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Mixed-Use Eco-Skyscrapers as a Solution for Urban Environmental Management

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ABSTRACT: The myth of the idyllic, self sufficient, decentralized and autarchic community located in the countryside as the panacea for human settlements remains, unfortunately, a myth, states Yeang (1999). Cities will continue to expand and grow outwards, slowly engulfing the suburbs and finally the rural areas. The basic reason for expansion is the rise in population which necessitates more infrastructure, residences, offices and entertainment facilities, hence, more land. Migration of people from rural areas to the urban areas for better work opportunities and a higher standard of living will continue to increase, especially in the developing countries. With a limited amount of land and soaring real estate prices, high density structures like skyscrapers will continue to be built in future as well. Since skyscrapers are energy guzzlers, designing them efficiently and sustainably is essential. If mixed-use skyscrapers are designed to incorporate numerous amenities for people from different economic backgrounds in the same building, then commuting can be definitely reduced to a large extent. This will aid in reducing the vehicular emissions, will aid in decongestion of traffic on the street and eventually the carbon footprint of the city can be reduced significantly. This paper will make an attempt to provide some solutions for the issues of Urban Environmental Management by setting some new guidelines for Urban Planning and making use of green and sustainable mixed-use skyscrapers as an alternative for the current cityscape.

Keywords: Mixed-Use, Skyscrapers, Sustainable, Urban, Traffic, Commute.

I. INTRODUCTION

A Mixed-use Eco-skyscraper could deal with complex issues of how the skyscraper interacts with the street and the neighborhood. The massing of the building needs to be in harmony with streetscape and the surroundings. The skyscraper will not overpower the pedestrian but will create public and green spaces at ground and podium levels and then gradually rise up in the air.

The level of Urbanization has increased from 27.81% in 2001 Census to 31.16% in 2011 Census and the proportion of rural population has declined from 72.19% to 68.84%, Census (2011). 'Urban sprawl' is a phenomenon that is commonly seen with increase in the population of the city. The cities are getting saturated and people are ultimately migrating to suburbs and low residential development areas as they become economically more feasible and also allow for bigger residential units or individual plots that may be extremely difficult to afford in the cities.

This is bound to happen as people prefer to work in cities because of better employment opportunities, education, medical facilities and other basic and necessary infrastructure that may be lacking in a lot of small towns and villages in India. As a result of which, the cities are going to grow outwards engulfing suburbs and finally the rural areas. This is leading to loss of rural and agricultural land. Urban sprawl in many ways is eminent but efforts could be taken that the city grows out in a sustainable manner embracing and not engulfing and polluting everything around itself.

II. ADDRESSING THE ISSUES

A. Traffic Issue

Hilberseimer (1927) goes on to predict the issue of traffic would become the alpha and omega of the entire city organism. Hilberseimer (1927) further states that the solution to the traffic problem cannot be arrived at through an increase in the possibilities of circulations, but only by making traffic as unnecessary as possible.

The office of the Registrar General of India released data on commutes for the 200 million working Indians who are neither employed in agriculture nor in household industries. The data shows that nevertheless, nearly a third of these workers do not commute, meaning that they live in or adjacent to their workplaces. Commuting for work is even less common among women workers - 45% of women do not commute for work - and higher in rural than in urban areas. Among those 140 million workers who do commute for work, the distances tend to be quite small. A quarter of commuters travel less than 1 km to work, and another third travel between two and five km. Just 30 million people travel more than 10 km to work, and just 17 million of them have a commute over 20 km, reports Census(2011) .

