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High Rise Buildings: Assessment Approach

Khaled Heba, Haitham Sadek Selim, Asaad Ali Abu Ghazala*

Department of Architecture, Al-Azhar University, Onaizah Private Colleges, Saudi Arabia

Abstract Nowadays, high-rise buildings are developing very fast to cater to the increase in demand in major urban cities. Cities are now competing in the construction of skyscrapers, a sign of progress, sophistication and urbanization. There are a many of important factors to consider during a design process of a tall building which need to be examined from a wider urban scale to a narrower architectural scale. as such location and site selection, land-use, integration of landscape elements, the use of natural energy resources (wind, sun, vegetation.), the livable urban areas and building areas and nodes (plazas, inner outer courtyards of the building, service floors), transportation, façade design, material usage. Compatibility between a building and its environment is a significant architectural conversation that should be assessed and evaluated together when trying to find solutions through sustainable architectural design considerations. This paper is aimed to argue the relation between tall buildings and the built environment from the sustainable point of view. Based on the analytical and theoretical way.

Keywords High rise building, Sustainability, New technology

1. High Rise Buildings Definition

The word “skyscraper” or tall building is a relative term for a building which seems to reach the sky. For example, a building of only 30 floors may be considered a skyscraper if it protrudes above its built environment and changes the overall skyline. In other words, a 30-story building can be called a skyscraper in predominantly low-rise cities, whereas the same building may not be necessarily called a skyscraper in cities such as New York and Hong Kong. It is generally believed that this term originated from the mast of a ship “scraping” the sky in the wind, as used by U.S. journalists in the 19th century. The Emporis defines a “skyscraper” as “a multi-story building whose architectural height is at least 100 meters” (Günel & Ilgin, 2014) it is clear that by increasing density – the number of people per unit area – many economic, environmental and social benefits can be realized. The most prominent tall buildings are called ‘high-rise buildings’ in most countries and ‘tower blocks’ in Britain and some European countries. The terms do not have internationally agreed definitions.” (Craighead, 2009) However, a high-rise building can be defined as follows:

- “ Any structure where the height can have a serious impact on evacuation ” (The International Conference on Fire Safety in High-Rise Buildings). (Craighead, 2009)
- “For most purposes, the cut-off point for high-rise buildings is around seven stories. Sometimes, seven stories or higher define a high-rise, and sometimes the definition is more than seven stories. Sometimes, the definition is stated in terms of linear height (feet or meters) rather than stories. (Hall Jr, 2005)
- “Generally, a high-rise structure is considered to be one that extends higher than the maximum reach of available fire-fighting equipment. In absolute numbers, this has been set variously between 75 feet (23 meters) and 100 feet (30 meters),” (Knoke, 2006) or about seven to ten stories (depending on the slab-to-slab distance between floors).

Figure 1. Since the end of the last century, Asia and the Arabic region have constructed a large amount and the tallest high-rises in the world. (https://edition.cnn.com)

* Corresponding author:
asaadali2000@hotmail.com (Asaad Ali Abu Ghazala)
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The Council on Tall Buildings and Urban Habitat (CTBUH) of the USA defines tall buildings in three ways: "architectural height excluding technical equipment such as antennas and flagpoles; height from the ground to the highest flooring; and height from the ground to the highest point of the structure including technical equipment such as antennas and flagpoles (A. B. Gültekin & Yavaşbatmaz, 2013). also, ASHRAE Technical Committee TC 9.12, Tall Buildings, defines a tall building as one whose height is greater than 91 m. The Council on Tall Buildings and Urban Habitat defines a tall building as one in which the height strongly influences planning, design, or use (Chidiac, Catania, Morofsky, Foo, & Buildings, 2011).

