Title: **Garden City, Megacity: Rethinking Cities For the Age of Global Warming**

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Garden City, Megacity: Rethinking Cities For the Age of Global Warming

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The 20th-century city developed in response to industrialization and population growth, with a planning vision encoded in regulations that limited evolving with the times. The 21st century city needs to respond to pressing current issues – climate change, resource scarcity, rapid urbanization, and digital technology. Championing sociable architecture and sustainable cities, the authors have developed prototypes for the 21st century, devising a building rating system that measures indices of greenery, community, civic generosity, ecosystems, and self-sufficiency. This paper shares the authors' strategies and vision for the 21st-century Garden City Megacity that is hyper-dense, connected, and vibrant, with a diverse, beautiful, and generous public realm, yet self-sufficient in energy, water, and food.

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Introduction

Cities are growing at a phenomenal rate, with the number of megacities in the world having more than tripled in the past 25 years. The rush toward urbanization is expected to continue, with population and land-use growth projected to add 2.5 billion people to the world's urban population by 2050, 90% of which will be concentrated in Asia and Africa. Caught in an unprecedented growth spurt, these cities are undergoing an "urban puberty" phase and are rapidly outgrowing their infrastructure. Contributing about 70% of the world's carbon emissions, cities are causing an escalating rise in global temperatures that will lead to inevitable crisis if governments, urban planners, and architects fail to urgently rethink the way that cities are planned.

Since 2001, the authors have designed and built a series of prototypes as part of a process of urban re-evaluation, adopting the Asian megacity as an ideal testing ground for new urban typologies and architectural strategies. Reimagining the early 20th-century garden city, the authors propose that a multi-layered, high-density, high-amenity 21st-century megacity that is dense and vertical, yet sociable and sustainable, is the only way forward. The "Garden City Megacity" is built on a series of "Macro-Architecture Micro-Urbanism" strategies that radically intensify land use, multiply green space, and integrate climate-specific solutions to reduce the environmental impact of cities and improve the quality of life for people.

Layering Cities

Over the last two centuries – as towns became cities and cities became megacities – land has been taken for granted, as an infinite horizontal site for building, farming, and mining. The combined effects of land exploitation, exploding megacity populations, rapid urbanization, and economic growth have led to the degradation of land quality and quantity, the depletion of non-renewable energy sources, and the rise of global warming. Land scarcity is also reflected in the competition to meet the conflicting needs of a city, resulting in high land costs and stark trade-offs between various land uses.

The authors propose visualizing a city in terms of layers – as a three-dimensional matrix, rather than as a two-dimensional grid (see Figure 1). This calls for innovative land use solutions that involve a replanning of cities – vertically, not horizontally. On top of reclaiming, restoring, and re-energizing our

Figure 1. Axonometric diagram of the "Layered City."

> "Visualize a city in terms of layers – as a three-dimensional matrix, rather than as a two-dimensional grid. This calls for innovative land use solutions that involve a replanning of cities – vertically, not horizontally."

existing land, new land must be created. The use of land needs to be intensified by layering urban (and rural) environments – residential, recreational, commercial, agricultural, and infrastructural – above and below the existing ground level of the city.

These strategies for "layering cities" aim at offering a good quality of life for people by creating highly dense urban environments that are also highly vibrant, humane, and resilient in the sustainable long term. The layered approach introduces "multiple ground levels" of various functions at strategic horizons in the sky (see Figure 2). This achieves high-density, high-amenity developments where civic, community, and green spaces are multiplied over the same limited land area. Complementary programs of the right proportions are also integrated into vertical, mixed-use "cities within cities" that generate a 24/7 live-work-play vibrancy. To ensure human-scaled "domesticated structures," the authors' designs take references from the surrounding district and incorporate external spaces (e.g., sky streets/parks) into the high-rise, recreating the proportions of neighborhood streetscapes (see Figure 3).