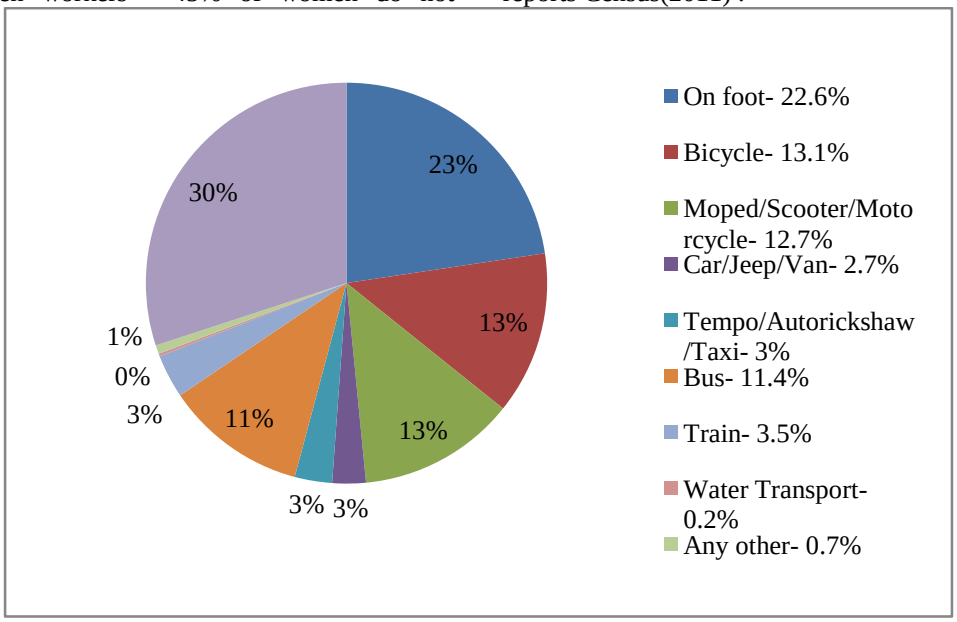

Fig.1. Commute Chart, Census 2011.

The commute chart indicates that the number of people travelling on foot and on bicycle for work in India is around 23% and 13% respectively, which is quite significant. This raises the question of how pedestrian and bicyclist friendly the Indian streets are? Nearly 30% of the working people do not commute. The housing units in urban areas may need to be designed a way so, that working spaces are integrated into the residence design, wherever, required. They need to be segregated for delineation of private and semi-private or semi-public spaces. This concept of 'live-work 'interlocked units could even be incorporated into apartment designs. Does this call for a necessary change in bylaws so, as to offer more flexibility to people living closer to their workplaces? Does this call for innovative design solutions for current built forms?

B. Traffic Solutions

Adequate width of sidewalks and bicycle lanes which are shaded with trees thus becomes an indispensable requirement and should be provided along the major and minor thoroughfares. The buildings need to move farther away from the streets providing more space for pedestrian traffic and wheelchair users, a dedicated lane for the bicyclists, provision of diagonal parking, a buffer area containing plantation and a designated area for the street vendors. Public amenities like benches, toilets, water sprouts, etc. need to be designed along the streetscape.

The Centre for Science and Environment (CSE) has done a study that puts Delhi on the top of list of fatal road accidents and the main victims are pedestrians and cyclists. The share of fatal accidents in the total is up from 18% in 2003 to 25% in 2012. Delhi records an average of five road accident deaths per day - four of these are of pedestrians and two-wheeler riders. Every week, two cyclists and one car rider dies in Delhi. The worst accident hotspots have been detected near Flyovers and junctions.

Footbridges or pedestrian overcrossing, provided with ramps or subways at accident hotspots or every few kilometres could be proposed making the crossing for the pedestrians and cyclists safer. Thus the safety issues dealing with pedestrian and vehicular traffic can be dealt by segregating them wherever possible. We still need to address the issue of reducing traffic and this could be done by making travelling as unnecessary as possible. There is an essential need for designing larger number of affordable units so, as to provide more housing options in the city itself, thus discouraging people to commute from suburbs to the city for work. However, this still doesn't the resolve the traffic issue largely, as people living in the city will still be commuting to their work places. This brings the need of designing large number of Mixed-use Skyscrapers in urban areas where people could live and work, and have retail, healthcare, entertainment and other necessary facilities, which will make commuting as unnecessary as possible.

