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The Logic of Vertical Density: Tall Buildings in the 21st Century City

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Abstract

This paper attempts to summarize recent debates on tall buildings. It first explains the driving forces of constructing tall buildings including population increase, rural-to-urban migration, demographic change, agglomeration, and human aspiration. Next, it discusses disadvantages and challenging factors that are frequently raised in making a case against tall buildings including economics, environmental factors, historic context, public safety, and psychological issues. The paper concludes by affirming that tall buildings will persist in the 21st century due to strong commitment to urban sustainability and significant population increase worldwide.

Keywords: Tall buildings, Vertical density, Driving forces, Advantages, Disadvantages

1. Introduction

Tall buildings require exceptional fortitude from many stakeholders including property owners, developers, planners, architects, and engineers. They 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.

Surprisingly, the past decade proved that these views are invalid because we have witnessed an unprecedented construction boom of tall and supertall buildings worldwide. This is corroborated by the Council of Tall Buildings and Urban Habitat (CTBUH), which went even further in observing that the past decade has witnessed the completion of more skyscrapers than any previous period in history. This resurgence of tall buildings is notwithstanding the recent global economic recession. An aggressive race to earn the world's tallest building title continues, while at the same time, cities are constructing higher buildings in greater numbers (Wood, 2011), (Fig. 1).

The tallest building of the world, until 1996, was the 442 m (1,451 ft) high Willis Tower in Chicago (Fig. 2). That title was stripped by the Petronas Towers in Kuala Lumpur standing at 452 m (1,483 ft), (Fig. 3). Soon after, in 2004, Taipei 101 in Taipei surpassed the Petronas Towers by soaring to a height of 509 m (1,670 ft) to become the world's tallest building (Fig. 4). It retained the title until Burj Khalifa was completed in 2010, which rises to 828 m (2,717 ft), (Fig. 5). Shanghai Tower, under construction, will rise to 632 m (2,074 ft) and then becomes the world's second tallest building (Fig. 6). However, the recently approved Kingdom Tower in

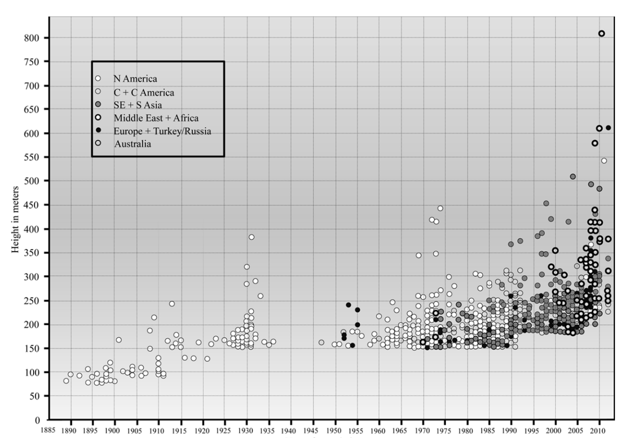

Figure 1. Tendency to build higher and in greater numbers in the past two decades, 1990-2010. An exponential rise in height can be seen since 1990 culminating in the dramatic climb in 2010 with the construction of Burj Khalifa, Dubai *(Graph by K. Al-Kodmany; adopted from Skyscrapercity.com).*

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Figure 2. Willis Tower (formerly Sear Tower) in Chicago (center). Rising to a height of 443 m (1,454 ft), it became a symbol of Chicago and remained the world's tallest building during 1973-1998. It is currently the tallest building in the U.S. *(Photograph by K. Al-Kodmany).*

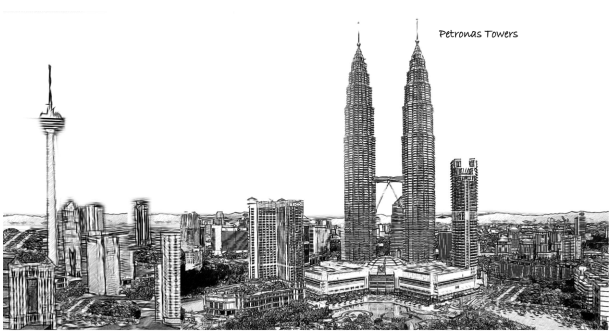

Figure 3. Petronas Towers in Kuala Lumpur, Malaysia. Rising to a height of 452 m (1,483 ft), it became the world's tallest building in 1998. It marked the first time when the record of the world's tallest building moved to another country from the U.S. *(Sketch by K. Al-Kodmany).*

Jeddah Saudi Arabia will surpass Burj Khalifa by reaching unprecedented height of 1000 m (3280 ft), and upon its completion it will become the world's tallest building (Fig. 7).

Therefore, a basic but pressing question is often posed: Why tall buildings? In the distant past, the primary question of building tall was "how" since there were less sophisticated building materials, technologies, structural analysis methods, and construction techniques. Today, however, substantial improvement in all these areas has eased this question. Technically, we can fulfill Frank Lloyd Wright's vision of constructing a mile-high tower. Compared to our ancestors we are more aware of the effect of our creation on the environment and conscious of the growing shortages of natural resources that dictate us to use them prudently. The question then becomes "why?" Why are tall buildings inevitable; why are they reshaping the skylines of cities; and why do we need

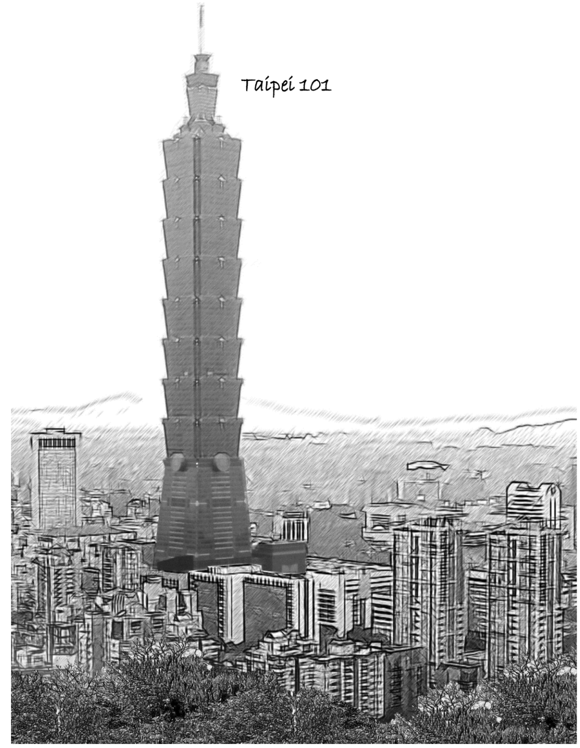

Figure 4. The 101-story Taipei 101 in Taipei, Taiwan. Standing at a height of 509 m (1,670 ft), it became the world's tallest in 2004 and remained the tallest until the opening of Burj Khalifa in Dubai in 2010 *(Sketch by K. Al-Kodmany).*

Figure 5. Dubai, the new "instant" high-rise city with its most notable tower, Burj Khalifa, the world's tallest building *(Courtesy: Adrian Smith + Gordon Gill Architecture; photograph by J. Steinkamp).*

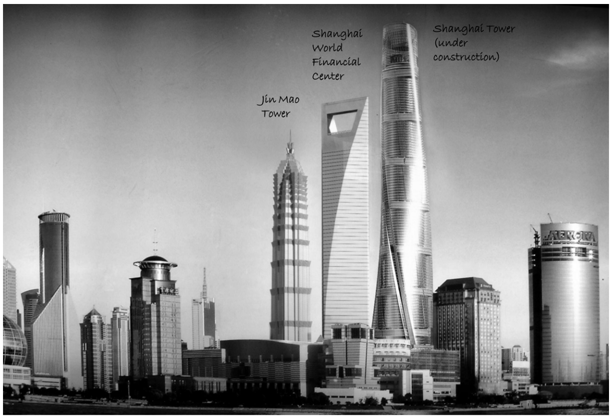

Figure 6. Planned to reach 632 m (2,073 feet) height, the 128-story Shanghai Tower (right), under construction, will surpass its neighbors to the left, the 88-story Jin Mao Tower (420 m/ 1,379 ft) and the 101-story Shanghai World Financial Center (492 m/ 1,614 ft) *(Photograph of rendering by K. Al-Kodmany).*

Figure 7. The recently approved proposal of the Kingdom Tower in Jeddah, Saudi Arabia. It is planned to rise to 1,000 m (3,280 ft), and when built, will become the world's tallest building. Anticipated year of completion is 2018 *(Courtesy: Adrian Smith + Gordon Gill Architecture).*

more of them in the 21st century?