To further foster a sense of identity and belonging, concepts of neighborhood and community that are specific to the unique culture and context of the project are first studied and then translated into the contemporary high-rise as a system of "sky villages."

"Layering Cities" also necessitates innovating the way in which both architecture and infrastructure/urbanism are combined in large-scale, radical yet synergistic ways. This "both-and" concept requires a strategic rethinking of building typologies, with considerations for energy production, water rights, air rights, and biodiversity indices to support self-sufficient townships and natural ecosystems in our cities. The traditional "bar graph" skyline, for instance, is picturesque but problematic. It gives visual interest at a distance, but the ground level can be very repetitive. The varied heights of buildings also overshadow each other, presenting a self-shading problem that is a disaster for solar collection in cities. To overcome this, the authors propose an "inverted skyline" (see Figure 4), which creates opportunities for

Figure 2. The layered approach introduces "multiple ground levels" of various functions at strategic horizons in the sky.

Figure 3. Sky streets and parks recreate the proportions of neighborhood streetscapes at height.

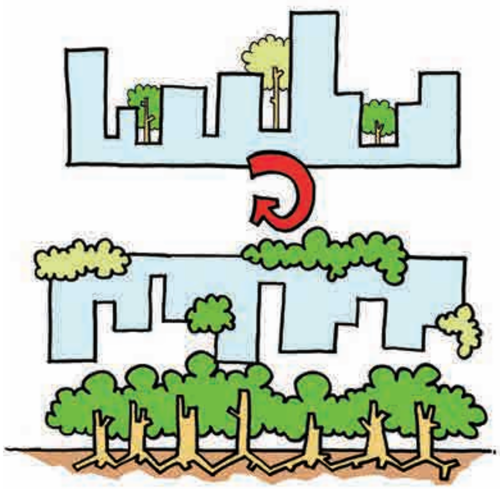

Figure 4. The "Inverted Skyline."

Figure 5. An "Inverted Skyline" creates the potential to cover cities in photovoltaic panels.

installing large-scale solar energy farms on the roof, while eliminating the current problems of low solar efficiency yields due to overshadowing, thus making 100% zero-energy developments possible (see Figure 5).

Planting Cities

The relentless tide of rapid urbanization has also caused green, open, and civic spaces to shrink at an unprecedented rate, while chronic traffic congestion and vehicular and industrial pollution further compound the city's environmental condition. Cities have become harsh concrete jungles, with hard surfaces directly contributing to the urban heat island effect. Citizens are also leading increasingly insular lives, with minimal contact with nature. The authors' strategies for "Planting Cities" aim at reintroducing biophilic design into buildings. This not only improves human well-being/comfort and environmental quality, but also restores biodiversity into the city and keeps the natural balance of ecosystems and wildlife habitats.

"Screens of Green" incorporated into building façades create a strong identity for the development, while providing visual relief for neighbors and the public. Serving as environmental filters, they provide shade, cut out glare and dust, reduce heat, improve air quality, and dampen traffic noise. Focusing on the human experience of nature, "topographic architecture" transforms megastructures into landforms for hosting landscape, creating an inhabited topography that generates psychological comfort for building occupants and passers-by alike (see Figure 6).

In view of the limited access to sunlight within dense cities, gardens at ground level can actually be at a disadvantage, as compared to gardens elevated within buildings that receive more light. The authors propose "sky gardens" that thrive in densely settled tropical cities, taking advantage of the climate and the degree of sunlight, while strategically relating to the building's context, orientation, proportions, structure, and circulation zones. Publicly accessible "sky parks" incorporated at strategic "new ground levels," on the other hand, compensate for the lack of ground-level parks and serve as civic gifts.

Breathing Cities

The archetypal Modernist model for high-rise buildings was originally devised for the cold-climate cities of the United States. The towers were engineered to maximize the ratio of a building's volume to its surface area, and were wrapped in glass envelopes in which inhabitants were kept comfortable mechanically. Regardless of appropriateness to local conditions, these glossy, hermetically sealed towers have been replicated across the globe, consuming about 40% of the world's energy, without any real reinvention of the basic typology to suit the changing times and local climate.