C. Decongesting the City - Solutions

The conventional buildings will take the form of tall mixed-use towers, which are around 30 storeys to 60 storeys tall, spaced at a distance of around 200-300 meters apart, a hypothesis. The lower stories which will serve as public and semi-public spaces with extensively landscaped areas will have slightly higher ground coverage area and will be closer to the street. The horizontal spacing will depend on the height of the towers, the taller the building the greater the horizontal distance between the adjacent buildings. The height of the skyscrapers will depend on the urban density of a particular city. This will aid in decongesting the streets and the city centre itself. Le-Corbusier hypotheses of 'A City of Towers' and 'City of Three Million' were well thought ideas and influenced urban planner Lucio Costa and architect Oscar Niemeyer to design the new city of Brasilia, which is the federal capital of Brazil. Brasília is now a UNESCO World Heritage Site due to its modernist architecture and uniquely artistic urban planning.These towers, rising up at great distances from one another will give same accommodation that has up till now been spread out over the superficial area; they will leave open enormous spaces in which would run, well away from them, the noisy arterial roads, full of traffic which becomes increasingly rapid. At the foot of towers would stretch the parks: trees covering the whole town, states Corbusier (1923).

However, an ideal city cannot have skyscrapers only. A combination of high rises, low-rises and parks (which serve as lungs) can be a very powerful and practical idea. The towers represented in the various sketches done by Corbusier on the theme of 'A city of Towers' concept were mainly identical in shape and size and essentially an extrusion of a geometrical shape, and a floor plan that basically depicts a Greek Cross. The entire tower is built by repetition of the same floor plate size. The geometrical form used by Corbusier is generic and does not essentially deal with the climatic conditions, however, a bioclimatic skyscraper is going to take its form depending on site conditions and is thus going to be unique for each site. The building would rather grow from the ground in the form of ant or termite hill. A mixed-use skyscraper could overcome the banal repetition of floors that characterizes so many commercial high rise buildings, states Johnson (2008).

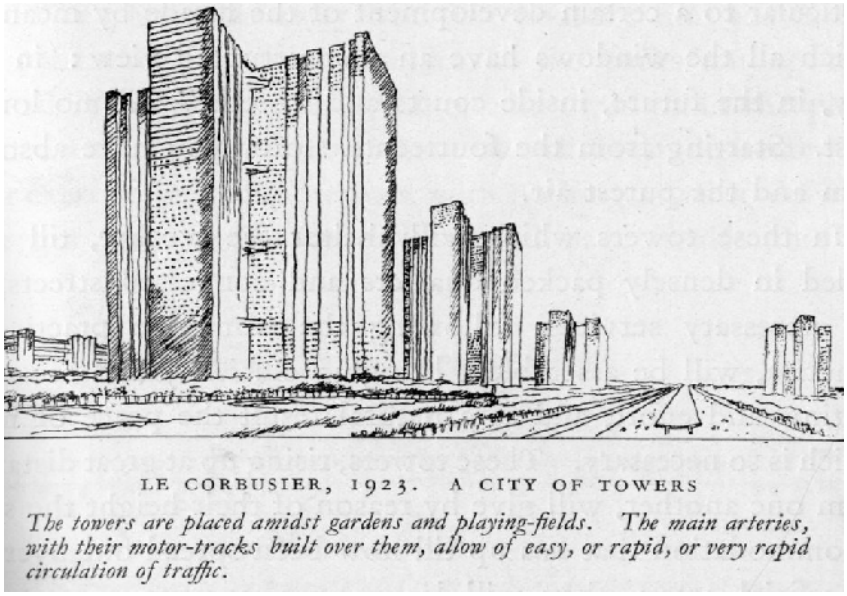

Fig. 2. A City of Towers, Le Corbusier (1923, Plate 57).

III. CASE STUDIES

The Commerzbank Tower is a 53 story high rise office building. It is shaped as a 60m wide rounded equilateral triangle with a central, triangular atrium. At nine different levels, the atrium opens up to one of the three sides, forming large sky gardens. These open areas allow natural light and ventilation into the building. The curtain wall is designed with operable windows, allowing each individual to benefit from natural light and fresh air. The facility saves as much as 30% of their energy consumption needs annually

Fig. 3. Commerzbank Tower, Germany, Norman Foster & Partners (1997).