This paper attempts to address these questions first by clarifying the definitions and usage of some common terms - such as skyscrapers, tall buildings, and high-rises. Next, it explains the driving forces behind constructing tall buildings including population increase, rural-to-urban migration, demographic change, agglomeration, and human aspiration. Later, it presents disadvantages and challenging factors for building tall, including economics, environmental factors, historic context, public safety, and psychological issues that are frequently raised in making a case against tall buildings. The paper concludes by predicting that tall buildings activities will continue in the foreseeable future.

2. Definitions

Tall building: There is no universally accepted definition of a "tall building." Governmental bodies around the world differ in how they define "tall buildings." For example, the German regulations define "tall buildings" as buildings higher than 22 m (72 ft) with rooms for the permanent accommodations of people (Ross, 2004). This limit is derived from the length of ladders used by the firefighters. The Leicester City Council in the U.K. defines a tall building as a building over 20 m (66 ft) in height; and/or a building of any height, which is substantially higher than the predominant height of the buildings in the surrounding area; and/or a building, which would make a significant impact on the skyline of the city (LCC, 2007). In Ireland, Cork City defines tall buildings as buildings of 10 stories and higher (CCC, 2004). The ASHRAE (American Society of Heating, Refrigerating and Air-conditioning Engineers) Technical Committee for Tall Buildings defines them as buildings higher than 91 m (300 ft) (Ellis, 2004).

However, CTBUH resolves the confusion by providing a framework for a definition. It set the following criteria required to qualify a building to be described as tall (CTBUH, 2011): 1. Height relative to context; 2. Proportion; and 3. Building technologies related to height.

According to the first criterion, the building should significantly exceed the general building heights of its surroundings. By this criterion, however, as the average height for buildings increases, what is considered tall at a particular time may not be considered tall at another time. For example, in Dubai, in the 1980s, 10-story buildings were considered tall. However, as the city grew rapidly and built an abundance of ultra-tall buildings, including the 163-story Burj Khalifa, 10-story buildings lost their standing as tall buildings. Also, buildings defined as tall in one particular place may not be considered tall in another place. Whereas, a 10-story building may not be considered a tall building in a high-rise city such as Hong Kong, in a predominantly low-rise city such as Damascus or Malta, this height may be distinctly taller than the norm. This paper emphasizes the first criterion, the height relative to a context.

The second criterion for tallness implies verticality and states that the building should be slender enough so that it gives the appearance of a tall building, especially against low urban backgrounds. There are numerous large-footprint buildings which are quite tall but their size/floor area rules them out as being classified as tall buildings. This means that tall buildings are higher and thinner than "groundscrapers," which also may be high, but tend to have a much larger footprint and bulkier appearance.

The third and relatively weak criterion--height-related building technologies--suggests that the building may be considered tall if it contains technologies attributed to tallness (e.g. specific vertical transport technologies, and structural systems efficient against lateral forces, etc.).

Supertall building: CTBUH defines "supertall" as being any building over 300 m (984 ft) in height. As of early 2010 there were only approximately 50 buildings around the world in excess of this height completed and occupied (ICC, 2006).

Ultra-tall building: This term refers to extremely tall buildings. The terms "ultra-tall" and "supertall" can be taken interchangeably.

High-rise: There is no universal agreement on when a building becomes classified as a high-rise. A building consisting of many floors is generally considered as high-rise by the public. In the U.S., with some exceptions, high-rise facilities typically are defined as structures with occupied floors 23 m (75 ft) or more above the lowest level of fire department vehicle access; this definition is based on the reach of 30 m (100 ft) aerial fire apparatuses, and accounts for typical setbacks (ICC, 2006). The Emporis Standards Committee, which administers an online real estate database that contains one of the largest collections of high-rise buildings, defines a "high-rise" building as "a multi-storey structure between 35-100 meters tall, or a building of unknown height from 12-39 floors" (EM, 2011).

Skyscraper: The word "skyscraper" 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 sky-scraper 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-storey building whose architectural height is at least 100 meters" (EM, 2011).

Tower: Towers are tall structures in which their heights are greater than their widths by a significant margin. Towers generally are built to take advantage of their height and can stand alone or as part of a larger structure. The term "tower" is an inclusive term that includes tall structures of different types used for habitation and non-habitation purposes (e.g. water towers, telecommunication towers, transmission towers, solar towers, etc.)

3. Why Tall Buildings: Advantages and Driving Forces

Very often a rhetorical question is asked: "Why tall buildings?" Arguably, there are critics who decry tall buildings as intrusive, interfering with our organic way of living. On the other hand, there are proponents of tall buildings who believe these buildings are destined to continue as a building type to resolve the problem of increasing density of cities unless an alternate solution is found. There are several reasons why tall buildings originated and evolved to their present state of development. The following examines these reasons.

3.1. Population

Among the most pressing issues that have spurred tall building development, and likely to continue to do so, is the exponential increase in urban population worldwide, (Fig. 8). Currently almost half of the world is urban when 20 years ago it was only one-third. By 2030, it is expected that about 60 percent of the world's population will be urban. In 2050, over 80 percent of the world population will live in urban areas and the world's population is expected to reach 9 billion. At that time, all major cities of the world, particularly those in Asia, Africa, and Latin America, will have enormous populations, probably ranging from 30 million to 50 million, or more (United Nations, 2010). Accommodating these large populations in urban settlements will be a colossal challenge.

Rural-to-urban migration is one of the causes of urban population increase. Between 1945 and 1985, the urban population of South Korea grew from 14.5 percent to 65.4 percent, and to 78.3 percent of the total population by 2000. In China, it is projected that by 2025, 350 million people will migrate from rural to urban environ-

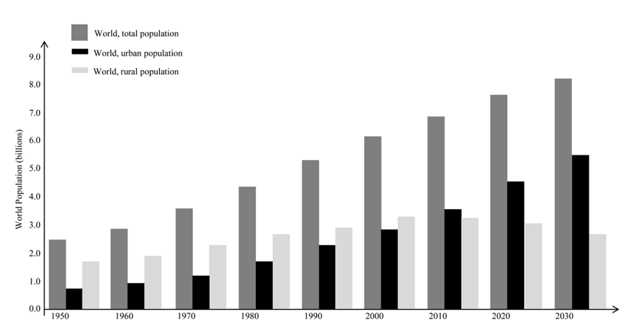

Figure 8. World population growth, 1950 to 2030. The urban population shows an increasing trend since 1950 and exceeds the rural population between 2005-2010 and continues to increase at a higher rate with respect to rural population beyond this period *(Graph by K. Al-Kodmany; adopted from WPP, 2010).*

ments (Aston, 2009). Marcos Fava Neves commented that "This will require five million buildings……equivalent of ten cities the size of New York" (Neves, 2010, p. 28). In other words, Chinese cities need to build to accommodate a population increase equivalent to the U.S. population in just 15 years. In such cases, high-rise development is almost certain to be part of the solution (Collines et al., 2008).

3.2. Global competition and globalization

The current trend for tall buildings reflects the increasing impact of global competition on the development of the world's major cities. These cities compete on the global stage to have the title of tallest building with which to announce the confidence and global nature of their economies. An iconic tall building enhances the global image of the city. It quickly characterizes the city as "international" promoting its significant economy and advancement. Political leaders have supported constructing tall buildings in order to present their countries as emerging global economic powers. For example, President Mahathir Mohammad of Malaysia publicly and strongly backed the building of the then tallest building in the world, the Petronas Towers in Kuala Lumpur, as a symbol of Malaysia's entry into the global economy (Beedle et al, 2007).

