

The program outlines the reasons behind the need for more sustainable building practices in a clear, informative and impartial way. It also provides wide-ranging yet detailed guidance on the ways in which this change is best achieved (AECB CarbonLite, 2010).

**More information on Software**

Deriving energy and emissions projections requires a model of building use such as BRE’s Domestic Energy Model (BREDEM) and a SAP-based calculation procedure.

![Energy Performance Certificate](image)

**Figure 2: Sample certificate for energy rating of a non-domestic building. Source: AECB CarbonLite, 2010.**
Analysis and usefulness in Nigerian education
The researchers are of the opinion that there can be benefit from the path that the CarbonLite program has taken in Nigeria’s journey towards creating sustainable architecture by:

- Introducing computerized energy rating for buildings.
- Introducing software used to promote the practice.
- Training and education of both students and practicing professionals.
- Computerised monitoring and feedback database.
- Case studies of monitored buildings with web-based learning zone.

Energy modelling software tools are used to estimate projected energy usage. Energy modelling uses computer-based tools to simulate the energy use of a building throughout a year of operation. Examples of models include EQUEST, Energy-10, Visual DOE and DOE-2 while Therm software models individual building components (New York State Department of Environmental Conservation, 2010).

The more energy-efficient the building fabric becomes, the more important it becomes to predict its heat loss accurately. Even a small increase in the amount of energy used to maintain temperature becomes significant as a proportion of the total. The non-space heating energy consumption also increases in relative importance so that, if the objective is to minimize energy use and CO₂ emissions, this needs to be done at the whole building level to include all fans and pumps, lighting, appliances and cooking (Planet Science, 2010).

DOE-2
The DOE-2 program for building energy use analysis provides the building construction and research communities with an up-to-date, unbiased computer program that predicts the hourly energy use and energy cost of a building given hourly weather information and a description of the building and its HVAC equipment and utility rate structure (DOE-2 & eQUEST Software, 2010). The purpose of DOE-2 is to aid in the analysis of energy usage in buildings. Below is the structure of DOE-2 (Figure 3).
Analysis and usefulness in Nigerian education
The research suggests that Nigeria can benefit from the program by being able to estimate energy consumption, interior environmental conditions and energy operation cost of a building at different times of the day as well as for different seasons even at the design phase. Students can learn about this method and practice its application during their project design.

eQUEST
eQUEST enables the performance of detailed analysis of building design technologies using today’s most sophisticated building energy use simulation techniques but without requiring extensive experience in the “art” of building performance modelling.

This is accomplished by combining a building creation wizard, an Energy Efficiency Measure (EEM) wizard, and graphical reporting with a simulation “engine” derived from an advanced version of the DOE-2 building energy use simulation program (Doe-2 & eQUEST Software, 2010).

ENERGY-10
ENERGY-10 software is a powerful design tool that analyzes and illustrates the energy and cost savings that can be achieved through more than a dozen sustainable design strategies. Hourly energy simulations help you quantify, assess, and clearly depict the benefits of daylighting, passive solar heating, natural ventilation, well-insulated envelopes, better windows, lighting systems, mechanical equipment, and more (National Institute of Building Sciences, 2010).
A short guide to Energy-10
The AutoBuild section creates a reference case building given only five inputs – location, building use category, size, HVAC, and utility rates (Northwest Builders Network, Inc., 2010). See figure 4.

Figure 4: The AutoBuild section. Source: Northwest Builders Network, Inc., 2010.

With the Apply feature, one can select from a menu of energy-efficient strategies (EESs) that enables creation of low-energy case buildings. The reference case is then used as the basis for comparison (Northwest Builders Network, Inc., 2010). See Figure 5.

Figure 5: The Apply feature. Source: Northwest Builders Network, Inc., 2010.
ENERGY-10's powerful Rank feature sequentially prioritizes and applies defined energy-efficiency strategies, evaluates the outcome, and indicates the optimum choices for a building (figure 6).

![Figure 6: The Rank feature. Source: Northwest Builders Network, Inc., 2010.](image)

**Analysis and usefulness in Nigerian education**

In Nigeria, a software program with hourly energy simulations to help quantify, assess, and clearly depict the benefits of daylighting, passive solar heating, natural ventilation, well-insulated envelopes, better windows, lighting systems and mechanical equipment is invaluable. Implementing this method for improving sustainable building design at the learning phase for students of architecture in Nigeria can play a vital role in their education.

**Therm**

*Therm* can model two-dimensional heat-transfer effects in building components such as windows, walls, foundations, roofs, and doors; appliances; and other products where thermal bridges are of concern. *Therm*’s heat-transfer analysis allows for evaluation of a product’s energy efficiency and local temperature patterns, which may relate directly to problems with condensation, moisture damage, and structural integrity (*Therm* Software Website, 2010). See Figures 7-10 for sample screen shots.
Figure 7: Sample cross section. Source: Therm software website, 2010.