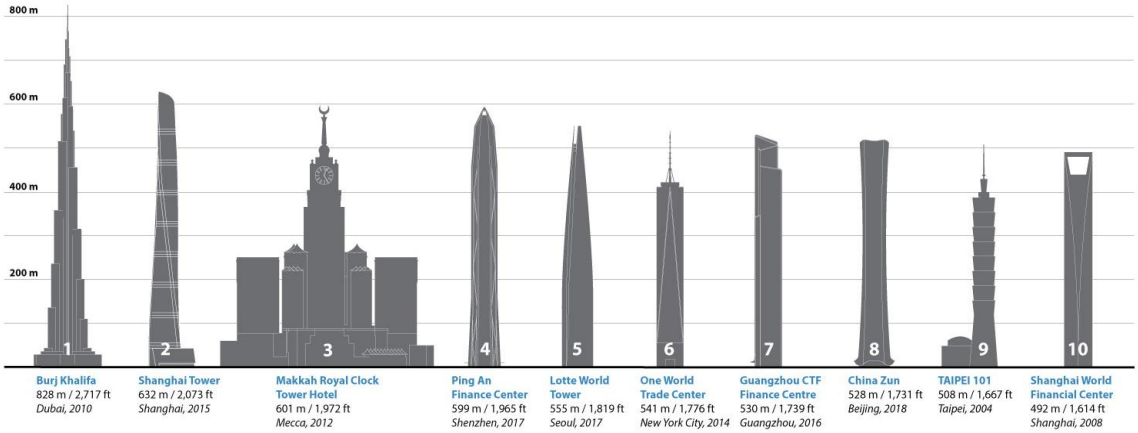

Figure 2. Height to Architectural Top method …the architectural top of the building, including spires, but not including antennae, signage, flagpoles or other functional-technical equipment. This measurement is the most widely utilized and is employed to define the Source: (CTBUH rankings of the "World's Tallest Buildings")

2. Types of High-Rise Buildings

There are different types of high-rise buildings classified according to their primary use. This book addresses the following ones:

1. **Office buildings.** An office building is a "structure designed for the conduct of business, generally divided into individual offices and offering space for rent or lease." (Van Horne & Wachowicz, 2005).
2. **Hotel buildings.** "The term 'hotel' is an all-inclusive designation for facilities that provide comfortable lodging and generally, but not always food, beverage, entertainment, a business environment, and other 'away from home' services." (Beaudry, 1996) There are also hotels that contain residences. Known as hotel-residences, this type of occupancy is later addressed in mixed-use buildings.
3. **Residential and apartment buildings**. A residential building contains separate residences where a person may live or regularly stay. Each residence contains independent cooking and bathroom facilities and may be known as an apartment, a residence, a tenement, or a condominium. An apartment building is "a building containing more than one dwelling unit." "Apartment buildings are those structures containing three or more living units with independent cooking and bathroom facilities, whether designated as apartment houses, … condominiums, or garden apartments." (Cote, 2008)
4. **Mixed-use buildings**. A mixed-use building may contain offices, apartments, residences, and hotel rooms in separate sections of the same building. Hotel residences are another type of mixed-use occupancy.

3. History of Tall Buildings

Historically, the ambition to reach the sky is has been reflected in every culture, particularly in ceremonial and symbolic buildings such as the Tower of Babylon, the Pyramids in Egypt, Buddhist Temples, cathedrals and mosques. The industrial revolution contributed a functional aspect, where block buildings of two to four floors were built next to factories to house laborers.

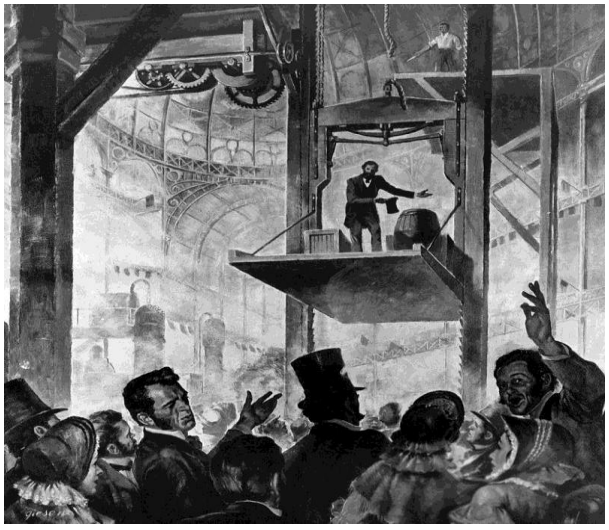

Figure 3. Otis Publicly Demonstrates the World's First Safety Elevator. In 1854, Elisha Graves Otis at the Crystal Palace Exposition in New York. Source: (https://en.wikipedia.org/wiki/Elisha_Otis)

Cities were growing quickly at the turn of the twentieth century, and as a result architects began to design buildings with a vertical orientation.

