

The Line: A Zero Gravity Theory for Urban Design

Wadia Albarqawi¹

¹ Department of Islamic Architecture, Umm Al-Qura University, Makkah, Saudi Arabia

Correspondence: Wadia Albarqawi, Department of Islamic Architecture, Umm Al-Qura University, Makkah, Saudi Arabia. E-mail: wabarqawi@uqu.edu.sa

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Abstract

Investigating The Line, Saudi Arabia's newest megacity, through the lenses of the Cartesian and Relativity paradigms appears paradoxical, but it is critical to our understanding of future cities. Most cities worldwide have been experimenting with various concepts to connect people to nature but have yet to succeed. The Line pioneered a zero-gravity approach to balancing people's relationships with nature and people with themselves. This paper examines the essential urban design concepts and theories during the last century's quantum leaps in their development. The goal is to provide a framework for future cities by uncovering concepts for future cities regarding layout, density, urban space, and urban ecology through a comparative analysis with The Line.

Keywords: urban design, urban theory, urban ecology, humanizing cities, future cities

1. Introduction

In January 2021, His Royal Highness Mohammed bin Salman, Crown Prince and Chairman of the NEOM Board of Directors, launched the initial idea of The Line. It is a city in NEOM, a vast land to the northwest of Saudi Arabia. Little details were revealed with a glam of the future city. Later in July 2022, His Royal Highness announced the design for The Line, a model that would change the humans' concepts of urbanity. According to NEOM (2022), The Line occupies 5% of NEOM's land, is only 200 meters wide, extends for 170 kilometers long, and is 500 meters above sea level. It will be home to 9 million residents and will be built on a footprint of 34 square kilometers (NEOM, 2022). Instead of free-speed road systems of conventional cities, The Line will be free from roads and cars (NEOM, 2022). People can access facilities within a five-minute walk, while underground high-speed rail with a transit of 20 minutes stations will enable connectivity to the other essential facilities. HRH Crown Prince Mohammed bin Salman said:

"At THE LINE's launch last year, we committed to a civilizational revolution that puts humans first based on a radical change in urban planning. The designs revealed today for the city's vertically layered communities will challenge the traditional flat, horizontal cities and create a model for nature preservation and enhanced human livability. [T]HE LINE will tackle humanity's challenges in urban life today and will shine a light on alternative ways to live." (NEOM, 2022)

The Line's components are vertically structured, from residential units, schools, and workplaces to public parks and open spaces. It resembles a skyscraper with a green vertical corridor but spans 170 kilometers horizontally. People can freely wander to the top floors, from side to side, and along the city liner expansion in all three directions. The exterior walls will be large mirror façades that wrap around the inside, forming an ecological system and reflecting the surrounding landscape. The Line is a human-centered city that works with the other NEOM cities, particularly OXAGON, the industrial and innovation city, and TROJENA, the mountain tourism destination and outdoor skiing city, to shape the future of human urbanism.



Figure 1. The Location of The Line



Figure 2. Overall view of The Line



Figure 3. Sea side view of The Line

How did the concept of The Line come about? Moreover, what are the lessons that can inspire other cities around the world? This paper investigates former urban design theories that tackle the design of the future city. It draws a line linking these theories and their latest interpretations, where the outcome sheds light on urban design principles to transform current cities into futuristic ones.

2. Methods

This paper reviews the extensive literature on urban design theories and methods, but it does not cover all of them; instead, it highlights the most important theories that have shaped the majority of today's cities. It focuses on the philosophical shift from Newton's Cartesian philosophy to Einstein's Special Theory of Relativity as the two primary philosophies that shaped the perceptions of most urbanists. Then, based on a review of NEOM-released project documents, it compares and contrasts these theories with The Line's design. The comparison includes city layout and configurations, density, spatial quality, ecology, and population. The goal is

to provide insight into how these theories were developed and aided in conceptualizing The Line. The goal is to abstract some urban design principles to help cities in the future.

3. Literature Review

Cartesian philosophy started to influence Western science society by the end of the seventeenth century. René Descartes applied analytical methods that broke up thoughts and problems into small bits and solved them as separate pieces (Arida, 2002). Certain knowledge—can be derived through reason from innate ideas. Based on Descartes's Cartesian paradigm that "All science is certain," Isaac Newton developed a mathematical formulation of the mechanistic view of nature (Arida, 2002). For Newton, the universe functions as a machine in absolute space and absolute time, an empty three-dimensional space independent from the phenomena inhabiting it.