Fig. 4. Sky Habitat, Singapore, Safdie Architects (2015).

Sky Habitat comprises of two 38-storey high-rise towers and a total of 509 residential units. The stepped towers are connected by three landscaped, 30-metre-long sky bridges.This alignment allows the flow of fresh air through the whole building, daylight and the integration of extensive recreational facilities on the ground. All the units have their individual green balconies. The project is well connected to public transport facilities.

IV. GREEN AND SUSTAINABLE STRATEGIES

Touching tall buildings is abundant ambient energy in the form of sunlight and wind, only a little of which needs to be harvested to serve all their energy needs, states Buchanan (2007). There is an indispensable need of designing self sufficient or more aptly Sustainable Mixed-Use Eco Skyscraper which can address bigger issues like generating its own energy, growing its food, harvesting rain-water, recycling grey water and dealing with issues of converting solid waste back into energy. Ultimately, there is minimal or no pollution involved at all. The buildings need to be like a living machine. I think buildings should imitate ecological systems, quotes Yeang (1999). Ecological systems in nature before we had human beings interfere with them exist in a state of stasis - they are self-supporting, self-sustaining, quotes Yeang (1999). Ecological design concept is therefore extremely complex and is more about interconnectedness and interdependencies. All human activities affect the biosphere in some way or the other.

This in turn leads to changes in our environmental system which in turn affects us and other species within an ecosystem. Some of the strategies that are currently being used for designing of Skyscrapers or could be incorporated will be discussed below.

A. Photovoltaic Energy

Photovoltaic cells enable solar collection that can be integrated into the sunshades on the facade of the skyscraper, used extensively on the roof and used in open parking spaces as well. The CIS Tower in Manchester, England (2006 Renovated)uses Building Integrated Photovoltaic (BIPV) cells technology as cladding. It began feeding electricity to the national grid in 2005 thus becoming a permanent green energy solution.This green building also has 24 wind turbines on the roof generating 10% of the tower's electricity. The building generates 333,000 kwh of electricity annually and saves around 162 tonnes of CO_2 emissions, a major GHG.

B. Wind Harvesting Strategies

This can be done by making use of turbines, preferably vertical axis wind turbines to harness energy. Some of these turbines are integrated with photovoltaic cells and thus function as wind-solar hybrid systems. The positioning of these Wind Turbines on a tall-building is very critical; otherwise satisfactory results won't be achieved. The wind turbines at Bahrain World Trade Center (2008) deliver approximately 15% of the energy needs of the building, or 1300 megawatt-hours per year.

C. Daylighting And Natural Ventilation

Incorporating maximum day lighting by proper orientation of the building on the site and making simulation models while designing a building. The orientation of the building in relation to the seasonal paths of the sun across the sky has a significant impact on the thermal value and performance, suggests Deshmukh (1992). Skyscrapers should be provided with operable windows wherever possible. A mixed mode of ventilation can be used so, that artificial ventilation can also be available when the inside temperature is not favourable for human comfort. This can also done by using intelligent building systems.

D. High Performance Glazing

Use of high performance glazing like double glazing or triple glazing with low E-value glass. These can prove to be extremely energy efficient, especially for high rise office buildings which are sometimes entirely wrapped in glass.

E. Solar Shading Devices

Solar shading devices like sunshade louvers which double as light-shelves, solar rods or other conventional shading devices aid in reducing glare to the minimum and also allows deeper penetration of natural light into the building. This ensures minimizing the use of artificial or electrical lighting.The sunshade louvers aid in establishing comfortable micro-climates in habitable spaces along the building's exterior.

F. Service Core Positioning

Positioning of Service Cores in a skyscraper is of great importance. Apart from the structural importance, it affects the thermal performance of the building.

G. Regenerative Elevators

Regenerative elevators make use of a regenerative drive that converts the excess energy generated by an elevator into electricity and can be reused elsewhere in the building. An elevator can account for 2–10% of a building's total energy consumption.