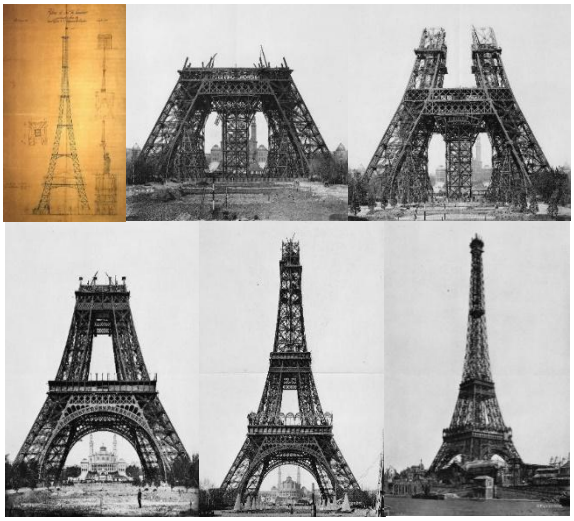

Figure 4. Eiffel Tower: is a wrought-iron lattice tower on the Champ de Mars in Paris, France. It is named after the engineer Gustave Eiffel, whose company designed and built the tower. Constructed from 1887 to 1889. Source: (Wikipedia)

Tall buildings can be seen all over the world, they can be used to show of wealth and power, religious beliefs or to push the boundaries of engineering. The ancient Egyptians built the pyramids nearly 5000 years ago as tombs for their Pharaohs and their consorts, and to this day they are still standing as some of the oldest high-rise structures in the world. Likewise the Gothic cathedrals of Europe were the skyscrapers of medieval time, rising far above anything else in Europe, however all the early high-rise structures have one thing in common, they have a structural system made of masonry which limited the building height due to the high self-weight of the material (Craighead, 2009). People had been building hoists of various kinds for hundreds of years. And they all had the same serious defect: they plunged to the bottom every time the lifting cable snapped". the 'vertical transportation industry' began in ancient Greece. In 236 BC, mathematician Archimedes built a hoisting device using ropes and pulleys. A few centuries later, Roman gladiators and lions rode primitive elevators to reach the floor of the Coliseum. Donkey-powered lifts were the rage of the Middle Ages.… By the 1800s, steam-powered hoists began transporting miners to and from underground veins of ore" (Craighead, 2009) In 19th century many of American architects went to Paris for training and education and brought back with them ideas that influenced their architecture. In Paris, the Eiffel Tower, at 300m (984 ft) in 1889, was surely a catalyst for new heights with its remarkable architectural qualities and became known as an engineering masterpiece. The U.S. also exported cultural and architectural ideas and developments to Europe that included the skyscraper, a clearly American innovation with its beginning in Chicago. (Beedle, 1988) Before then, buildings could not be built taller than five or six stories, because there was no way to transport people and objects to the higher floors; the invention of the elevator allowed buildings to rise beyond those limitations.

Referring to comments made by Otis Company officials, "Otis hadn't invented the first hoist. But he had invented the first 'safe' hoist. In 1853, Elisha Graves Otis introduced the world's first safety elevator in Yonkers, New York. This invention changed the shape of the modern world (Swarr, Legarth, & Huang, 1999). In the late-nineteenth century, engineers began experimenting with new ways of using iron and steel. Traditionally these materials were used for transportation structures such as bridges, train tracks, and railway stations. Through trial and error, engineers developed steel skeletons made of vertical columns and horizontal beams to support tall buildings (Khan, 1972). The Home Insurance Building (1884–85) in Chicago was the first to be constructed with a complete steel-frame structure. These design innovations were also used in the construction of famous structures such as the Eiffel Tower, the Statue of Liberty, and the Brooklyn Bridge (Condit, 1973). The two sectors that dominated the first generation of tall buildings were newspapers and insurance corporations, both seeking image and power in the city. Domosh figured out the symbolic role of skyscrapers as a reflective image of economic paradigm changes: "These first tall buildings need to be understood as attempts by this new economic class to fulfill two parallel goals – to find appropriate expression for its new power and to legitimize that power by placing it within the constructs established by the more traditional elite, thereby conveying a civic as well as a commercial message." (Domosh, 1988).