By the twenty century, Newton's Cartesian philosophy shaped most of the cities around the globe. Le Corbusier developed the idea of the "city as a machine" and the "building as a machine" based on Newton's Cartesian philosophy, "a universe is a machine" (Arida, 2002). In 1924 Le Corbusier published his idea of the city in an urban design book translated and published in 1949 as *The City of Tomorrow and its Planning* (Corbusier, 1929). Le Corbusier addressed the congestion in most city centers; streets were crowded with automobile traffic, and pedestrians' movements resulted in serious accidents. Air pollution increased due to factories and industrial activities of the industrial age. Based on "Functionalism," he segregated the city into zones: administrative, cultural, educational, and residential. Le Corbusier suggested tall buildings in the city's center for administrative and commercial purposes and designed residential units in a vast parkland on the edges (Corbusier, 1929). The center and the residential areas, along with the other zones, are linked by roads and streets of different categories based on heavy, light, and fast roads (Corbusier, 1929). Le Corbusier's city of tomorrow is a clear separation of space and time as people spend most of their working time in the center and then depart to their units, leaving the center empty.

Then the Modern Movement exported the "international style" based on the assumption that it answers all cities' problems. However, it widens the gap between people and nature. The Modern Movement advocacy of international style reflects independence from nature and context, time and space assuming a universal solution, and absolute answers suitable for all conditions and regardless of various conditions and nature. Based on Descartes and Newton's ideas, the Modernist Movement addressed physical forms but failed to touch people's souls. Globalization today repeats the same mistake of the international style, assuming a solar solution for all human communities regardless of place and culture specificities (Lang, 2009).

In 1905 Albert Einstein introduced *the Special Theory of Relativity*, the basis of the quantum theory today (Arida, 2002). Instead of Newton's absolute space and time, space and time are relative in dialectical relations. Time flowed at different rates depending on where and when it was measured (Arida, 2002). For explaining the phenomenon of gravity, for example, Newton advises that it is a force between two objects, but Einstein's physics suggests that it is a bending of space-time by any large object. Thus instead of certainty, absolute truth, fixed assumption, and control, Einstein's relativity theory suggests uncertainty, potential, and freedom. Moreover, according to the Cartesian paradigm, every two particles represent categories limited in space and time as an independent system. In contrast, in the quantum paradigm, every two particles represent a wave of a non-local notion covering unlimited areas of space and time linked to other waves as interconnected systems (Arida, 2002). Thus, the changes in the configuration of each wave effect are affected by other elements. The notion of duality in the quantum paradigm replaced dualism in the Cartesian paradigm. In other words, Quantum theory addressed the city as complementary dualities, uncertainty, choices at all scales, interactive relationships, emergent qualities, and sustainable, vibrant ecologies. In Aridas's words, "a language best described the complex artifact that is the city: the urban and the activities, the stones, and the buildings" (Arida, 2002).

Many urban theorists criticized the Modern Movement for its effect on the quality of urban space, but the most profound critique came from non-professional urbanists. Jane Jacobs was a journalist but surely an urban theorist, as the American biographer and science writer Robert Kanigel calls her, an "urban visionary" (Williams, 2016). In 1961, Jacobs published *The Death and Life of Great American Cities* (Jacobs, 1992). Jacobs observed that buildings were priorities over people in most of the modernist conceptions of the city; thus, she focused on the nonphysical aspect of the city, such as the loss of the sense of place and identity caused by zoning and planning rules, and a disregard for the scale at which people interact with their built environment. Jacobs advocated for socioeconomic and cultural diversity via architectural variety and vitality in public places. Jacobs advocates the notion of mixed-use to promote street vitality and the design of shared spaces that are overlooked by windows to contribute to urban safety or what she called "Eyes on the streets" (Jacobs, 1992).

The 1970s and 1980s marked the postmodern era; Postmodernism emerged in an attempt to control Modernism through urban design research and practice. The most profound effort was developed from Robert Venturi's *Complexity and Contradiction in Architecture* (Venturi & Brownlee, 1977). But it was seen as nostalgia rather than dealing with the city's complexity (Gel, 1987). In *Life Between Buildings* Gehl street legibility by examining people's activities in open spaces (Gehl, 1987). People interact with each other in public spaces. Roger Trancik, in *Finding Lost Space: Theories of Urban Design*, 1991, focused on places where people live, work, and socially interact (Trancik, 1991).