The authors' strategies for "Breathing Cities" call for a return principles, with the aim of creating sensible climatic designs that achieve thermal comfort without the need to rely solely on mechanical systems. Vernacular and passive responses to climate are adapted into the tropical high-rise form and translated into contemporary technologies. By opening up internal spaces to the climate and nature, buildings can "breathe" again.

"Vernacular and passive responses to climate are adapted into the tropical high-rise form and translated into contemporary technologies. By opening up internal spaces to the climate and nature, buildings can 'breathe' again."

Figure 6. "Topographic architecture" transforms megastructures into landforms for hosting landscape, creating an inhabited topography.

Figure 7. In "tropical community spaces," buildings provide shelter for mass activities.

Shade, shelter, and breeze being vital to the usability of the civic/public spaces in the tropics, the authors' approach is to create "tropical community spaces" by leveraging the building form and footprint to serve as urban umbrellas over gathering areas (see Figure 7). These are placed strategically in the path of linear "horizontal breezeways" that work in combination with wind deflectors to draw breezes and bring natural daylight through the development. "Vertical breezeways," on the other hand, are designed as continuous internal voids within towers, and work on the principle of the hot stack effect, drawing cool air into communal areas as the warm air rises. To facilitate good thermal comfort at grade, buildings are configured and shaped to direct breezes to the porous community ground plane below, creating "breezeway courtyards."

Instead of compact, solid, and monolithic buildings, "breezeway towers" are designed as open-lattice megastructures that dynamically interact with their environment (see Figure 8). "One-unit-thick" designs further enable the incorporation of windows on all sides, maximizing cross-ventilation, natural daylight, and views through units. Within densely built-up areas in the city center, well-ventilated "breezeway atriums" are carved out of high-rise towers, offering an alternative to fully glazed, air-conditioned skyscrapers. This creates dynamic internal views, which frame, soften, and mediate the surrounding dense urban fabric (see Figures 9 and 10).

Rating Cities

The strategies presented here must be assessed within a larger picture, with holistic

Figure 8. Skyville @ Dawson, Singapore was designed as a "breezeway tower." © Patrick Bingham-Hall

Figure 9. The Oasia Tower, Singapore has a "breezeway atrium" at the top, and its exoskeleton offers an alternative to full glazing. © Patrick Bingham-Hall

Figure 10. The Oasia Tower, Singapore – breezeway atrium. © Tansri Muliani

Figure 11. Skyville @ Dawson, Singapore. © Tansri Muliani

Skyville @ Dawson, Singapore

- Twelve 47-story **breezeway towers** are placed on a triple diamond-shaped plan, which facilitates ventilation and sunlight penetration and enables views from every apartment.
- **Vertical breezeways** utilize thermal displacement to generate cooling upward airflow between the towers.
- Twelve **sky villages,** each comprising 80 apartments, are layered within **breezeway atria,** cooled and ventilated by **horizontal breezeways.**
- **Multiple ground levels,** 11 floors apart, provide locations for **sky gardens** and **tropical community spaces,** and maintain human scale in a **domesticated megastructure.**
- **Sky parks** on the roof and extensive public parkland at ground level form part of a **high-density, high-amenity** urban environment.
- Each apartment is **one unit thick,** in order to enable cross-ventilation, increase exposure to daylight, and provide a wider outlook.