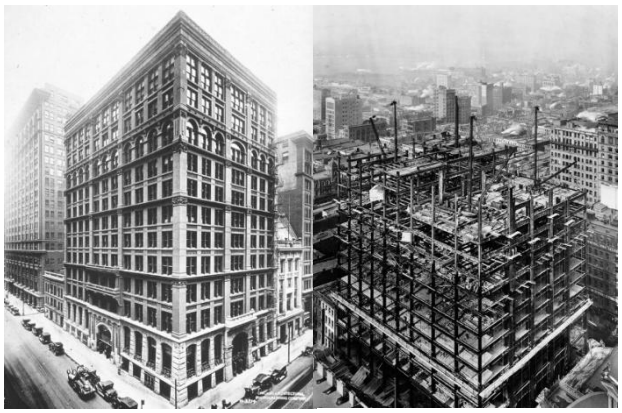

Figure 5. Home Insurance Building 1885. s 10-story building, designed by engineer William Le Baron Jenney, is generally considered the world's first skyscraper. Source: (Swarr, Legarth, & Huang, 1999)

Many specialists classified the tall building as an " industrial mass production", The idea of using industrial mass-production building systems as a basis for design has its origins in the 1920s (Scott, 2007). Frank Lloyd Wright's design for the S.C. Johnson and Son Office Building in Racine, Wisconsin of 1939 is an example of design integration versus standard practices of construction. Wright, like many architects, thought that a functional building should be tightly integrated and, therefore, would be less expensive. In an integrated building, in which the separate systems are tightly interlocked, more functions can be performed by each element. In modern construction,

elements tend to be independent and specialized rather than monolithic, integrated, and multifunctional. This is especially true in large-scale buildings like high-rises where specialization of labor and materials in the building industry requires a high level of organization and coordination among the suppliers and fabricators. (Giedion, 1971).

Figure 6. The Ritz Tower 42-story luxury residencial building located at 465 Park Avenue on the corner of East57thStreet in Midtown Manhattan, New York City. Source: (https://en.wikipedia.org/wiki/Ritz_Tower)

Changes in living patterns in the twentieth century have bought new demand for new housing solutions as well as a desire to limit the spread of urban areas into agricultural lands, for that reason, tall building may therefore be a logical progression but in terms of serving the needs of a rising population, the high-rise experience has not always been positive. In Denmark, England, Germany and even the U.S., experiments in the seventies and eighties showed that living vertically may not meet the expectations of the residents used to living at ground-level; in numerous cases, authorities were forced to demolish residential towers built only a few years earlier. For many years, the United States was the leading country when it came to high-rise buildings, both in the amount of buildings being built and the maximum height. Since the end of the last century, Asia and the Arabic region have constructed a large amount and the tallest high-rises in the world. These have included the Petronas Towers in Malaysia, Taipei 101 in Taiwan and Burj Khalifa in Dubai (Craighead, 2009).

The next point will discuss the relationship between tall buildings and social, transportation, environment, and place making.

4. Tall Building and Social Sides

Literature suggests that high-rises are less satisfactory than other housing forms for most people, that they are not optimal for children, that social relations are more impersonal and helping behavior is less than in other housing forms, that crime and fear of crime are greater (Gifford, 2007). In the same context, early in 1967, Hans Blumenfeld in his important work The Modern Metropolis disapproved tall buildings because they damage the historic fabric of cities (Blumenfeld, 1967).

Posteriorly Christopher Alexander and colleagues in their seminal book A Pattern Language rejected the high-rise city altogether as a viable human habitat. According to Alexander he argued that, tall buildings have no genuine advantages, except in speculative gains for banks and land owners, Alexander added that "tall buildings is not cheaper, they do not help create open space, they destroy the townscape, they destroy social life, they promote crime, they make life difficult for children, they are expensive to maintain, they wreck the open spaces near them, and they damage light and air and view. In Pattern 21: FOUR-STORY LIMIT in his outstanding and famous book "the pattern language", he said "There is abundant evidence to show that high buildings make people crazy. Therefore, in any urban area, no matter how dense, keep the majority of buildings four stories high or less. It is possible that certain buildings should exceed this limit, but they should never be buildings for human habitation". (Alexander, 1977). In the same context, James Howard Kunstler, argues that skyscrapers generate urban pathologies, they also demand lots of energy and are expensive to retrofit.

Also Ken Yeang, whom consider as a leading figure on sustainable tall building developments, stated that, "At the outset, we should be clear that the skyscraper is not an ecological building type ", he argued that, tall buildings require excessive materials and sophisticated structural systems to build so that they are able to withstand greater wind forces that prevail at higher altitudes and they also demand greater energy to construct, operate, and costly maintenance (Yeang, 2008). Although Léon Krier, one of the most distinguished supporter of the New Urbanism movement, but he explains in his book The Architecture of Community that, buildings should have no more than five floors (Krier, 2009).

