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Sustainability in Architecture: Low-tech or High-tech?

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Abstract

The concept of sustainability has been becoming more and more important all over the world. It is an urgent need to make all processes "sustainable" in order to protect the environment and human life. Numerous technical innovations are emerging to ensure sustainability. These rapid developments, especially in architecture, make it increasingly difficult to distinguish the concepts of sustainability and technological innovations from each other. Sustainability has started to take place in our lives as a completely technology-oriented concept. This article is to seek an answer to the question of whether the concept of sustainability in architecture can be achieved with low technology. It also discusses which approach should adopt to ensure sustainability.

Keywords: Sustainable Architecture; Vernacular Architecture; Technology; Low- Tech; High-Tech.

1. Introduction

Climate change is one of the biggest global problems facing the world today. The vast majority of research on climate shows that human activities cause rapid changes in climate, which can cause serious environmental damage. In addition to a strong scientific consensus on this issue, 97 percent of experts agree that climate change is caused by human activities (National Oceanic and Atmospheric Administration, 2005). Anthropogenic emissions of greenhouse gases have been increasing since the industrial revolution due to global economic growth, population growth, and urbanization. According to the data, the world has clearly shown a warming trend since pre-industrial times, and average temperatures are now higher than 1.5 ° C compared to pre-industrial times (IPCC, 2018). Cities and urbanization are the main contributors to climate change. Although cities cover only 2% of the earth's surface, they consume 78 percent of global energy and are responsible for more than 60 percent of greenhouse gas emissions, according to UN-Habitat (UN, 2020). More than half of the energy consumption by cities comes from buildings (ARUP, 2020). This means making buildings sustainable, one of the most fundamental things that can be done to combat climate change.

The term "sustainable" was first used in 1987 by the United Nations Brundtland Commission; the term is defined as "development that meets today's needs without compromising the ability of future generations to meet their own needs" (WCED, 1987). Since then, more than 140 definitions have emerged to describe sustainability (Johnston et al., 2007). Sustainability definitions centered on humans and the environment were made at the beginning (e.g WCED, 1987), then, along with the development of technology, it started to evolve into a concept that centered on technology (Anthopoulos, 2015). This is an indication that the term sustainability changes according to the conditions of the day. Today, many studies state that sustainability should be taken together with technology (Dao et al., 2011; Laws et al., 2004).

The last few decades can be characterized by the introduction of high-tech solutions into our daily life. Along with these technological advances, building technologies have changed and improved rapidly. Intelligent/smart controls in energy storage, energy efficiency, and energy conversion areas allow theoretically buildings to generate approximately more energy than they consume annually (e.g. Aldrich, 2003; Coley & Schukat, 2002). These rapid developments were isolated from a holistic approach and almost all took place in technology-oriented sectors. This has created great confidence in technology to solve environmental problems in the world. Sustainability in architecture starts to be perceived as a technology-oriented concept. The manuscript is to seek an answer to the question of whether the concept of sustainability in architecture can be achieved with low technology.

While high-tech approaches in architecture promise greater comfort, control, and efficiency (e.g Huang et al., 2016), in turn, low-tech approaches propose a more conservative use of resources thanks to easy-to-use technologies with potentially lower environmental and social impacts (e.g Kazimee, 2010)). Moreover, low-tech approaches emphasize a human-centered perspective (e.g Wells & Stiefel, 2018), high-tech approaches aim to reduce the burden of inhabitants by putting technology at the center (Firlaq et al., 2015). This article also aims to discuss which approach should adopt to ensure sustainability.