In some parts of the world, globalization has immensely promoted local economy and consequently the construction of tall buildings. For example, the City of Shenzhen, China, was a small fishing village in the 1970s. Due to global forces and rapid foreign investment, it was transformed to a modern city of skyscrapers. Foreign nationals have invested billions of dollars for building factories and forming joint ventures. It now is reputedly one of the fastest growing cities in the world, and it is one of the most successful Special Economic Zones in China. Shenzhen is home to the headquarters of numerous high-tech companies that house their offices in major tall and supertall buildings (Figs. 9 and 10).

3.3. Urban regeneration

Many city centers in developed countries that suffered from migration of their population to the suburbs in the 1970s-90s have witnessed a major return to their centers in recent years. The convenience of urban living again is gaining favor by a greater number of today's population. Younger people desire city-center living, preferring to live where they can find residences close to work. Older members of society desire to live in the city to free themselves from the demanding maintenance of properties, to reduce driving, and to escape the feelings of loneliness and isolation experienced in suburbs. City centers provide plenty of socio-cultural activities and services that cover daily needs such as shopping, groceries, and healthcare within walking distances. Therefore, many cities are witnessing an urban renaissance and a desire to return to high-rise living. Urban regeneration does not necessitate tall building construction. However, in urban cores tall buildings optimize on land utility and may offset the expenses of costly land and construction. Consequently, tall buildings have been used to regenerate dilapidated urban cores (Riley and Nordenson, 2003).

3.4. Agglomeration

In city centers, the need for tallness is also a matter of economics and agglomeration. Urban agglomeration hinges

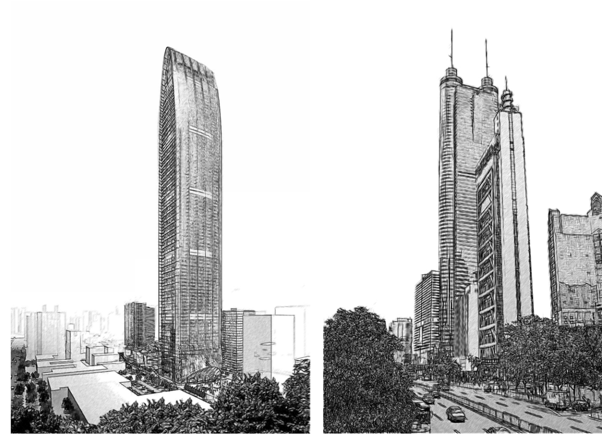

Figure 10. Newest and tallest buildings in Shenzhen, China. Kingkey 100 rises to 439 m (1,440 ft) and it is the tallest building in the city (left). Shun Hing Square rises to 384 m (1,260 ft) and it is the second tallest building in the city (right) *(Sketch by K. Al-Kodmany).*

Figure 9. Shenzhen, China, a small fishing village in the 1970s is now a major city of skyscrapers. It is considered one of the most successful Special Economic Zones as a result of the vibrant economy made possible by rapid foreign investment. It has become a business and financial center in a short period of time and aspires to compete with nearby Hong Kong *(Sketch by K. Al-Kodmany).*

on proximity of activities, and tall buildings do just that. Clustering of tall buildings fosters urban synergy among the provided diverse activities and specialized services. The high concentration of activities creates "knowledge spillovers" between firms in the same sector and across sectors that lead to increased innovation. In a denser and diverse environment, knowledge can spill into unintended fields, and significant share of knowledge transfer occurs informally. Audretsch explains: "Since knowledge is generated and transmitted more efficiently via local proximity, economic activity based on new knowledge has a high propensity to cluster within a geographic region….Greater geographic concentration of production leads to more, and not less, dispersion of innovative activity…." (Audretsch, 2008). The presence of an abundance of firms offering similar products spurs competition, innovation, and efficiency. Agglomeration improves economy of scale and can increase productivity through access to denser markets. Access to competing suppliers helps firms procure more efficient, cheaper, and more appropriate inputs.

Researchers have attempted to quantify the impact of agglomeration. Buchanan's research shows that "a doubling of employment density within a given area can lead to a 12.5% additional increase in output per worker in that area. For the service sector, the figure is far higher at 22%" (Buchanan, 2008). Buchanan's research has estimated that moving 80,000 jobs in London to high-density locations could increase the output of workers by £206 million (Buchanan, 2011).

3.5. Land prices

Land prices always have been a prime driver for tall buildings. Famed architect Louis Sullivan coined the phrase "Form follows function;" however, a better phrase for skyscrapers came from Cass Gilbert in 1900, "A skyscraper is a machine that makes the land pay" (Landau and Willis, 1996). In large cities, properties are more expensive, and buildings grow upward. Low land costs clearly keep buildings closer to the ground; tall buildings are not an attractive option for small towns. Carol Willis has coined the expression "form follows finance" in which she argues that the economics of tall buildings play a key role in shaping a tall building (Willis, 1995).

Land prices recently have been significant drivers for tall building development in many cities seeking to repopulate their urban centers with residential-recreational compliments to the predominantly commercial-retail Central Business Districts. These relatively new markets help drive up city center land prices, which makes building tall for investment return increasingly necessary. In the City of London, land prices are among the highest in the world, and great economic advantages exist for developers to maximize the rentable floor space of an area of land by building high (Watts, 2007). Consequently, in the recent past, London has witnessed the construction of several tall buildings.

In cities like New York, Hong Kong, and Singapore, of course, there is no choice because geographic boundaries limit horizontal growth. In Singapore and urban Hong Kong, land prices are so high that almost the entire population lives in high-rise apartments (Ali et al., 1995). Of Hong Kong's 1000 square kilometers of land, only around 25% is build-able; and yet it needs to house some 7.5 million inhabitants. Land value is very high, in the range of US$30,000 per square meter, and therefore, developers maximize the site by building very tall buildings, between 50 to 80 floors, (Ng, 2005), (Fig. 11). Central London also suffers from high land prices and as a result, there has been recent demand on tall buildings (Fig. 12). In the case of New York, Rem Koolhaas in his book, *Delirious New York,* explained that Manhattan has no choice but extruding the city grid vertically (Koolhaas, 1978). Similarly, in Mecca, Saudi Arabia, land nearby the Holy Mosque (Al-Masjid Al-Haram) is limited and extremely expensive, and therefore it has recently witnessed significant high-rise development, such as the 95-story Abraj Al-Bait Towers (Fig. 13).

Figure 11. Hong Kong's buildable land is limited because it is situated between steep mountains and water bodies. Consequently, vertical density is employed throughout *(Sketch by K. Al-Kodmany).*

Figure 12. Due to high land prices, London has witnessed the construction of several tall buildings in recent years *(Photograph by K. Al-Kodmany).*

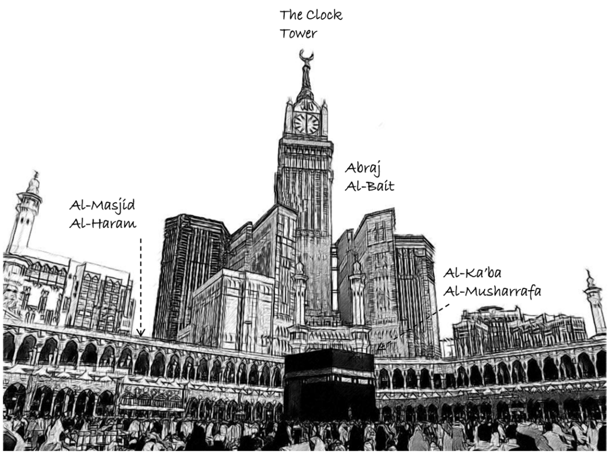

Figure 13. Abraj Al-Bait towers in Makka, Saudi Arabia were built upward due to extremely high land value at the Holy Site but they were criticized for overpowering the Holy Mosque next to it (foreground) *(Sketch by K. Al-Kodmany).*

3.6. Land consumption

Sustainability promotes compact urban living and density is viewed as a tool to create a more sustainable city. Many planners and institutions such as the Urban Land Institute in the United States are supporting this view: "By strategically increasing the number of dwelling units per acre, cities not only will go a long way toward meeting their sustainability objectives, but also will be competitive, resilient, and great places to live" (Murphy et al., 2008). They argue that dense arrangements help preserve open space, a core goal of sustainability, which aims to preserve many different types of open spaces, including natural areas in and around cities and localities, that provide habitat for plants and animals, recreational spaces, farm and ranch lands, places of natural beauty, critical environmental areas (e.g., wetlands), and recreational community spaces. Protection of open space ensures that prime farm and ranch lands are available, and it prevents flood damage. The availability of open space provides significant environmental quality and health benefits that include improving air pollution, attenuating noise, controlling wind, providing erosion control, and moderating temperatures. Open space also protects surface and ground water resources by filtering trash, debris, and chemical pollutants before they enter a water system.