Eventually, both of the Danish architect and urban designer Jan Gehl in his book "Life Between Buildings" and "Cities for People" critiqued high-rise cities and praised low-rise ones in various parts of the world for they emphasize the value of human scale and provide abundant opportunities for healthy social interaction (J. Gehl, 2011).

According to Jeanne Gang, "The problem is that the highly visible position of the tall building in global culture has led to one-liners and symbolism in a superficial battle for identity" They have often been associated with irrelevant, ostentatious design meant to gain popularity and attention (Gang, 2008).

From social point of view, social science literature reveals that people have multiple concerns about high-rise living including suitability for family living and raising children, neighborly relationships and helpfulness, personal behavior and comfort, perception of safety, tenants' relation to outdoor spaces and connection to street life (Pruetz, 2017). In addition to, High-rises' tenants often feel that they are cooped up in finite spaces of an encapsulated world that fosters loneliness. These environments may make inhabitants also feel claustrophobic, creating a **rat-cage** mentality.

Figure 7. Following the unfortunate collapse of the World Trade Center towers in September, 2011, skeptics took a pessimistic view by calling skyscrapers death traps and predicted their demise as a building typology. Source (Wikipedia, New York times)

Figure 8. Bahrin WTC the first skyscraper in the world to integrate wind turbines into its design. Source (http://www.skyscrapercenter.com)

Further, high-rise living could promote poor interpersonal relationships and weak neighborly relationships that may result in a psychological depression. In some cases, the "isolated" nature of high-rise buildings could promote crime. Further, scholars argue that low-rise living is closer to nature and facilitates a stronger community-oriented social life (Prezza, Amici, Roberti, & Tedeschi, 2001).

According to Robert Gifford in his work "The Consequences of Living in High-Rise Buildings" he details six types of fears found in high-rise living as follows: Users worry that a family member or a loved child jumps from a window, fear masses of "strangers" that share the same building or floor, Users fear a fire that may trap them in the building, fear a devastating earthquake that will topple the building over them, users may fear becoming ill from communicable diseases generated by the masses who live there and eventually, post 9/11, high-rise residents fear that their buildings become terrorist targets. (Gifford, 2007) The collapse of the World Trade Center (WTC) on September 11, 2001 reinforced opinions of tall buildings as unsafe and caused some critics to conclude that this event marked the end of tall buildings.

Constantinos Doxiadis, argued that High-rise buildings work against man himself because they isolate him from others, and this isolation is an important factor in the rising crime rate, also children's suffer even more because they lose their direct contact with nature and other children's. He added that, High-rise buildings work against society because they prevent the units of social importance—the family, the neighborhood, etc., from functioning naturally and as normally as in low-rise environments (Madanipour, 2010). Many specializes argued, living in very tall buildings has many physical, mental and social implications. From a physiological point of view, any distancing from the ground impinges on balance and stability, and people who live for extended periods at high attitudes develop adaptations such as expansion of the blood-vessels, higher levels of hemoglobin and greater lung capacity (Gonçalves, 2010). Spatially and socially, a high rise building is a dead-end street (cul-de-sac). Researchers in England and Denmark have recorded the negative effects on community life of former low-rise home residents who had freedom to move around and develop relations with neighbors of their choice. Research shows that after moving to an apartment building, residents' feelings of isolation increase in direct relation to the height of the building and the number of residents it houses, result from confinement to an apartment with few outside windows (due to strong winds), categorical separation between the different floors, the number of elevators, etc. However, critics and perceptions did not impact tall building development since the past decade has witnessed an unprecedented construction boom of tall buildings around the world. (Sunder, 2004).

5. Transportation and Traffic

Tall building can create problems, such as overcrowding around it that can decrease the quality of life unless conceived and adequately mitigated during the planning stage for the building's long term function. (Ali & Al-Kodmany, 2012) In addition to Tall buildings increase demand on transportation and infrastructure. Possible

mitigation for increased traffic includes expansion of traffic capacities on roads and at intersections and multiplication of public transit options, which require major public works and construction. Likewise, a new tall building will place additional load on the existing power grid, water supply, and sewer systems. If a tall building is built in an undeveloped area, new cost-intensive infrastructure must be provided, for that reasons, Tall buildings require exceptional fortitude from many stakeholders including property owners, developers, planners, architects, and engineers.