In 2002 Kean Yeang introduced *Reinventing the Skyscraper: A Vertical Theory of Urban Design*, arguing that the urban design approach should include the city's social, economic, and environmental aspects along with its physicality (Yeang, 2002). The skyscraper is inevitable, allowing high density to sustain the economy with diverse spaces to maintain social interaction with open public spaces to engage with nature. The skyscraper should reflect vertically the same quality of urban spaces found in horizontal neighborhoods. For example, Yeang started with the primary opened public space that extended vertically from the underground level to the upper levels forming a shaft and allowing light and air. He added a green corridor, an indoor ramp full of trees and vegetation extending vertically from the podium roof through the shaft. The shaft and green corridor end up with attractive spaces: restaurants and café (Yeang & Powell, 2007). The approach can be applied to a group of skyscrapers connected with bridges creating an ecological system and vertical legible urban spaces. According to Yeang:

"Designing the eco skyscraper involves configuring its built form and operational systems so that they integrate with nature benignly and seamlessly over its life cycle by imitating the structure, processes, and properties of ecosystems, an approach referred to here as ecomimesis" (Yeang & Powell, 2007).

Yeang integrated buildings with the natural environment and called for regional planning to create urban ecology patterns (Yeang & Powell, 2007).

Although Yeang's approach focused on humans connecting with nature, he also examined urban physicality, specifically the skyscraper. According to urban theorist Matthew Carmona, most urbanist approaches focus on urban physicality rather than urban processes. How would people interact on the top floors far above ground? What spatial quality should such interactions be possible? What kind of diversity is necessary to promote economic activities in skyscrapers? For Carmona, the heart of urban design is the process of shaping places based on complexity and variety (Carmona, 2014). Carmona suggested an interactive urban design process and the need to engage stakeholders and public participants in the design process (Carmona, 2014).

To this end, Le Corbusier's theories and ideals have inspired numerous cities worldwide. Cities began to lose their social framework and transform into machines that ignored human nature. Jacobs attempted to comprehend how cities function in actual life, not as a physical result but as a social and economic complexity. Yeang incorporated an ecological theme to encourage people to interact with nature. From understanding urbanism, cities were categorized as Economic, Planned, Designing, Heritage, Mobile, Public, Multicultural, Digital, Green, Healthy, and Political (Rogers et al., 2020). The Designing of the city intersected with architects and planners and was influenced by today's date and science, and no doubt economy and politics play a significant role in shaping them. However, Indigenous cities and the political and dominant colonial power associated with them are excluded in the debate of The Line as the area has not experienced any colonial enterprise. The other exception is heritage cities since the city will be built from scratch. Cities with historical significance invest in heritage to construct their identities: the historical physical environments and the places within them. The only heritage in the Line is the unique surrounding nature, which begins at the sea coast and continues through hills and valleys to heights and mountains.

The significant transformations of cities that occurred during the last century's early industrialization process were caused by economic changes. It was followed by "deindustrialization" to address many issues; as a result, planners were involved in attempts to restructure cities by focusing on public interest and supporting transportation projects (Rogers et al., 2020). On the other hand, designers were more concerned with human-centered approaches and ecological urbanism. Public spaces were prioritized to increase activity and social interactions but also because public spaces can become sites of tension and conflict linked to political actions and movements. While multiculturalism is encouraged and viewed as the primary factor in boosting city economies, it can also result in slams and deterioration of cities due to ethnic tensions over space usage (Rogers et al., 2020). A green city concept is based on understanding the ecosystem damage caused by urbanization and how this is compromising liveability and reconciling the impacts to achieve better ecosystem, people, and built outcomes. High optical infrastructure, big data, and data science applications to cities are equivalent to urban

design and planning (Rogers et al., 2020). Data science focuses on the processes, whereas urban design and planning focus on the form of cities (Rogers et al., 2020). The growing connection between health and urban planning is the key to focusing on making our cities fairer and for all (Rogers et al., 2020). It will be all if we draw a table and place these categories on the vertical and horizontal columns to see where The Line fit. The Line resembles all the cities' as mentioned earlier' formats without copying them.