In many instances it is less expensive for a community to maintain open space that naturally maintains water quality, reduces runoff, and controls flooding than to use engineered infrastructure, such as water filtration plants and storm sewers. Lands with natural ground cover have no surface runoff problems because 90% of the water infiltrates into the ground and only 10% contributes to runoff. However, when 75% of the site is covered with impervious surfaces, 55% of the precipitation becomes runoff. On paved parking lots, 98% of precipitation becomes runoff. A 2002 survey of 27 water suppliers found that for every 10% increase in forest cover in a municipal water system's watershed, the cost of water treatment decreased by 20% (Newman et al., 1999). Furthermore, protection of open space provides many fiscal benefits, including increasing local property value (thereby increasing property tax bases) and providing tourism dollars.

Tall buildings support dense arrangements and help to preserve open and natural spaces by accommodating many more people on a smaller amount of land area than that of low-rise buildings. A tall building is, in effect, a vertical transformation of horizontal expansion. When developments expand vertically, public space, agricultural lands, and wilderness remain untouched. Tall buildings maximize building area with a minimum physical footprint. Accommodating the same number of people in a tall building of 50 stories versus five stories requires about one-tenth of the land, for example (Pank et al., 2002).

Commercial and residential towers free the ground plane for ample green space, which supports connectivity and social vibrancy. Through his "Towers-in-the-Park" model, Le Corbusier advocated the high-density city mainly for the purpose of increasing access to nature. Freeing up spaces for parkland brings about "essential joys" of light, air, and greenery. This will support creating healthy and walkable communities as well. Consequently, a number of key world cities in recent years have adopted policies that support tall building development. In this regard, Robert Tavernor, 2007, p. 1, explains:

"Urban Sustainability has been equated in Towards an Urban Renaissance (1999), with the need for compact, dense, vibrant urban cores. To this end, tall buildings are regarded by the Mayor of London as an integral part of the Greater London Authority's sustainable vision for the capital. The London Plan (2004) provides Greater London with a spatial development strategy in which tall buildings will make a highly visible contribution."

3.7. Energy and climate change

The earth's surface is warming due to greenhouse gas emissions, largely from burning fossil fuels. If global temperatures rise as projected, sea levels would rise by several meters, causing widespread flooding. Global warming could also cause droughts and disrupt agriculture. According to a NASA study, the Arctic perennial sea ice has been decreasing at a rate of 9% per decade since the 1970s, and is likely caused by climate change. These issues are remarkable since they can profoundly impact our cities. For example, only a six meter rise in sea level would submerge all of South Florida (NASA, 2003, p.2).

Consequently, fighting global warming and reducing CO_2 emissions are becoming prime goals of many cities.

The Kyoto Protocol, a protocol to the United Nations Framework Convention on Climate Change (UNFCCC or FCCC), was created in 1997 to fight global warming, and over 180 states joined the protocol by 2009. As a result, today many countries are adopting aggressive national carbon emission reduction targets. Local and national organizations' research stresses the need to reduce the emission of CO_2. Pacala's and Socolow's study shows a trajectory of CO_2 emissions, suggesting that the production of CO_2 will hit 560 ppm CO_2 around 2050, a doubling of CO_2 from the pre-industrial concentration. This increase in emissions will result in damaging the climate; hence the desperate need to stabilize carbon emissions (Fig. 14), (Pacala, 2004).

Tall buildings by themselves consume an enormous amount of energy, but have, in fact, the potential to consume less energy than low-rise complexes for the following reasons. The roof is a prime source of energy loss in a building (Fig. 15). As such, a 50-story building of ten apartments per floor has one roof, and 500 single-family homes have 500 roofs. Intuitively, energy loss from 500 roofs is greater than that from one roof. Also, power in tall buildings can be served with a shorter length of distribution lines than in low-rise complexes, when identical total space served is considered (Dalton et al., 2008; Yeang, 2009). However, pumping water to higher floors and the requirement for elevators consume additional energy in tall buildings. Foster et al.'s research supports the claim that, on the whole, tall buildings save energy relative to an equivalent floor area of low-rise buildings. They explained: "Manhattan can be considered the greenest place in America, if measured by energy use per inhabitant. If New York City were a state, it would be 12th in population and last in energy consumption" (Foster et al., 2008).

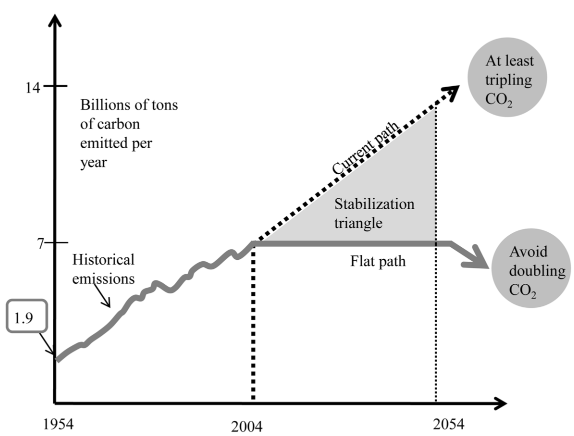

Figure 14. The graph (quantity of carbon emission per year vs. time) shows the need to stabilize CO_2 emissions at current levels rather than allowing it to continue to increase at an accelerated rate *(Graph by K. Al-Kodmany; adopted from Pacala et al., 2004).*

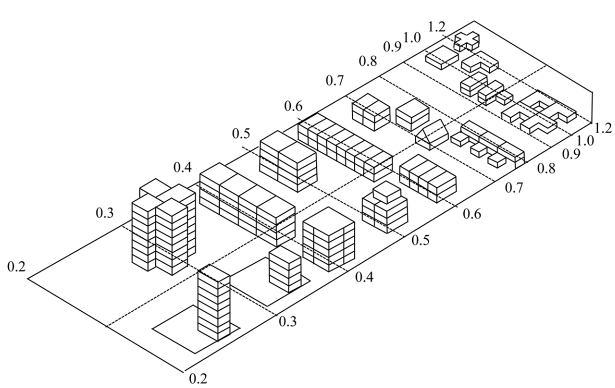

Figure 15. Heat transfer leading to energy loss takes place through a building's façade and roof. The diagram shows the values of the ratio of building's envelope plus roof surfaces to the floor areas for different building heights with equivalent floor areas. The taller the building the lower is the value, and consequently the more energy-efficient is the building *(Drawing by K. Al-Kodmany; adopted from Lehmann et al., 2007).*

A new generation of tall buildings, "Green Skyscrapers," improves energy efficiency, and helps to combat global warming. Good tall building design that incorporates energy-saving technologies also can substantially reduce carbon dioxide (CO_2) emissions. Green skyscrapers have the potential to produce as much energy as they consume, or produce even more energy than they consume, described as "positive" energy buildings. The Green Skyscraper model is important since the building sector today accounts for 30% to 40% of global energy use (Al-Kodmany, 2010).