For that reason, traffic impact assessment studies should be required to identify its effect on the existing transportation systems.

Figure 9. Trump International Hotel and Tower (New York City) Source (www.tripadvisor.com, www.telegraph.co.uk)

6. Tall Buildings from Economical / Environmental Perspective

Tall buildings are costly for they require special engineering expertise as well as special construction equipment. They exert significant demand on infrastructure and transportation systems, and affect the historic fabric while reshaping the city skyline. Furthermore, they influence the micro-environment by casting shadows and blocking views and sun light. They also consume massive quantities of energy and require a high operational cost. For these reasons some critics have viewed tall buildings as an undesirable "urban evil" that reduces the quality of urban life. Further, following the unfortunate collapse of the World Trade Center towers in September, 2011, skeptics took a pessimistic view by calling skyscrapers death traps and predicted their demise as a building typology. Although, Tall buildings may have potential environmental advantages, such as ample access to sunlight and wind for the incorporation of solar panels and wind turbines. However, tall buildings produce adverse effects the microclimate, due to wind funneling and turbulence, which may inconvenience pedestrians around them. Also, tall buildings create overshadowing problems and cast large shadows, affecting adjacent properties by blocking sunlight. In the same context, many specialists argued that, Tall buildings are environmentally damaging when they fail to incorporate energy efficient design solutions in their heating, cooling, and ventilation systems. If they are unattractive, tall buildings can harm the image of a city.

7. The Conflict with Place-Making

Place-making is a concept that emerged after it became clear that it was necessary for the urban design to consider the cultural, social, economic, political and spatial factors as well as the importance of people's activities and perceptions of urban public places.

Tall buildings frequently evoke the image of a nerve-racking, workaholic business environment. In addition, in residential areas they convey the perception of living in crowded apartments that are more akin to cages than living spaces. Inhumanely high towers often shatter the human scale by dwarfing nearby public spaces and buildings, particularly those of a historic character (J. J. W. D. Gehl, 2010) Also, tall building proposals often are challenging because of their inevitable impact on the historic urban fabric.

Figure 10. The new Mecca and Losing the importance of the Kaaba through skyscrapers. Source(www.britannica.com/place/Mecca)

The impact of high-rise development is critical for the conservation of the built heritage of cities, and many cities suffer from a lack of a strategic approach to managing tall buildings. Buenos Aires, Sao Paulo, and Mexico City are, Dubai, Mecca are losing their local distinctiveness and urban character through the ad hoc construction of tall buildings (Short, 2004). Future of tall buildings should foster placemaking by relating to their specific locations, respecting the built heritage, and connecting with the socio-cultural conditions. Nowadays, the present researchers seek to assess the current situation regarding tall buildings in the developing areas of Asia and the Middle East –especially from the perspectives of place-making, the image of a city, and identity (Sinclair & Systems, 2015). Design of new tall buildings should supplement, not contradiction with the historic fabric. And this is a challenge to make tall buildings support place-making concept.

Figure 11. The Pearl River Tower (Guangzhou, China) Source: (www.designbuild-network.com)

8. Tall Buildings form Sustainable Perspective

During the past 40 years a significant realization that the current model of development is unsustainable. In other words, we are living beyond our means. From the loss of biodiversity with the felling of rainforest's or over fishing to the negative effect our consumption patterns are having on the environment and the climate. Our way of life is placing an increasing burden on the planet – this cannot be sustained." regrettably, it is a worldwide fact that we are not even meeting our current needs, let alone considering the needs of future generations.

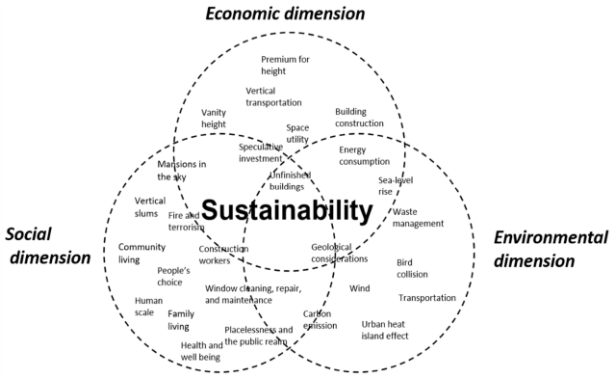

Figure 12. Overall vision of the sustainability concept Source: (Al-Kodmany, K 2015)

Approximately 17% of water sources, 25% of forestry products and 40% of energy sources are consumed by the building sector. (Say, Wood, & Journal, 2008) The manufacturing, construction, operation, maintenance, repair and demolition activities of the buildings affect natural environment and therefore buildings may harm the environment throughout their life cycles.