Green Plot Ratio		**110%**
Community Plot Ratio		**140%**
Civic Generosity Index		**100%**
Ecosystem Contribution Index		**40%**
Self-sufficiency Index	Energy	**44%**
	Food	**0%**
	Water	**60%**

Table 1. City rating as applied to Skyville @ Dawson, Singapore.

planning of the city being the priority. Twentieth-century cities were planned as collections of segregated components, which were measured in terms of their economic productivity. The value of buildings was assessed only by capital cost efficiency – building plot ratios, net-to-gross floor values, and surface-to-volume ratios – rather than their overall contribution to the city as components within a self-sufficient system. Twenty-first-century cities, on the other hand, must be about people and integration, with buildings assessed in terms of their contribution to social and environmental sustainability, as well as their economic viability. To gauge this, the authors have devised a social and ecological rating system for all city buildings, conducted on behalf of a city's residents, rather than its property developers. The applied example is Skyville @ Dawson, a WOHA project completed in 2015 (see Figure 11 and Table 1).

"Green Plot Ratio" measures the amount of landscaped surfaces within a building over its site area, with the aim of reintroducing biodiversity and green relief into the city. "Community Plot Ratio," on the other hand, measures the total amount of community space within a building over its site area, with the aim of encouraging social gathering and human interaction at various scales. To measure the extent to which a building encourages and facilitates the public life of a city, the authors devised a "Civic Generosity Index." This rewards buildings that exhibit good neighborliness in the way they gift the city visually or spatially. The adoption of "urban ecological" approaches to support wildlife within cities is also recognized under an "Ecosystem Contribution Index," which measures the degree to which a building supplements a city's ecosystem. Aiming for fully sustainable buildings and cities, the city rating system gives high priority to a "Self-Sufficiency Index" that measures a building's capacity to provide its own energy, food, and water.

Self-Sufficient City

As part of the ICSID World Design Congress 2009, WOHA spearheaded a vertical studio to explore an idealistic self-sufficient city for Singapore in 2050. In 2014, the authors evolved these ideas and produced a tangible and buildable blueprint for a new town master plan proposal in northern Jakarta.

The design challenge was to house 210,000 people on a 730-hectare site that is overgrown with secondary rainforest and constrained by a 60-meter building height control limit. To create a tropical "eco-town-in-a-forest," which would retain over half of the existing green landscape, the authors integrated the site's horizontal land-use allocations with the stratification of their self-sufficient city prototype (see Figure 12).