3.8. Transportation and infrastructure

Tall buildings are generally recognized as an efficient type of compact development that helps reduce travelling distances and the emission of carbon. Compact development is needed since the outward expansion of cities into the suburbs has resulted in an increase in travel time, energy consumption, and CO_2 emission. A comprehensive review of dozens of studies, published by the Urban Land Institute, uncovered that since 1980, the number of miles Americans drive has grown three times faster than the population and almost twice as fast as vehicle registrations. The researchers conclude that one of the best ways to reduce carbon emission is to build compact places where people can accomplish more with less driving. Compact development reduces driving from 20 to 40 percent (Ewing, 2008). Also, compact development maximizes the opportunity for combining journeys. Lunch hours and journeys to and from work can be utilized for errands such as shopping, banking, and going to the library or dry cleaners. In so doing, people maximize the efficiencies of their journeys. A concentration of multi-story development reduces costs and energy involved in transportation and urban services. Studies illustrate that cities such as Hong Kong and Singapore, where clustering of tall buildings is the norm, are among the world's most transport-energy efficient, and environmentally friendly (Figs. 16 and 17), (Newman et al., 1987). Tall buildings in a compact urban core can reduce the per capita carbon footprint of a city with suburbia.

The high cost of maintaining sprawling infrastructure hurts taxpayers and contributes to the fiscal crisis that many local governments face. The cost to provide public infrastructure and services for a given community in new sprawling development is higher than to service the same community in a "smart growth" or infill development. By and large, vertical arrangement facilitates more efficient infrastructure. Simply put, a 500-unit single-family subdivision requires many more roads, sidewalks, sewers, hydro lines, power and gas lines, light standards, fire hydrants, etc., than that of a 500-unit tall building, which allows integrating these systems efficiently (Guthrie, 2008; Ali, 2010). Therefore, tall buildings can play an important role in creating sustainable cities.

3.9. Human aspirations, symbolism, and ego

According to Roberto Assagioli, a pioneer of psychosynthesis theories, the conception of height has to do with "self-realization," "self-actualization," and "human potential"; and consequently, humans always have admired tall structures since ancient times. A commonality of the "seven wonders" of the ancient worlds (e.g., the Temple of Artemis at Ephesus, the Lighthouse of Alexandria, and the Great Pyramids of Egypt) is that all are tall and visible. Human spirit and resilience were the driving forces behind the skyscraper phenomenon that started in the late nineteenth century. Louis Sullivan's passion that

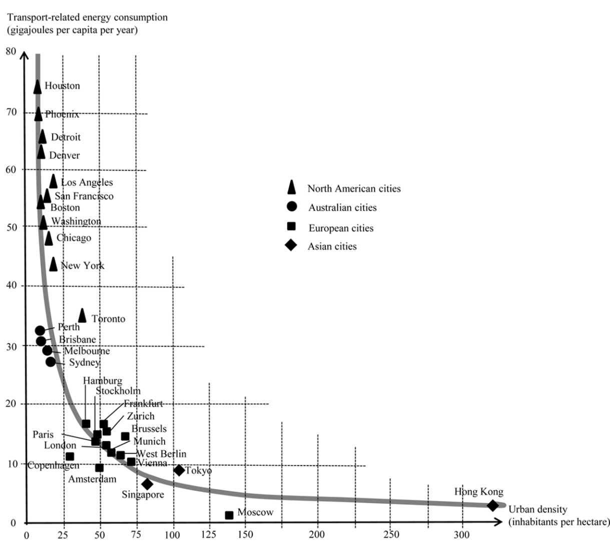

Figure 16. Urban density and transport-related energy consumption. Denser cities consume less transport energy *(Graph by K. Al-Kodmany; adopted from Newman et al., 1987).*

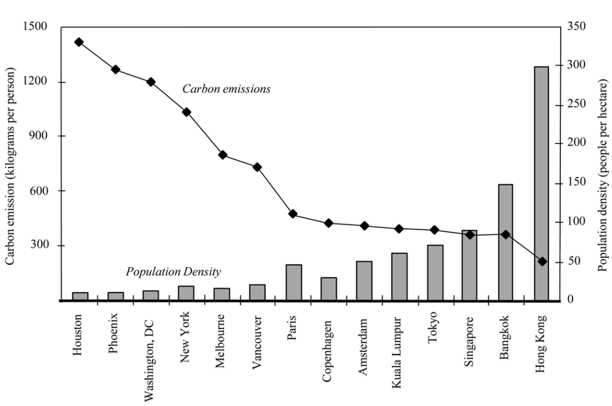

Figure 17. Denser cities tend to have lower carbon emissions from transportation. Hong Kong with the greatest population density has the lowest per capita carbon emission whereas the opposite is true for Houston *(Graph by K. Al-Kodmany; adopted from Guthrie, 2008).*

Figure 18. Canary Wharf in London. Concentration of modern tall buildings stimulated the redevelopment of the area and gave immediate international recognition to this new commercial and financial district *(Photograph by K. Al-Kodmany).*

Figure 19. Downtown Los Angeles, CA. If we remove tall buildings, it would be difficult to think about Los Angeles as a modern sity. Despite the associated problems with tall buildings, they often boost city's imageability and give it "urban glamour," or cinematic qualities. Many films and postcards have included shots of tall buildings to identify and symbolize major cities *(Photograph by K. Al-Kodmany).*

architecture be "a living art" led him to design several of the greatest early skyscrapers.

Tall buildings can project a sense of socio-economic power and promote the city as a leading and modern commercial center (Figs. 18 and 19). Skyscrapers epitomize people's pride in their cities, and showcase the achievements of modern architecture and engineering. Indeed, the skyscraper, more than any other building type, has the capacity to capture the public imagination. Tall structures provide identity for a city, such as Big Ben is London, the Eiffel Tower is Paris, the Space Needle is Seattle, the Burj Khalifa is Dubai, and so on.

Observation decks celebrate human ascendance over the sky and the surrounding landscape by providing unique views of the world below. Humanity has a preoccupation with building large and building tall to defy gravity. "Tall has power" (Kostof, 1999). Imagining large cities without skyscrapers is antithetical to the human spirit, pride, and identity (Lynch 1960).

Therefore, human ego has a role in building tall. The skyscraper offers pride to citizens and politicians, as well as to those involved in the design and construction of a structure - the tallest, biggest, strongest, most beautiful, etc. (Ali, 2005). At the 2009 CTBUH conference, Chicago's Mayor Daley was asked, "Do you see a future in which Chicago would again be a world leader with the "World's Tallest Building?" He answered, "I hope so, sure, I am always looking for developers and architects and all those in the financing for taller buildings. Yes, I think it is important for us, it really enhances the skyline. It shows that we are willing to challenge our city, and especially with taller skyscrapers. Yes, I am 100% for it" (CTBUH, 2009, p.19).

Developers look at tall buildings as advertisements which acquire prestige, and are well worth the extra money needed to build above optimum building height. According to developer Donald Trump, ego plays a very important role in the building of skyscrapers. Owners think the tallest buildings will be the most popular (Bascomb, 2003). Technology will continue to improve the physical systems of the skyscraper and the city, however, the human spirit will be the driving force behind this improvement and will define the future of tall buildings.

3.10. Emerging technologies

As today's technology becomes increasingly sophisticated, architects have an opportunity to build taller and exercise their latest and greatest aesthetic expressions. Developers and architects increasingly are employing new technologies and aesthetics to boost their reputation, prestige, and enhance their business. Developers and architects have been pushing the boundaries of how architecture is perceived and architecture's potential through visionary projects and technological innovation. At the time of this writing, some are continuing with such visions of building up to as high as 2 miles (3.2 km). Therefore, new technologies are motivating architects to provide new innovative and attractive design.

The demand for higher-quality tall buildings has resulted in the advancement of science. The search for higher quality encouraged research in areas such as mechanical, electrical, computer sciences, façade engineering, glazing, structural framing systems, ceiling systems, lighting, ventilation, exit strategies, and water recycling systems, among others. Tall buildings have challenged technology and allowed us to build towers more efficiently and sustainably; and to create internal environments that are comfortable, productive, and energy efficient. Upon completing the construction of the Trump Tower in Chicago in 2009 (a 423 m/1389 ft high, 98-story tower), Professor Dae Kim, CTBUH chairman, said of the tower: "It pushes technological boundaries to achieve its great height, making a powerful mark on the Chicago skyline," (Wood, 2011).