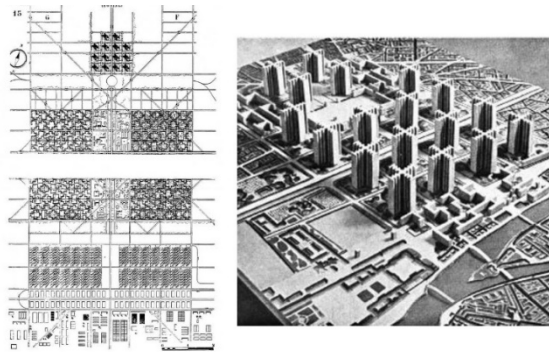


Figure 4. Le Corbusier vision for the City of Tomorrow

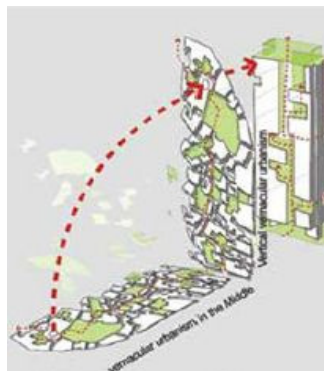


Figure 5. Yeang vision for the new skyscrapers

4. Results

The modular framework of Le Corbusier aimed to initiate a relationship between man and physical buildings in terms of proportions but restricted the experience of space to a machine based on the function of each part. The spatial quality was static, not fluid, in Le Corbusier's paradigm. Moreover, people must commute from their homes to the skyscraper until they reach the ground level, where the entrance and the lobby are. Then, the elevators lift them vertically from the lobby to the desired floor. Finally, they move horizontally but within that into enclosed capsules. The experience is meaningless if there is any.

Dealing with the city's complexity required a new paradigm in configuring spaces and time. The relativity paradigm seems appealing. Yeang's approach to reinventing the skyscraper was based on enriching people's experience and advocating urban ecology. People access open public spaces during their journey inside the skyscraper. The units have their own open spaces in roof gardens and terraces. The open public spaces with roof gardens and terraces enhance the relationship between people and nature. Yeang's skyscraper model was called an urban ecology, allowing air and light to penetrate inner spaces. Nonetheless, the conditions in the upper levels are different from that at the ground level. The experience remains somewhat restricted by the law of physic.

The Line endorses zero gravity urbanism allowing people to move freely in three dimensions vertically, horizontally, or diagonally. The interchange between solid/void, indoor/outdoor, and people/nature enriches people's experience. People can move from their residential units to workplaces on the upper level and vertically on the same level to spend leisure time in the suspended stadium. No traces of modular structure nor projections of roof gardens; instead, suspended structures and organic forms for people to experience.

5. The Zero Gravity Theory of Urbanism

Zero gravity urbanism is the cornerstone of designing The Line. Gravity was the main challenge from the Egyptian Pyramids to the tallest skyscraper in the world, Burj Khalifa. Over centuries, construction techniques from the typical loadbearing walls, domes, and arches to columns and beams and then flat slabs, space trusses, and space frames aimed to deal with gravity but never overcome the fact that all objects fall. The promo of The Line shows a bored girl sitting in a typical city center; she saw the light coming from the NEOM logo, so she followed the light. The girl jumped into the logo and suddenly started floating, reflecting the zero-gravity concept of The Line. She moved between parklands and buildings until reaching the top. It ended with the phrase "A New Wonder of the World" (NEOM, 2022). Zero gravity urbanism is a zero restriction paradigm to innovate an imaginative living built environment.

During the early period of the industrial age, most cities suffered from congested centers. The city was chaotic with eligible urban spaces. Le Corbusier introduced the notion of zoning based on functionalism. The center is the mind of the city where the economy is generated; thus, tall buildings (skyscrapers) must be in the center for official and commercial activities. Cultural centers and exhibitions are also in the center, along with restaurants and community centers. He suggested roads of three levels:

- Heavy traffic for goods below ground.
- Light traffic for goods at the ground level.
- High-speed traffic connects the city from north to south and east to west.

Residential areas are in the parklands far from the center: citizen of the city who work and live in it, suburban dwellers who work in the industrial zones and do not come to the city but live in garden cities, and the mixed how in business zones bet bring their families to the garden cities. Le Corbusier decongested the center, increased density, and allowed people to enjoy open spaces but assumed a machine for people to live in and called it a city. Le Corbusier's proposal created soulless ambiguous spaces, a manifestation of the Cartesian paradigm. Later, urban sprawl emerged in many cities, increasing pressure on infrastructure and more dependency on cars resulting in high levels of air pollution.

The mix-used approach emerged mainly after Jacobs's criticisms of zoning. The idea is to provide mixed-used spaces in a building or to gather buildings of different uses in an area. In all cases, this will create more diverse places. Diversity means more enjoyable places and more activities, and vitality. However, developing focal places of mix-uses and diversity required car parking plots and broad streets to deal with the generated traffic. The notion evolved into the five minutes walk cores to reduce car dependency. Multiple central cores within five minute's walk between them emerged but appeared as a scattered centers in the neighborhoods.