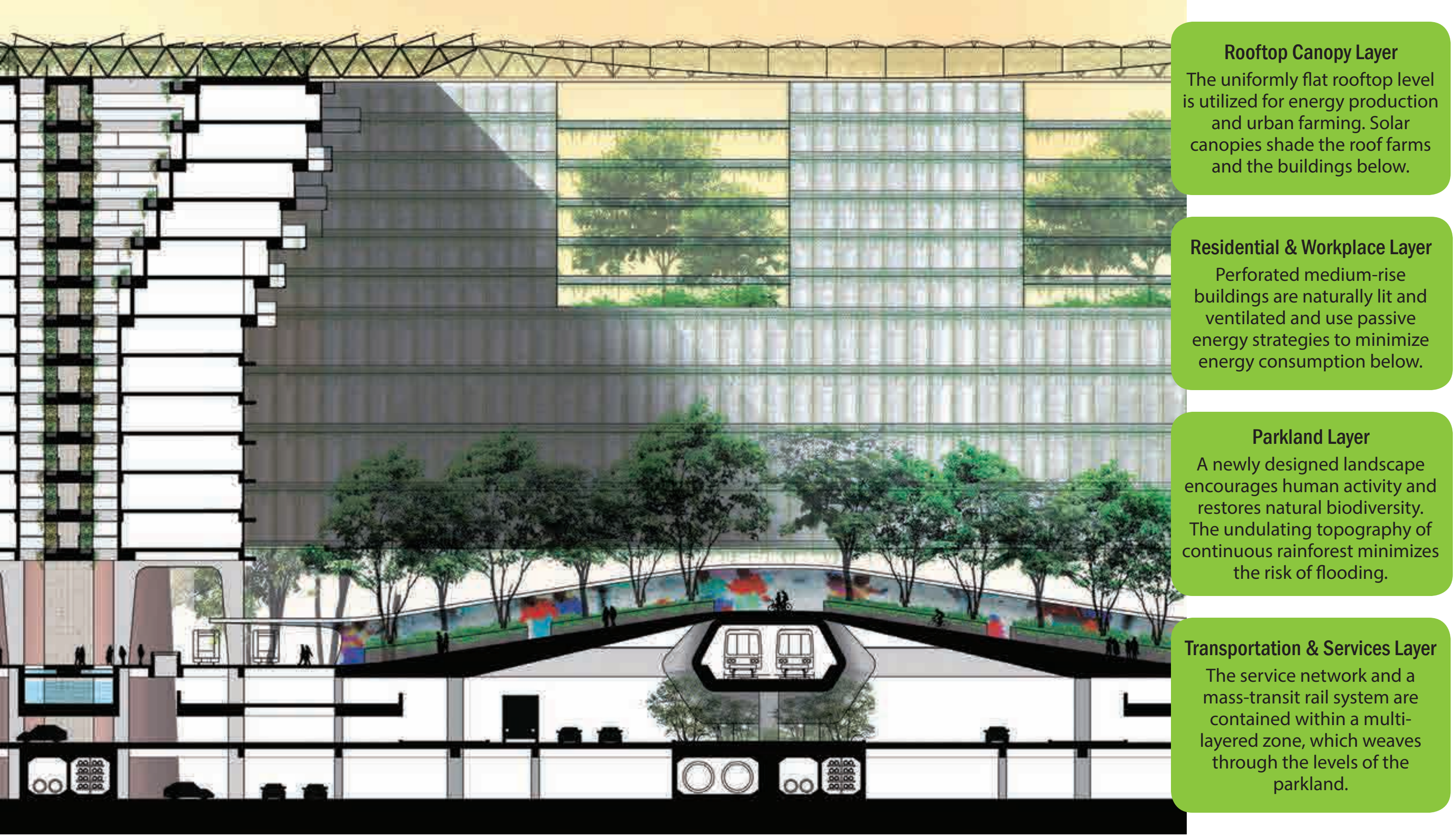

Figure 12. The four-layer "self-sufficient city."

That stratification consists of four layers: a "transportation and services layer" that contains all service networks and vehicles; a "parkland layer" beneath buildings that comprises "tropical community spaces" for public functions and social interaction; a "residential and workplace layer" organized into a series of "breezeway courtyards/towers" with cross-ventilated "one-unit-thick" apartments; and a "rooftop canopy layer" that is both protective and productive, providing shade and shelter as well as solar energy and food harvested from "sky field" crops.

The new town was planned to be totally self-sufficient in terms of energy production, water supply, waste disposal, and food production, while having the minimal possible impact on existing flora and fauna. Effective passive design in combination with more than three square kilometers of photovoltaic panels installed on the rooftop canopy layer would enable the town to operate with net zero-energy consumption. Adopting an "inverted skyline" typology, all building rooftops were capped at the same height, ensuring that no energy losses occurred from over-shadowing.

The master plan prioritized pedestrian connectivity with well-connected mobility paths. Apart from trams and bicycles, the Parkland Layer would be vehicle-free, so that "tropical community spaces" and public gardens could thrive in a safe and unpolluted environment. The terrain would be sculpted to provide a diverse topographic landscape, with terraced knolls overlooking forest glades and the waterways of the town's reservoir. "Sky streets" on "multiple ground levels" in the residential and workplace layer would link a series of "sky villages," so that residents can interact and form community bonds within their own aerial neighborhoods. "Sky parks" would share space with the urban farmland on the rooftops, so that recreational areas have a view and form part of a cheerful and productive village lifestyle.

The authors' concept of a self-sufficient city is not a romantic utopian ideal. It is a realistic vision for our urban future, with a blueprint for sustainable development and a progressive philosophy for a dense and vertical, yet sociable and sustainable 21st-century garden city megacity. ■

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