Present and future research addresses the possibilities of using powerful technology such as biomimesis and nanotechnology. Scientific tall building research is generating new products such as anti-reflective façade coatings with designs based on moths' eyes! Technological advances, such as the use of blast furnace slag in high-strength concrete, offer higher performance and sustainability benefits.

4. Arguments Against Tall Buildings: Disadvantages and Challenges

Many of the major advantages of tall buildings are mirror images of their potential drawbacks. For example, tall buildings make efficient use of costly land, but doing so may create a race in pumping up land prices. Increased height provides tenants with spectacular views of the city; however, increased height can also induce phobias associated with living in high floors. Further, tall buildings enjoy low-energy vertical transportation; however, such form of transportation takes away space from the building and could also discourage walking. Tall buildings promote compact and efficient development, but may cause overcrowding and congestion. Delivery services could face congestion in areas with a high concentration of tall buildings but such delivery system reduces driving distances. For example, a UPS man must drive about 200 km (125 mi) to make one day's deliveries in a typical low density suburb in the U.S.; however, in Manhattan, a UPS driver can deliver the same number of deliveries while parked next to a single tall building (Owen, 2009). Furthermore, as an urban regeneration tool, tall buildings improve conditions within the urban core, but they may create a problem by displacing the poor. Vertical infill developments save the city from sprawl, but these projects are usually costly. In all cases, building tall is a major social, economic, and urban design endeavor. Due to their large sizes, when tall buildings fail, the repercussions and losses could be colossal.

4.1. Economics

Constructing tall and supertall buildings can be lucrative, for they support creating a cultural hub and super-economic engine that attracts people (residents, visitors, professionals, artists, etc.) and up-scale businesses from all over the world. However, in general, tall building construction requires an extra premium to construct because of their need for sophisticated foundations, structural systems to carry high wind loads, and high-tech mechanical, electrical, elevator, and fire-resistant systems. In addition, a large core area is needed to accommodate elevators and building services systems. Although mega-story skyscrapers provide more interior space than typical low-rise buildings on a given plot of land, they also cost more to significantly fortify them against the fierce natural forces of gravity, high wind, and earth tremors. Stronger structural systems are needed to withstand a stronger wind at higher altitude, and to carry larger loads. The slenderness ratio makes the structural system more expensive. Vertical transportation, including elevators and stairways, is needed for daily and emergency use. While 70% of a skyscraper is usable space (the remainder being the building's elevator core, stairwells, and columns), more than 80% of low-rise spaces are useable (Mann, 1992). Tall buildings also suffer from higher operational costs, such as elevator maintenance and emergency response preparedness. Depending on circumstances, they potentially could be viewed as targets for malevolent attacks. Also, in difficult economic times, towers simply may not generate enough sales or rental value to support the high quality of design, materials, and detailing. This situation risks producing low quality towers that maximize floor area at the expense of good design.

It is important to note that the economics of building tall is ultimately a matter of local conditions and location. It can be the lowest-cost solution in a developed country in a location with other high-rises where the needed infrastructure and urban services are in place with adequate capacity. Tall buildings fit in well where business and organizational structures are geared to large-quantity operations, where building materials are plentiful, and where there is an adequate force of skilled labor. Building tall could be the highest-cost solution where those factors do not exist; the negative impact of these missing resources must be considered carefully. Without great care in such situations, the cost of adjacent land could be pushed up to create higher costs per unit for structures yet to be built. Further, in some situations where land costs are low, as in smaller cities, tall buildings may be unprofitable because of anticipated high vacancy rates. Also to be considered is the general economic climate at the particular point in time (Yeang, 2008).

The impact of tall buildings on property values varies. In some places, because of newly generated traffic and crowding, property values in nearby neighborhoods may diminish. The opposite also could be true due to the growth of the area displaying signs of economic prosperity. The concentration of jobs and services may create a higher demand for land which increases their property values (Demkin, 2004). Increasing property prices in cities can make housing in these areas increasingly unaffordable for many sections of the population.

4.2. Environmental impact

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 on the micro-climate, 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. Towers 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.

Tall buildings require an abundance of energy for operation and utilities. Many high-rises use more energy per resident than a well-built townhouse, and not much less than a small, well-built, single family home. The Canada Mortgage and Housing Corporation states that, "… on a floor area basis, (high-rises) consume more energy than single family dwellings - even though the high-rise unit has much less exposed exterior surface" (Fader, 2000). They also require a great amount of embodied energy, meaning the energy needed to construct the building and to produce and transport required materials. One of the principal problems with tall buildings of the past, even those offering great architecture, has been the failure to consider how the structure meets the ground and affects the surroundings and street life. Disappointingly, this remains a common problem. Many tall building developments offer little to promote active pedestrian and social life at ground level. From an urban design perspective, an environmental impact assessment is essential for any new tall building project.

4.3. Civil infrastructure

Building tall provides multiple benefits such as land utilization efficiencies, energy savings, and reduced commutes. However, it can create problems, such as overcrowding, that decrease quality of life unless conceived adequately during the planning stage for the long term function. Tall buildings surely 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. Traffic studies should be required to identify the traffic impacts on the existing transportation systems. Likewise, a new tall building will place additional load on the existing power grid and water supply and sewer systems. If a tall building is built in an undeveloped area, new infrastructure, which is cost intensive, must be provided.

4.4. Socio-cultural factors

Culture plays a key role in accepting or rejecting tall building development. In cities where living in a high-rise is the norm, local culture will have no problem with adding new tall buildings. People who were born and reared in tall buildings usually have no problem continuing to live in that environment. In contrast, people in some traditional societies who have been living for centuries in low-rise buildings may initially feel uncomfortable with living in high-rises until they become adjusted to the new lifestyle. Indeed, the type of social community created in the high-rise is different from that found in the low-rise (Al-Kodmany, 2000).

Residential tall buildings, in particular, are linked to their social effects. Many scholars have expressed concerns about the socio-psychological impacts of living in high-rise housing. While high-rise housing may be desirable for single people and couples, it may be less desirable for a family with children. For example, mothers often are concerned about losing eye contact with their children at play on the ground floor.

Some sociologists argue that the environment of tall buildings can make inhabitants feel claustrophobic by creating a rat-cage mentality. It is argued that low-rise living is closer to nature and facilitates a stronger community-oriented social life. As structures grow taller and taller, tenants become out of touch with the city life below. Constantine Doxiades, a reputable planner and architect, summed up this feeling in his writing:

"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. Children suffer even more because they lose their direct contact with nature, and with other children. High-rise buildings work against society because they prevent the units of social importance - the family, the neighborhood, etc., from functioning as naturally and as normally as before" (Blake, 1978, p.82).

4.5. Perception

Some ill-conceived tall buildings have created a stigma in the public's mind. The demolition of the Pruitt-Igoe housing project in St. Louis in 1972 has been ingrained in the minds of a generation of planners and architects. The demolition occurred in response to strong residential dissatisfaction and high levels of criminal activity. Economic class, race, and poor planning, as well as insensitive brutalist architecture, have been identified as reasons for the failure of this project. To many people, tall buildings became synonymous with cheaply built, poorly maintained, blocks of flats or offices which did not meet the needs of their users. Some tall buildings failed by not considering the social and community life of their residents.

However, perceptions of vertical architecture are changing. Improvements in the design of tall buildings and the way they connect with their surrounding environment have resulted in a new generation of buildings that are more harmonious with their urban contexts. In Australia, Harry Seidler designed tall buildings - the Riverside Development of 1986 in Brisbane, Grosvenor Place of 1988 in Sydney, and the QV1 Office Tower of 1991 in Perth - with landscaped public plazas which contributed to the quality of urban life. Sky gardens in the Menara Mesiniaga in Kuala Lumpur, Malaysia, and the Commerzbank in Frankfurt, Germany, and an open ground-floor garden in the Capita Centre of 1989 in Sydney, Australia, show how green spaces can be incorporated into tall buildings, even on the most cramped central city sites and thereby contribute to the sustainability of cities.