Figure 8: Sample isotherm results. Source: Therm software website (2010).
Figure 9: Sample colour infrared results. Source: Therm software website, 2010.

Figure 10: Sample greenhouse window. Cross Section.  
Source: Therm software website, 2010.
Analysis and usefulness in Nigerian education
The calculation of heat transfer can play a vital role in the choice of correct building materials which can aid in optimum thermal comfort of interior environments as well as reduced energy consumption.

8. The Nigerian Scenario: Challenges and Strategies for Incorporation
From the above study it is pertinent that universities should initiate the effective use of some of the selected tools (software) and should adopt practical and effective ways of using them. This should be supported by all stakeholders in the education system.

The educational system should incorporate the new techniques of rating systems as based on analysis of BREEAM, LEED, Green Star, and HQE. New techniques should be taught to prepare the professionals for effective use in practice and to meet the global standard. This is in respect of setting the standard for best practice in sustainable design and new measures incorporated in describing a building's environmental performance. At the initial stage some existing systems can be adopted giving time for the development of customised Nigerian software. The challenges are mainly in adopting a suitable system and in effective incorporation into the curriculum of the universities which is also associated with extra expenditure of training the lecturers especially in the field of environmental sciences.

The benefits of introducing computerized energy rating software for buildings such as the CarbonLite program can help in creating sustainable architecture, in promoting the practice and elevating the educational system. This can be done by computerised monitoring and feedback database. It can be initiated by carrying out case studies of monitored buildings with web-based learning zone.

Energy modelling software and tools such as introduced in this paper (DOE-2, eQUEST, ENERGY-1 and Therm) can be effectively used in estimating the proposed building's energy consumption, interior environmental conditions and energy operation cost at different times of the day as well as seasons even at the design phase. Implementing this method for improving sustainable building design can play a vital role in students’ education. Calculating heat transfer can play a vital role in choice of correct building materials which can aid in optimum thermal comfort of interior environments as well as reduced energy consumption.

9. Relevance to the Future of the Nigerian Development Agenda
Of the 7-point agenda of the Federal Government of Nigeria (which are power and energy, food security, wealth creation, transportation, land reforms, security and education), the agenda on power and energy is relevant to the issues of sustainability which could be addressed through sustainable development in architectural education as proposed by this paper. A genuine model of sustainable development would seek to emphasize and be mindful of the ecosystems (ecological sphere) and its ability to continue its level of growth over time. It is all about the wise use of the planet’s resources. This makes sustainability and sustainable development to be a concern about collective values and related choices of a more or less political nature and perhaps a fundamental political issue of the century and a key issue of the architectural curriculum development promoting National Development.

Education on green architecture and the existing energy rating systems on a national level will create a more informed approach towards designing sustainable buildings. A sponsored research is recommended to facilitate the training of students alongside the training of trainers. While more research is recommended on which rating system can be effectively applied in the country, it is emphasised that Nigeria can launch its own rating system for green architecture and sustainable building design system through the professional bodies or NGOs interested in green architecture.
10. Conclusion
For any progress to be made in entrenching sustainable development in architectural education, the following steps should be taken:

1. Sustainability should be fully integrated into the architecture curricula of all schools of architecture in Nigeria as a matter of urgency. This should be incorporated in the content of studio work and through dedicated environmental science courses. The time frame should be set to compulsorily incorporate the courses on sustainability in all the departments of architecture based on the experimental courses as explained below.

2. Within the shortest time a few leading departments should experimentally incorporate some of the recommended rating systems for green architecture and sustainable design. They should select any of the energy rating software as well as energy modelling software and introduce the tools in sustainable building design. The students should be subjected to real life experiments within the scope that can be handled at their level. The experimental courses should be properly funded. The findings should be widely propagated. In each department two or three lecturers should be specifically trained to carry on the experimental courses.

3. The Architects Registration Council of Nigeria (ARCON) and the Nigerian Institute of Architects (NIA) should enforce compliance through departmental accreditation processes. The matter of training the trainers should not be underestimated. Seminars and workshops should be regularly organised to acquaint lecturers with the concept of sustainability as there is a general lack of awareness amongst even teachers.

4. It could be very beneficial to carry along all stakeholders in the educational system. This could be done by propagating the findings and sharing the experience (successes and failures) with the public through public seminars, publications in popular newspapers and TV and radio broadcasts.

The authors strongly believe that promoting sustainable architecture as recommended in this paper could be very beneficial to students, practicing architects and the society at large.

11. References