The Line adopted a linear distribution of mix-used facilities, which extend vertically within a five-minute walk in every direction. The Line configuration is a development from the conventional city into three dimensions neighborhoods. To emphasize walkability, the zero-car model was another grand idea, mutual but not equal to the zero gravity model. The zero-car approach provides more spaces for people to walk and enjoy a healthy life. The zero-car approach is practical from the economic point of view of individuals. People no longer have to spend money on cars, car insurance, fuel, and parking. They can reach their destinations by walking or using the railway with fewer fees to pay.

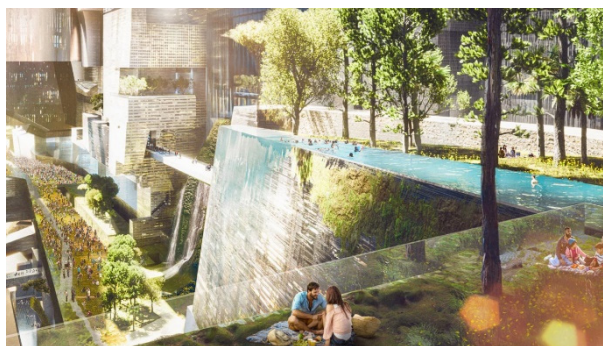


Figure 6. The integration of People with Nature in The Line.

5.1 Urban Density

High density is the key to the success of many twenty-century cities around the globe. High density does not mean congestion; it is the number of people in a specific area. From an economic point of view, high density means more consumers, demands, and commercial activities, thus thriving businesses. Le Corbusier and Yeang considered high density, but their approaches were different. The Le Corbusian model created a business hub in the center, leaving the rest of the city unserved, while Yeang turned skyscrapers into desired destinations. The center has a high density in the Le Corbusier model, while the residential zones have fewer density levels. It means a high dependency on cars and public transport to reach the center, thus a high level of air pollution. Yeang's model of skyscrapers depends on creating viable places at different levels within the building, meaning less commuting, less car dependency, and less air pollution. Jan Gehl, a prominent urban designer, and expert on sustainable urbanism, find a correlation between high density and air pollution. The higher density, the less car dependency, which means less air pollution (Gehl, 1987). The Line pushed density beyond limits. According to The Line's official website, higher density creates new business opportunities, and some 380,000 jobs will be created by 2030 (NEOM official Website, 2022). High density with the zero-car approach means a zero-air pollution environment. Providing sufficient needs and requirements on the one hand and providing public space for communities to engage and socialize together is the result of the high density in The Line.



Figure 7. View of the Line form above notice the stadium

5.2 The Spatial Quality and Perception

Le Corbusier's five points of architecture: pillars, the roof garden, free plan, free façade, and the horizontal window, free space from the control of traditional construction methods; however, the configuration of spaces remains somewhat systematic. There was a separation between the city's physical form and nature. On the contrary, Yeang proposed engaging spaces in the skyscrapers indoor/outdoor, solid/void, and private/public. In Le Corbusier, these elements were systemically arranged, while in Yeang, they were vertically organized. In both cases, they never reflect the space-time continuum and bending.

Peter Eisenman's experiment in configuring spaces is remarkable. A pair of cubes were the bases. Then, in each pair, two cubes with their upper sides twisted but their bases still linked to the original cubes. Eisenman used an oblique view outline of two cubes. Then he duplicates, rotates, and shifts it into a succession of overlapping outlines, each integrating within a third to a half of an outline. This overlapping creates a succession of spaces between them. The goal was to investigate the potential of the spaces in between places. Group identification is defined as the perception of belonging to a broader human group based on shared human attributes. Spatial identity is formed through a series of nuanced memories and associations of a familiar physical site (Eisenman, 1999). In urban design, Shelton observed that linearity in Western cities results from the linear way of thinking as the writing on the page in a linear format, while in Eastern cities, building forms were the result of areal perception as the Eastern writing (Shelton, 2012). Although The Line extends linearly for kilometers, it also extends vertically in volumetric formate.

The Line incorporates the spatial quality and people's perception of the spaces to form unique places. According to philosopher Elizabeth Grosz, the virtual exists, but its physical form is not yet complete, so there are several possibilities for being. The real could be regarded as the ultimate manifestation of the virtual. Through differentiation and divergence, the real is negotiating its presence in the virtual (Grosz, 2001). The Line zero gravity urbanism: three-dimensional mix-uses layout and high level of urban density along with the integration of people with nature eventually offer unprecedented spatial quality. Architects and interior designers must be

creative and persuasive, while engineers and constructors must be imaginative and innovative. As a team, they need to persuade us that The Line is about new ideas and concepts, and they can be realized through new construction methods and techniques.