4.6. Public safety and perceptions

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. 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. The collapse of the WTC has initiated rigorous research to improve tall building safety, security, and other aspects such as environmental quality. Particularly, the U.S. National Institute of Standards and Technology (NIST) has carried out extensive research on the causes of the collapse and on ways to improve the safety of tall buildings (Sunder, 2004). Many developers have taken advantage of research findings and recommendations by taking them into consideration. Replacement of the WTC includes plans to reconstruct tall buildings at the same location again. The new 541 m (1776 ft) tall One World Trade Center (Freedom Tower) is under construction and the developer plans to build additional towers on the site.

4.7. Historic context and placemaking

In terms of the built heritage, tall building proposals often are challenging because of their inevitable impact on the historic urban fabric. The impact of high-rise development is critical for the conservation of the built heritage of cities such as Kyoto, Shanghai, Jerusalem, Damascus, London, and Paris. Many cities suffer from a lack of a strategic approach to managing tall buildings. Buenos Aires, Sao Paulo, and Mexico City are losing their local distinctiveness and urban character through the *ad hoc* construction of tall buildings (Al-Kodmany, 2011; Short, 2004).

The design of new tall buildings should complement, not conflict with, the historic fabric. For instance, in the City of London, the fine medieval grain of the streets could be better maintained by the relatively small footprint of tall buildings rather than the much bigger footprint of "groundscrapers."

Another challenge is to make tall buildings support placemaking. Many tall buildings - both the sculptural iconic and simple "refrigerator" boxes - seem to have been designed as disconnected, stand-alone, "isolationist" pieces. The prevailing transportable "one-size-fits-all" skyscraper model has created a striking global homogeneity. Instead, tall buildings should connect with their immediate and city-wide socio-economic web. Future tall buildings should foster placemaking by relating to their specific locations, respecting the built heritage, and connecting with the socio-cultural conditions.

4.8. Digital revolution

Wireless and paperless communications have facilitated the interaction of people at disparate locations in various parts of cities, across countries, and around the world. People can work at home, other locations, or on laptop computers while traveling. The Digital Revolution has created a mobile and connected workforce. The Global Village of the early 21st century has declared that "distance is dead" and business can be carried out in the relatively inexpensive low-rise suburbs.

However, human interaction in clustered environments has persisted. Apparently, efficient telecommunication has reduced the importance of the centrality of the urban core and thereby has increased the viability of less expensive and convenient suburban sites as venues for conducting business. Although pessimists have raised concerns about the persistence of tall buildings in high-density urban cores, and enthusiasm for supertall towers may wane in the near future - this has not yet happened. These predictions also conflict with the history of high-rise development, expected population explosions, and rapid urbanization. The ability of telecommunications to substitute for people interacting in proximity is questionable at best, since the needs for face-to-face conversation and seeing the body language of other parties are important elements in the business world. Chemistry between people cannot be substituted by digital links. Despite decreasing costs of telephone services and email connectivity, physical proximity still matters. Evidence indicates that a majority of telephone and email contact is between people in close physical proximity. Face-to-face contact remains crucial for communicating complex and tacit knowledge.

5. Concluding Remarks

The provided review highlighted controversial issues and conflicting views on tall buildings. Indeed, there are

Table 1. Population of Cities with 10 Million Inhabitants or More, 1950, 1975, 2000, and 2015 (*in millions*)

1950		1975		2000		2015	
City	Population	City	Population	City	Population	City	Population
1 New York	12.3	1 Tokyo	19.8	1 Tokyo	26.4	1 Tokyo	26.4
		2 New York	15.9	2 Mexico City	18.1	2 Bombay	26.1
		3 Shanghai	11.4	3 Bombay	18.1	3 Lagos	23.2
		4 Mexico City	11.2	4 Sao Paulo	17.8	4 Dhaka	21.1
		5 Sao Paulo	10.0	5 New York	16.6	5 Sao Paulo	20.4
				6 Lagos	13.4	6 Karachi	19.2
				7 Los Angeles	13.1	7 Mexico City	19.2
				8 Calcutta	12.9	8 New York	17.4
				9 Shanghai	12.9	9 Jakarta	17.3
				10 Buenos Aires	12.6	10 Calcutta	17.3
				11 Dhaka	12.3	11 Delhi	16.8
				12 Karachi	11.8	12Metro Manila	14.8
				13 Delhi	11.7	13 Shanghai	14.6
				14 Jakarta	11.0	14 Los Angeles	14.1
				15 Osaka	11.0	15 Buenos Aires	14.1
				16 Metro Manila	10.9	16 Cairo	13.8
				17 Beijing	10.8	17 Istanbul	12.5
				18 Rio de Janeiro	10.6	18 Beijing	12.3
				19 Cairo	10.6	19 Rio de Janeiro	11.9
						20 Osaka	11.0
						21 Tianjin	10.7
						22 Hyderabad	10.5
						23 Bangkok	10.1

clear advantages and disadvantages of building tall, which planners and architects should be aware of. There is a need to further discuss these issues so that we know how to capitalize on the advantages and minimize or mitigate the disadvantages. However, a more fundamental question persists: will tall buildings, as a building type, continue to prevail in the 21st Century? While it is impossible to provide a definitive scientific proof, this paper based on the provided review predicts that tall buildings activities will continue in the foreseeable future. The following highlights key reasons.

First, due to the influx of large numbers of people into cities from rural and suburban areas, many cities around the world will need to plan for rapid urban growth, and many cities already do. If growth cannot be stopped, then it must be managed. The places that will thrive are those prepared to grow to improve a city's quality of life. The number of megacities with a population of 10 million or more has climbed from 1 in 1950 to 5 in 1975 to 14 in 1995, and the number is expected to reach 23 by 2015, Table 1, (SRIBS, 2006). Megacities will continue to develop beyond 2015, a phenomenon requiring more skyscrapers to avoid urban sprawl and other associated problems. For example, the emergence of tall buildings in China is being driven by the increasing cost of land combined with increasing population and a dire need for urban regeneration. "It is anticipated that by 2015 more than half of the world's buildings will be in China and many of these buildings will be over 93 m tall" (SRIBS, 2006). In the advent of rapid urbanization, an urban theorist, Carol Willis, explained that cities will have three options: 1) horizontal overcrowding, 2) urban sprawl, and 3) vertical expansion. She views vertical expansion as the prevailing choice (CTBUH, 2010). This view is shared by a number of urban theorists and designers such as Ken Yeang, Roger Trancik, Richard Rogers, and Trevor Boddy. Also, in this regard Heller et al. wrote: "The forces which are shaping cities worldwide, related to the effects of population growth and urbanization, are compelling and unavoidable. In the near term, we should continue to see an expanding role for tall buildings in our urban fabric" (Heller, 2008, p.379).

Second, economically, it is true that tall building construction associates with economic conditions. However, we have been in a global economic recession since 2008, but factual data indicate that tall building constructions have continued to flourish. Although the year 2008 marked the beginning of a global economic crisis, it witnessed extensive high-rise construction and was labeled a "bumper year for skyscrapers" (Oldfield and Wood, 2009). Geographically speaking, the tallest 10 buildings completed in 2008 reinforce the prevailing trend that Asia and the Middle East are becoming the center of high-rise construction globally. The year 2009 continued the high-rise construction boom. It was a successful year for the American high-rise. Despite a continuing economic recession, the year 2010 has been the most active in the history of skyscrapers. Building heights and volumes of

Table 2. Ten tallest buildings completed in 2006

	Building Name	Location	Height (m/ft)	Floor count
1	Nina Tower 1	Hong Kong	319/1,046	80
2	Aspire Tower	Doha, Qatar	300/984	51
3	Eureka Tower	Melbourne, Australia	296/970	92
4	Millennium Tower	Dubai, UAE	285/935	61
5	Diwang International Chamber of Commerce	Nanjing, China	276/906	58
6	Dapeng International Plaza	Guangzhou, China	263/863	60
7	New Century Plaza Tower A	Nanjing, China	255/837	52
8	Midland Square	Nagoya, Japan	247/810	47
9	Al Fattan Tower	Dubai, UAE	245/804	54
10	Oasis Beach Tower	Dubai, UAE	245/804	54