The fundamental core of sustainable development is about five key principles: quality of life; fairness and equity; participation and partnership; care for our environment and respect for ecological constraints—recognizing there are 'environmental limits'; and thought for the future and the precautionary principle(Kuhlman & Farrington, 2010) A decisive move toward more sustainable development is crucial, both because it is the right thing to do, and because it is in our long-term best interests.(Sneddon, Howarth, & Norgaard, 2006).

There are a lot of important factors to consider during a sustainable design process of a tall building which need to be examined from a wider urban scale to a narrower architectural scale. Examples that may be given for these factors are location and site selection, land-use, integration of landscape elements, the use of natural energy resources (wind, sun, vegetation.), the livable urban areas and building areas and nodes (plazas, inner-outer courtyards of the building, service floors), transportation, façade design, material usage.

Costs of energy and natural resources used by tall buildings throughout their life cycle are higher compared to other structures because they have more floors. Therefore, tall buildings are perceived as the buildings that use energy and natural resources inefficiently. As a solution to this problem, a sustainable design concept has emerged for tall buildings. The aim of sustainable design for tall buildings is to create designs that reduce the use of natural resources, use local resources economically, do not disrupt ecological balance, minimize the harmful effects of buildings on the environment, and provide necessary conditions for human comfort and health.

9. Green or Sustainable Tall Building?

The green design indicators of key sustainability concepts for this paper, have been comprised of by considering both LEED (Leadership in Energy and Environmental Design) and BREEAM (Building Research Establishment Environmental Assessment Method) requirements. Furthermore, when dealing with design logistics of both a green and a sustainable building, it is inevitable to concentrate both on physical and social points in designing a tall building. Therefore, site location, site organization, transportation, urban skyline, material selection and façade design, entrance floor design, vertical design and the urban microclimate are the key concepts of sustainability which will be used for this research study. These main key sustainability standards define the boundary of both physical and social parts of sustainable design for tall buildings in this paper.

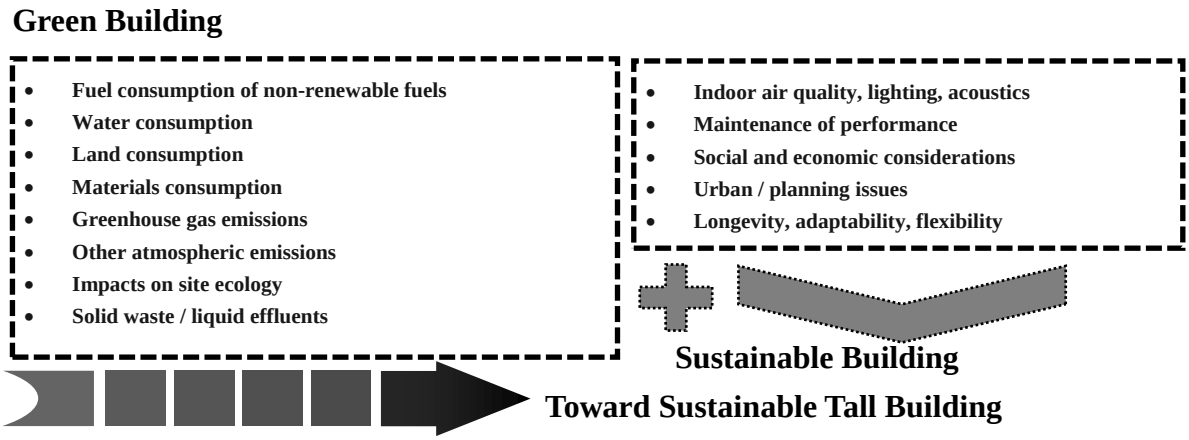

Figure 13. Green or sustainable tall building? Source: (Authors 2021)

Figure 14. Singapore's Ecological EDITT Tower Source: (www.designbuild-network.com)