2. High-tech VS Low-tech

According to the report of the International Energy Agency (IEA), the buildings are held responsible for 36% of the global energy consumption. After the industrial sector, the building sector is the second-largest contributor to climate change (IEA, 2020). The deepening of the climate change crisis has brought many steps towards reducing the carbon footprint of the built environment and the discussion about sustainable buildings on our agenda. This triggered the trend towards renewable resources for energy production (e.g solar, wind), improving the insulation of buildings, and high-tech solutions to reduce energy consumption. Along with the trend, several sustainable housing concepts have emerged such as a zero-carbon house, smart home, passive house. Each of these concepts is reflections of efforts to make the currently unsustainable housing sustainable. Before the industrial revolution, architecture was vernacular, as local materials were used and built according to local climatic conditions. After the industrial revolution, materials such as steel, concrete, and electrical equipment such as central heating or air conditioning provided freedom in building design and construction. As a result, uniform buildings that are less sensitive to the environment have begun to be built. With the rise of urbanization and the global population, the number of buildings that had little concern about air quality, water, or energy consumption has increased and began to affect our planet. In the last few decades only, humanity has become aware of this and began to take action. While some architects argue that making buildings sustainable can only be achieved by re-adopting traditional vernacular architectural elements (e.g. Mileto et al., 2014; Salman, 2018); others argue that it is a good method to equip buildings with technology (e.g. Chen et al., 2013).

3. Lessons From Past

The vernacular architecture consists of the experiences of people living in different climatic conditions through trial and error (Oliver, 1983, 1997). Besides, this architectural approach consists of design and construction techniques that include the use of locally available resources and are based on the environmental, cultural, and historical background of the people (Sassu, 2011). In addition to providing thermal comfort, it plays a role in maintaining environmental quality, not running out of resources, reducing greenhouse gas emissions, and reducing high energy use in a modern context (Maijakairamo, 1975). According to Chandel and Sarkar (2015) and Foruzanmehr and Vellinga (2011), improvements in energy efficiency, cost-effectiveness, and sustainability can be achieved by using vernacular techniques in modern buildings. Priya *et al.* (2012), on the other hand, stated that thermal comfort can be provided by the inclusion of spatial organization, building materials, passive solar design features in buildings. Literature on vernacular architecture shows building design decisions such as material, building shape, orientation plays a crucial to saving energy. Bostancioğlu *et al.* [24] revealed that there is a correlation between the shape, orientation, and general form of the built mass and the amount of energy consumed by the building. Shukla *et al.* (2009) showed that the house built using low-energy materials such as soil, sand, and cow dung not only reduce energy consumption but also decrease the amount of CO₂ released into the atmosphere. Praseeda *et al.* (2014) drew attention to the increase in energy in wall materials with the transition from vernacular (e.g. rubble stone masonry) to modern (e.g. burnt clay brick masonry). Priya *et al.* (2012) also stated vernacular architectural materials influence saving energy, since they are effective in maintaining indoor thermal comfort. Gupta (2014) said that using local materials as building materials reduces transportation costs, thereby reducing greenhouse gas (GHG) caused by transportation.

Agenda 21 in the "1992 Rio World Summit" (1992) emphasized that vernacular architecture plays a critical role in ensuring sustainability and energy efficiency in buildings. Use of local resources, regulation of energy-efficient design principles, and the use of labor-intensive techniques instead of energy-intensive construction techniques were also highlighted.

4. Benefits From Technology

Technology which has been steadily gaining popularity especially in architecture aims to simplify the routines and processes of the inhabitants, as it also makes life easier and more comfortable for them. In doing so, it aims to control and optimize resource usage.

Technology makes buildings remotely monitored, accessible or controllable, and can offer sensors and devices to meet the needs of their inhabitants (Reinisch *et al.*, 2011). The numerous technologies offer various advantages such as smart gateway, sensors, smart appliances. While the smart gateway helps bridge different technologies, sensors perform some important tasks such as determining the light intensity in a particular room and the temperature inside and outside the house. Smart applications can take action to ensure energy efficiency and thermal comfort after this measurement.

Some studies believe that technology will play an important role in the transition to a low carbon energy system (Balta-Ozkan *et al.*, 2014; Tejani *et al.*, 2011). In addition to that, technology provides new services such as elderly care (Ransing & Rajput, 2015), child care (Berrezueta-Guzman *et al.*, 2020) security, assisted living, health monitoring (Balta-Ozkan *et al.*, 2014).

5. Which Approach Is More Sustainable?

The vernacular architectural approach tends to favor the minimum energy and local materials required to construct, repair and operate a building (Chandel & Sarkar, 2015). The methods used are more sustainable and easier to manage than high-tech solutions (Intille, 2002). However, this approach risks making existing environmental resources more comfortable for human occupation.