Table 3. Ten tallest buildings completed in 2007

	Building Name	Location	Height (m/ft)	Floor count
1	Rose Rotana Tower	Dubai, UAE	333/1093	72
2	New York Times Tower	New York, USA	319/1046	52
3	China International Tower Center Tower B	Guangzhou, China	269/884	62
4	Naberezhnaya Tower C	Moscow, Russia	268/881	59
5	Hotel Panorama	Hong Kong, China	261/856	64
6	Dubai Towers 1	Manama, Bahrain	260/853	57
7	Dubai Towers 2	Manama, Bahrain	260/853	57
8	Emirates Marina Serviced Apartments & Spa	Dubai, UAE	254/832	63
9	Park Tower, Yintai Center	Beijing, China	250/820	63
10	Mid Town Tower	Tokyo, Japan	248/813	54

high-rises have increased. CTBUH data show that 66 buildings with a height of more than 200 m (656 ft) were constructed in 2010 - exceeding the previous record of 48 buildings completed in 2007. On January 4, 2010, Dubai

Table 4. Ten tallest buildings completed in 2008

	Building Name	Location	Height (m/ft)	Floor count
1	Shanghai World Financial Center	Shanghai, China	492/1614	101
2	Almas Tower	Dubai, UAE	363/1191	68
3	Minsheng Bank Building	Wunhan, China	331/1087	68
4	The Address Downtown Burj Dubai	Dubai, UAE	306/1004	63
5	One Island East	Hong Kong, China	298/979	69
6	Comcast Center	Philadelphia, USA	297/974	57
7	Emirates Crown	Dubai, UAE	296/971	63
8	The Cullinan I	Hong Kong, China	270/886	68
9	The Cullinan II	Hong Kong, China	270/886	68
10	One Lujiazui	Shanghai, China	269/883	51

Table 5. Ten tallest buildings completed in 2009

	Building Name	Location	Height (m/ft)	Floor count
1	Trump International Tower	Chicago, USA	423/1389	98
2	Bank of America Tower	New York, USA	365/1198	54
3	China World Trade Center III	Beijing, China	330/1084	74
4	Arraya Center Office Tower	Kuwait City, Kuwait	300/984	60
5	Aqua	Chicago, USA	262/858	87
6	Al Fardan Residences	Doha, Qatar	253/830	64
7	Shanghai IFC	Shanghai, China	250/820	58
8	Runhua International Building	Wuxi, China	248/814	48
9	Hongdu International Plaza	Wuxi, China	248/814	55
10	Xinjiekou Department Store Phase II	Nanjing, China	240/787	60

Table 6. Ten tallest buildings completed in 2010

	Building Name	Location	Height (m/ft)	Floor count
1	Burj Khalifa	Dubai, UAE	828/2,717	163
2	International Commerce Centre	Hong Kong	484/1,588	108
3	Nanjing Greenland Financial Center	Nanjing, China	450/1,476	89
4	Guangzhou International Finance Center	Guangzhou, China	438/1,435	103
5	The Index	Dubai, UAE	326/1,070	80
6	HHHR Tower	Dubai, UAE	318/1,042	72
7	Ocean Heights	Dubai, UAE	310/1,017	83
8	Capital City Moscow Tower	Moscow, Russia	302/989	67
9	Sky Tower	Abu Dhabi, UAE	292/959	74
10	Excellence Century Plaza Tower 1	Shenzhen, China	288/945	60

Table 7. Ten tallest buildings completed in 2011

	Building Name	Location	Height (m/ft)	Floor count
1	Kingkey 100	Shenzhen	442/1449	100
2	Al Hamra Firdous Tower	Kuwait City	413/1354	77
3	23 Marina	Dubai	393/1289	90
4	Tianjin Global Financial Center	Tianjin	337/1105	74
5	The Torch	Dubai	337/1105	79
6	Longxi International Hotel	Jiangyin	328/1076	74
7	Wenzhou Trade Center	Wenzhou	322/1056	68
8	Etihad Towers 2	Abu Dhabi	305/1002	80
9	Northeast Asia Trade Tower	Incheon	305/1001	68
10	Doosan Haeundae We've the Zenith Tower A	Busan	301/988	80

celebrated the grand opening of the world's tallest building, Burj Khalifa. Some other notable buildings completed in 2010 are the Nanjing Greenland Financial Center (450 m/1,476 ft) in Nanjing, China; the Index (326 m/1,070 ft) and HHHR Tower (318 m/1,042 ft) in Dubai, UAE; and the Capital City Moscow Tower (302 m/ 989 ft) in Moscow, Russia (CTBUH, 2011). Also, the year 2011 witnessed substantial tall building developments. Based on CTBUH annual data, Tables 2-7 compare the tallest buildings completed in 2006 and 2007, before recession, with those completed in 2008, 2009, 2010, and 2011 during the global recession. The comparison suggests an overall continuity of construction and an increase in building heights.

Economic prosperity and political power do not endure forever, and history shows that civilizations grow and contract. Construction booms and busts always are associated with economic and political cycles. The construction of supertall structures will fluctuate similarly to the rise and fall of stock markets. Nevertheless, because of pressing factors, such as massive population growth, rapid urbanization, and international commitment to a sustainable environment, tall building construction is likely to continue unless an alternate building type is found to serve the same goals.

Third, Sustainability or sustainable development is increasingly making its way the top of the agenda of many planning and urban design policies and regulations. Sustainability promotes dense and mixed-use living that reduces travel time and carbon emission. Although vertical density is not the only way to achieve dense living, it is a viable option particularly in areas where land is on demand and expensive. Julie Campoli and Alex MacLean, in their book *Visualizing Density* (2007), highlight examples where tall and supertall buildings have boosted density by up to nearly 300 residential units per acre, as is the case in some neighborhoods in New York City. Such capacity is unachievable with dense, low-rise developments. Generally speaking, the maximum number of units per acre achievable via dense low-rise development is about 45 units and about 70 units through midrise developments. In this regard, Gordon Gill writes: "...the skyscraper remains an inherently sustainable building form through its concentration of people and resources on a smaller parcel of land - and that will continue to be essential to the cities of the future - especially as urban migration and the densification of cities increases worldwide" (Wood, 2009, p.7).

Regarding the near future (10-15 years), many tall and supertall buildings are under constructions and others are in the planning stage worldwide. For example, in China, many existing cities including Beijing, Shanghai, Hangzhou, and Nanjing are building high-rises and many other high-rises are in the planning stage. The same is happening but to less extent in India and the Middle East. Al-Hareer City in Kuwait is building Burj Mubarak Al-kabir, about one kilometer (3280 ft) high tower, while Jeddah City in Saudi Arabia has approved the Kingdom Tower, which will rise to a similar height. Further, in the U.S. major cities, such as Chicago, New York, Miami, Houston, continue to build and plan to build high-rises.

Regarding the distant future, no one has a crystal ball to see what will happen 50 to 100 years from today, but it can be predicted that urban population will significantly increase as explained in section 3.1. It is expected that urban population will almost be doubled in the coming 40 years: increasing from 3.5 billion in 2010 to 6.5 billion in 2050 worldwide (UN, 2007). Can cities expand laterally without sprawling and destroying valuable agricultural land? The migration of rural population into cities in developing countries will continue unabated. People want to move to where the din and bustle of other people, a flurry of activities, social and recreational services, and above all, employment opportunities are. Because of this, once people get used to urban living, most of them often opt for living in an urban environment.

The tall building and the city are intertwined; and their future prospects are tied together. When a tall building is built it must work well with the city, not just at the present but also in the future. Both tall buildings and cities are multi-faceted and multi-disciplinary in nature. They both have a common goal of realizing a sustainable future for their posterity. Therefore, the integration of their respective systems and professional collaboration among planners, architects, engineers, developers, and contractors, as well as cooperation and support of the city officials and the public at large, are all essential. For the 21st century, it can be predicted that skyscrapers will have a significant international role in the global village.

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