Figure 8. Exploring the sea life in the Line

5.3 Urban Ecology

The Le Corbusier model for tomorrow's city suggested buildings in vast open parkland. It was an approach to integrate people with nature; however, the application showed segregation instead of integration. Yeang's model, in contrast, proposed full integration by imitating nature. He advocates the green corridor extending from the ground to the upper levels. Within a two-minute walk through the vertical garden, The Line provided instant and uninterrupted access to nature: a diversified open area hung on different levels with views of the surrounding natural landscape, mountains, and sky. The exterior walls are large mirrors from both sides, wrapping the inside and forming an ecological system. It reflects the surrounding landscape. The city will be zero-carbon by eliminating carbon-intensive infrastructures such as vehicles and highways. Its activities, including those of its industries, will be run entirely on renewable energy. Incorporating nature and open areas throughout will play a vital role in air quality purification. The environment has been meticulously constructed to provide an ideal combination of sunshine, shade, and natural ventilation to facilitate the formation of microclimatic areas.

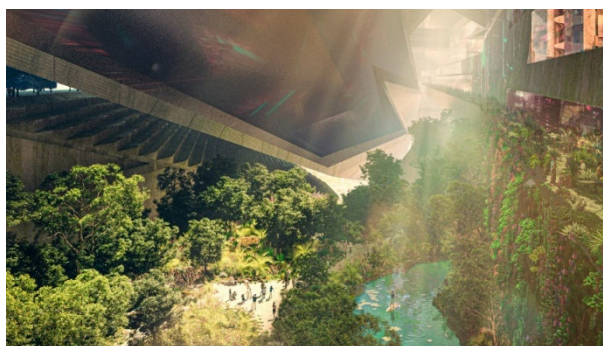


Figure 9. Creating an ecological system in the Line

5.4 The Inhabitants and Migration

Traditions and Modernity have the most profound impact on shaping communities and cities. Traditions provide a framework for social activities based on societal ideals. On the other hand, traditions develop into social practices that limit growth by duplicating old architectural forms when people mimic the past without understanding. Modernity, on the other hand, is connected with the Modernism Movement, which provides a better lifestyle and advanced technology while also indicating a break from the past via the imposition of new architectural forms. As a result, a binary position exists. I argued elsewhere that immigration is fundamental when dealing with tradition. Those who leave their homelands and become migrants are more likely to abandon their traditions, adopt new ones, or blend new ones with their own. Then Modernity should be divorced from its ideological origins and considered a series of advances and access to contemporary technologies. The goal is to build a knowledge base society. Building The Line from scratch means all inhabitants will be either international

immigrants or local migrants from all parts of Saudi Arabia. Of course, there will be portions of visitors as tourists and people in business. HRH Muhammad bin Salman announces that “NEOM will be a place for all people from across the globe to make their mark on the world in creative and innovative ways” (NEOM, 2022). The Line invites all humanity to form a global community. There will be no inherited dilemma of tradition/modernity binary.



Figure 10. Vertical urbanism in the Line

6. Conclusion

Most cities around the globe attempted to solve their social and economic problems through spatial and physical interventions. The Line is a paradigm shift in the future of urbanity. The hope is to inspire future cities to adopt the zero-urbanism approach. The vision is to solve city complexities by raising potential and innovation rather than fixing assumptions and ongoing urban regeneration. Cities' layout, urban density, and spatial quality of the city should enhance people's experience, and people's perceptions of their cities should reflect meanings and values. Cities of the future need to develop their urban ecology, not imitating nature, but rather by minimum footprint and using renewable energy. Migration plays a significant role in reforming society. On the one hand, it prevents traditions from imposing authority. On the other migration allow the fusion of collective thoughts and ideas to form society. Most efforts to address today's cities' socioeconomic concerns have been through physical interventions that assume an absolute solution, returning to the Cartesian paradigm and producing more problems than addressing them. In contrast, urban intervention confronted physics constraints such as gravity without finding proper solutions. Adopting the relativity paradigm to solve city complexity necessitates a quantum leap in urban approaches free of physics constraints, at least in terms of the way of thinking. The Line is a call for humanity to stand on one Line of equality, social justice, and quality of life in a place named earth.

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