On the other hand, high tech solution aims to improve the quality of life of the inhabitants by offering new services (e.g., health monitoring, elderly care) or more effective control and management of existing services. Since sustainability is still not central to the use of technology in buildings, these buildings contain materials that are difficult to recycle or reuse, they consume more energy than traditional buildings, despite saving energy, and require constant maintenance and updating. It is also possible that inhabitants can face numerous technical difficulties. The most important criticism of the use of technology in buildings is that it consumes more energy than they save (Grieder, 2007). According to Hilty et al (2004), pervasive computing technology discusses potential risks in health, social and environmental issues. Mankoff et al. (2008) blame the technology used in buildings for increased energy consumption and electronic waste.

Therefore, it is necessary to combine high and low technology solutions in order to eliminate the disadvantages caused by both approaches to make buildings sustainable.

6. Appropriate Technology

Awareness of the impact of the built environment on climate is increasing day by day. Besides, discussions on the sustainable construction of buildings, and the development and implementation of the sustainable solutions offered have begun. Architects have been stuck in an architectural interlock characterized by the construction of simple, cost-effective, uniform square-shaped buildings that ignore local climatic conditions. The only way to make buildings that are far from understanding local dynamics liveable was to use additional technology that increases energy consumption. These additional technologies have been made more energy-efficient due to the continuous development of technology. These solution proposals only solve the problems of the imperfect, unsustainable existing architecture. When it comes to new buildings, the additional technologies are insufficient, and new buildings must be reconsidered in a holistic way. In response to this problem, several architects now advocate a re-adoption of traditional, local architecture that really takes local conditions and local needs into account (Mileto et al., 2014; Salman, 2018). But as the reality of the 21st century, technology has touched architecture and provided undeniable benefits. A new proposal needs to be developed in order to get rid of the disadvantages of using excessive technology and to benefit from the advantages of vernacular architecture that takes people to the center that cares about local dynamics. This manuscript proposes "*appropriate technology*". The concept of "*appropriate technology*" in architecture refers to the period from the extraction of the building material to the end of the life of the building in new buildings. These processes should be handled holistically with the help of both technology and vernacular architecture passed down through generations. In other words, the building should be designed taking into account the local climatic conditions, with the comfort of the inhabitants, and in a way that provides energy savings - this energy-saving should cover not only the construction phase of the building but also the operational phase of the building - and be supported by adequate technology. This makes buildings not only vernacular but also the opportunity to be smart.

7. Conclusions

The industrial revolution triggered off pollution, resource consumption (including energy resources), and population growth. In the early 20th century, the adverse effects increasingly continued. In the late 20th century, environmental problems became global. On the building scale, energy-related problems have emerged. Buildings are the significant consumers of energy and responsible for 40% of all energy consumption and about 30% of global annual greenhouse gas emissions (UNEP, 2009).

"*Sustainability*" is a widely used term in a globalizing world and this term is used in different fields. Although the term has many meanings/definitions, generally the term means a better quality of life for everyone living now and for generations to come and it consists of the state of our communities influenced by a combination of economic, social, and environmental factors. To ensure sustainability especially in architecture, some studies offer using high-tech solutions, while others suggest a low-tech solution. While high-tech approaches to architecture promise greater control, comfort, and access, low-tech approaches, as seen in many vernacular buildings, are highly sustainable, as they do not increase a building's energy input or output during construction or operation of the building. However, both approaches have some advantages and challenges. As high-tech approaches promise to reduce the building's energy consumption, they do not take into account how much energy has been consumed by the technologies that make up the building, the low-tech approach poses a threat to the existing natural resources (especially on materials) due to the increasing world population, Therefore, this article presents the "*appropriate technology*" concept that

combines high and low-tech solutions to create truly energy-efficient buildings/designs, balancing the relationship between the energy output and the energy input of the building or resources used.

Consequently, the idea of "appropriate technology" might make smart and sustainable buildings more accessible, as the use of adequate technology combined with the use of vernacular architectural techniques can reduce the initial cost of the building relatively.

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Conflict of Interests

The authors declare no conflict of interest.

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