H. Cogeneration Plant

Combined Heat Power (CHP)involves local generation of heat and electricity - like a small power plant within the building and can achieve efficient savings over the use of conventional grid supplied electricity due to reduced transmission losses. The more the CHP operates, the greater the savings, and so a mixed use building with a more constant head load is an ideal location, suggests Holloway (2011). Bank of America Tower, New York (2009) has a clean-burning, on-site 5.0 megawatt cogeneration plant that covers approximately 65% of the building's annual energy use with clean, efficient power. The building has a LEED Platinum rating and is 55 stories tall.

I. Green Roof & Corner Sky Terraces

Integration of green roof and sky gardens into the building design and planting them with native plant species and small size trees. This aids in reducing the air conditioning load significantly. These spaces also allow for social activities like casual meetings and lunches.

J. Water Saving Measures

Recycling of Grey Water and using it for flushing of toilets or for landscaping, using of low-flow plumbing fixtures, dual-flush toilets and waterless urinals are some of the measures that can be taken to reduce building's water consumption. Using Drip Irrigation System saves usage of water by allowing water to drip slowly to the roots of plants either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing, and emitters. Making use of Rain Water Harvesting system by designing roof top tanks and on site replenishment. The Bank of America Tower, New York (2009) collects nearly all of the 1.2m of annual rain and snow that fall on the site and uses it as grey water to flush toilets and supply the cooling towers. These strategies, along with waterless urinals and low-flow fixtures, save approximately 7.7 million gallons of potable water per year.

K. Local Sourcing And Recycling Content

Using locally and regionally extracted and manufactured materials.Natural materials or low-embodied energy materials should be used in construction to have lesser impact on the environment. Recycled concrete and structure steel should also be used for the skyscraper. The Bank of America Tower, New York (2009) makes significant use of recycled content with 91% of construction and demolition waste diverted from landfill. Materials include steel made from 75% (minimum) recycled content and concrete made from cement containing 45% recycled content (blast furnace slag).

L. Solid Waste Management

Managing Solid Waste affectively becomes a major challenge for developing countries like India which is going through rapid urbanisation. Over 377 million urban people - 31% of the population - live in 7,935towns and cities and generate 62 million tonnes of municipal solid waste per annum. Only 43 million tonne is collected, 11.9 million is treated and 31 million tonne is dumped in landfill sites, reports Hindustan Times (2016). The skyscrapers needs to have provisions of separating bio-degradable waste and non-degradable waste on the site itself so, that the degradable waste could be sent to a compost plant located either on site or nearby, to be converted into manure. This manure can be used for landscaping and growing food on site. The non-degradable waste would either be recycled or be burnt to produce energy. The other forms of waste would be compressed in compactor machines and dumped at sanitary landfill.

M. Geothermal Energy

It is a clean and renewable form of energy. It can be harnessed from almost anywhere in the world to produce heat and electricity. Although geothermal is not the most widely used source of energy, it is one of the most efficient and sustainable systems today.At West end Duo (2006), a twin office tower in Frankfurt, Germany, geothermal pumps have been used. The building uses a radiant ceiling that is fed with cooled water in summer and heated water in winter ensuring low energy consumption. According to Energy. Gov, Geothermal pumps use 25%-50% less electricity than conventional heating or cooling systems.Geothermal energy is not dependent on weather conditions unlike solar and wind energy.

N. Public Transport & Vehicle Sharing

Mixed-Use skyscrapers should be strategically located allowing for proximity to public transport like metro, trains, buses , subways and over bridges. Also, the residents should have access to vehicle sharing program to save consumption of fuel.

V. CONCLUSION

The Mixed-use Eco Skyscrapers thus become an indispensable part of urban habitat and act as one of the viable solutions for 'Urban Environmental Management' in India. Thirty to sixty stories tall is an optimal height for designing a skyscraper ecologically. Architects like ‘Ken Yeang’ have researched that at these heights, a building can be designed to be energy efficient and economically viable. The street sections need to be redefined so, as to be suitable for the urban Indian conditions with wider sidewalks, segregated bicycle lanes, tree plantation, angular parking, space for vendors and dedicated lanes for public transport like buses and metro. New genre of skyscrapers are being built in India but they need to be mixed-use and sustainable.

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