Sustainability covers social, ecologic, and economic questions. The social aspect comprises cultural considerations, comfort, social integration, health, ergonomics, and functionality The economic aspect is assessed by value-engineering and commercial departments. The ecological aspect, however, is often reduced to energy efficiency only. Ecology is thus taken into consideration but to a relatively limited degree. (Council, 2003). Over the key sustainability concepts, a necessary perspective is inevitably the green building and green environmental standards. The best-known standards for sustainable building design are listed by US Green Building Council – LEED (Leadership in Energy and Environmental Design) certificate' and UK Green Building Council – BREAM (Building Research Establishment Environmental Assessment Methodology). LEED and BREEAM certificates generally insist on sustainability standards of buildings regarding: location, transportation, materials and resources, water efficiency, energy and atmosphere, indoor environmental quality, neighborhood pattern and design, infrastructure, renewable energy systems, health and well-being, waste management, pollution. These criteria are generally physical requirements but a sustainable building has to address social concerns as well.

Larsson clarifies the difference between a green building and sustainable building; "Currently the emphasis is on 'green', focusing mainly on environmental performance and often defined in operational terms. Sustainable approach is operationally defined as including social and economic factors" (Larsson & Environment, 2009).

10. Conclusions

Based on the pervious, the next table conclude the main indicators and criteria ratings in order to reach tall sustainable buildings, this table based on LEED & BREAM criteria, these criteria were developed by authors through the previous literature in this paper to add the social and place-making factors.

Tall buildings have a huge impact on the environment, playing crucial roles in creating the image of the city and offering immense potential to contribute positively to the urban fabric of our cities. A wealth of factors, including scale of construction and scope of programming, make this building typology intricate and unique. Architects assume significant responsibility to pay attention to the design process and innovate ways in which such projects are conceived and realized.

The authors stress that the approach for designing this remarkable building type is to date incomplete and lacking. Moving forward, the strategies for design and development must be comprehensive, integrative, holistic and far more responsive (i.e., socially, psychologically, culturally).

While some researchers consider tall buildings as "energy-hungry parasites" feeding upon the surrounding ecosystems and natural resources, consuming a huge amounts of discharges into the natural environment, and are therefore un-green, many others researchers confirmed that, skyscrapers can be designed as low-energy ecological, carbon neutral buildings and could be the self-evident ecological building type of the future.

Main Indicator	Criteria Ratings
Sustainable Site	Preventing pollution while construction (obligatory), the appropriate site selection, obtaining optimal density in built environments and vicinity to urban services, restoration of damaged sites and environmental pollutions, providing easy access to public transportation systems, invention appropriate parking capacity, maximizing outdoor, qualitative and quantitative management of rainfall, preventing heat island in non-roofed buildings and preventing heat island in roofed buildings, Reducing light pollutions.
Water Efficiency	Reducing water consumption (obligatory), saving water consumption of irrigation systems, waste recycle by using the innovative technologies.
Energy	Assurance of energy systems performance accuracy in the buildings (obligatory), minimum use of energy in the buildings (obligatory), preventing reduction of ozone layer through cooling instruments(obligatory) optimization of energy consumption in the buildings, using renewal energy resources, distinguished and evaluated energy consumption in building.
Materials	Gathering and saving renewable material (obligatory), reuse of the building with keeping non-structure elements of indoor building, managing wastes produced by construction, using recycled materials, using local materials, using materials with immediate recyclability.
Indoor Air Quality	Achieve to minimum desired air quality of indoor building (obligatory), controlling the amount of tobacco smoke released of the environment (obligatory), installing carbon dioxide measurement systems of building output air flow, increasing ventilation system, managing the quality of indoor air before operation of the building and at the time of construction, using materials with less pollution (including adhesives and linings, colors and covers, roofing and wooden products), controlling lighting systems, controlling heat and ventilation systems, heat comfort system design, providing natural light, providing appropriate view.
Innovation	Innovation in designing with the desired LEED factors
Regional Priorities	Importance to the local priorities.
Place-making	Compatibility with the historic fabric/ city image / vertical landscaping / the visual impact of a tall building on the surrounding historical views or landmarks
Social needs	The integration of a tall building with physical and social urban environment and street life/ public access through the site and existence of the pedestrian areas/ the connection between public spaces with the surrounding urban places existing within the tall building site// balconies and terraces/ solar shading devices

Figure 15. Sustainable criteria to assess the tall buildings (Authors, 2021)

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