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Spatial Planning Principles & Assessment Framework For Climate Adaptive & Resilient Cities in China

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Chinese cities have changed more in the past thirty years than they had in five thousand years before. They are at the front line of a changing climate. They account for more than half of the country's population, most of its economic activity and the majority of its energy-related emissions. Most of Chinese cities above 5 million and two of its main metropolitan regions are located in the low elevation coastal zone. Rising sea level, storm surge flooding, higher frequency and intensity of natural catastrophe could have widespread effects on populations, property and ecosystems, presenting threats to commerce, business, and livelihoods.

The role of Chinese cities in reducing risks and protecting their inhabitants is central to effective climate resilient policies. Adaptation must be included in planning of new cities and in retrofitting of existing cities. Urban spatial planning is a holistic approach for local communities to capture synergies between emissions reduction and adaptation, as well as sectorial and broader sustainability co-benefits. Creating climate resilient cities implies defining planning rules that allow for future evolution and adaptation to non-predictable conditions. Chinese spatial planners can increase climate resilience of cities by following 8 key principles derived from international best practices, from lessons of historically adaptive resilient cities, and from the general laws of ecological resilient systems.

For cities, resilience stands for the ability to adapt to a rapidly changing environment. It covers three closely related and interdependent issues:

- Climate resilient cities can adapt to the increase in the likelihood of weather-related natural disasters, such as floods and drought, or storms. Most of Chinese cities above 5 million and two of its main metropolitan regions are located in the low elevation coastal zone, which are areas with potentially high risks.
- Energy resilient cities are highly adaptive to increases and/or fluctuations in energy prices. Energy resilient cities are on a low dependency path to energy.
- Economic resilient cities are highly adaptive to real estate and financial markets fluctuations

The fact that Chinese cities in the process of fast urbanization are lacking developing time does not imply that they should be conceived as top down blueprints. Climate resilient cities must be nurtured as gardens, which will naturally grow and transform for centuries. Living systems, because they developed and became more complex over four billion years of evolution across many climate changes of an intensity far superior to the present one, are the best model for defining climate resilient cities. Evolution permitted the survival of species through constant transformations. In cities like in ecological systems, connecting and differentiating are evolution forces that act to create, through emergence, efficient and resilient urban structures. Resilient cities are highly structured wholes. They present differentiation, connectivity and structure at all scales.

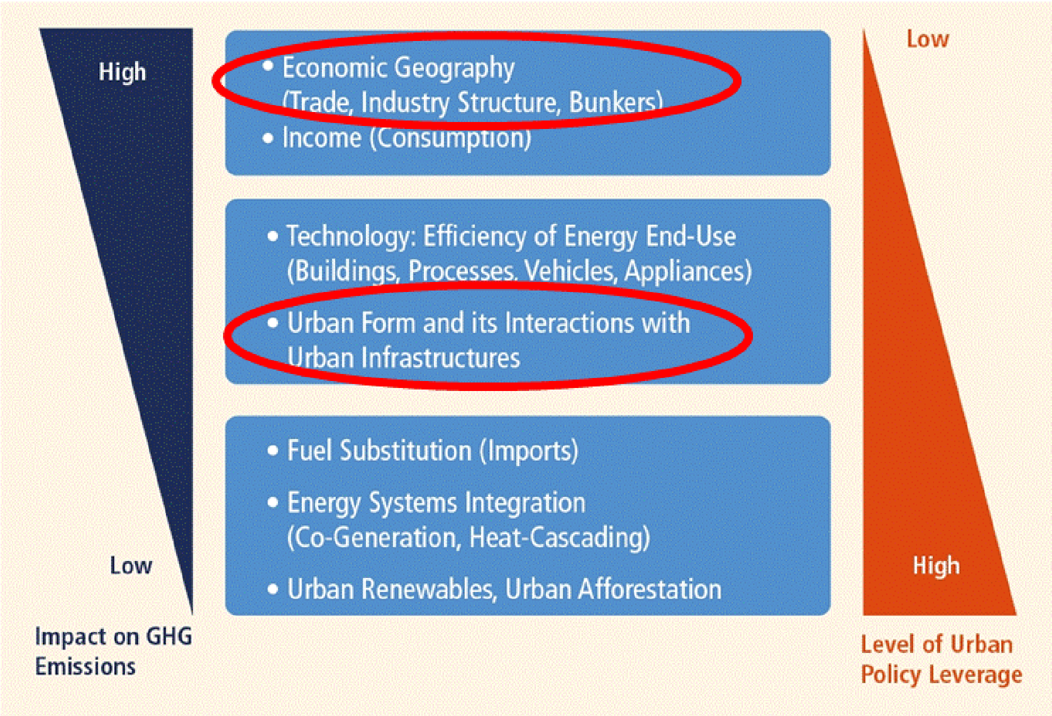
Planning strategies to give contemporary Chinese urban development the structural resilience of natural evolutionary systems can be summarized in 8 key principles for which we will propose monitoring indicators:

1. Compact Densification
2. Scaling
3. Functional Flexibility
4. Fine Grain Diversity
5. Highly Connected Networks
6. Synergy
7. Greening And Water Recycling
8. Urban-Rural Integration

Principle 1: COMPACT DENSIFICATION

Explanation of the principle

Spatial planning bridges the gap between adaptation and mitigation. According to 2014 IPCC report, reducing energy demand by economic geography, efficiency of buildings and technologies and efficient infrastructure and city form has the strongest impact on emissions reductions and the strongest policy leverage. Options for rapidly developing Chinese cities should focus on shaping their urban and infrastructure development trajectories. All approaches include co-locating high residential with high employment densities, achieving high land-use mixes, investing in public transit and articulating density around transit hubs (TOD).



Economic geography, urban form and infrastructure are amongst the leverage with the strongest impact on GHG emissions, energy consumptions and urban resilience

Why it matters for urban resilience

Transport energy can be divided by 2 to 4 by planning more compact, mixed use cities where most of urban amenities are reachable on foot at less than 10 minutes walk. Retrofitting existing buildings can reduce heating energy requirements by 50-75% in single-family housing and 50-90% in multi-family housing. For energy supply, reductions in GHG emissions can be achieved by the use of low-carbon technologies including renewables, carbon capture and storage, and switching from coal to gas.

Planning more compact and mixed use cities contributes to significantly decreasing energy dependency. Modal switch towards low carbon and low energy transportation means, such as mass transit, walking and cycling, is indeed made easier in compact and mixed use cities. Climate change and increasing scarcity in fossil energy sources will induce a steady and long term increase in energy prices. With a lower energy dependency, compact and mixed use cities will be more adaptive to energy price increases, and, as a result, more resilient.

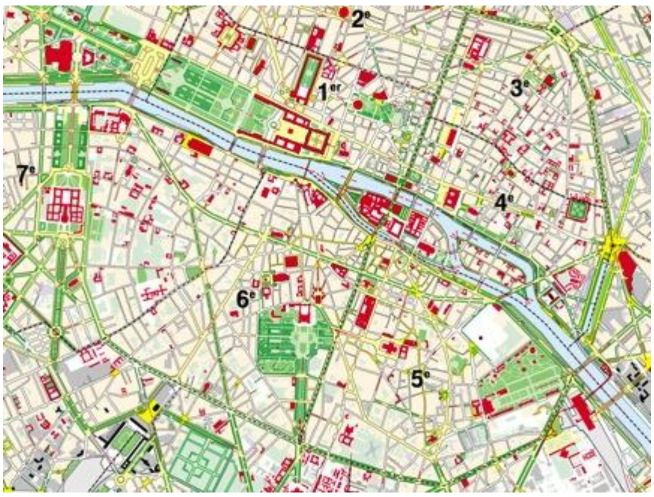
Metrics to assess the principle

Density can measure a series of different urban parameters at different scales. Measuring urban density requires first answering two questions:

- What is measured: population, jobs, activities, housings, legal entities, etc.
- At which scale: city, district, neighborhood, block, plot or building.

Once these two key elements defined, density is measured as a simple ratio. Population density at the neighborhood scale for instance captures the ratio of the number of inhabitants to the neighborhood area.

Taiyuan Shanxi Science Town, Core Area (20km²), 7,500 inhabitants per km² and 10,000 jobs/km²



Paris, district scale (17km²), 20-25,000 inhabitants per km² and 20-30,000 jobs/km²

Urban gross density captures the built density of the urban fabric. It captures on the district or neighborhood scale the total floor area over the district or neighborhood area.

Shanghai	HongKou	Siping	Lujiazui (CBD)	Lianyang	Villas
Selection	800x800 m	800x800 m	800x800 m	800x800 m	800x800 m
Building type	Low-rise housing: *Lilong*	Mid-rise housing: Slabs	High-rise housing: Towers and malls	High-rise housing: Towers and slabs	Isolated individual housing
Function	Housing	Housing	Office buildings	Housing	Residential
Gross urban density	1.9	1.2	1.2	3.7	0.3

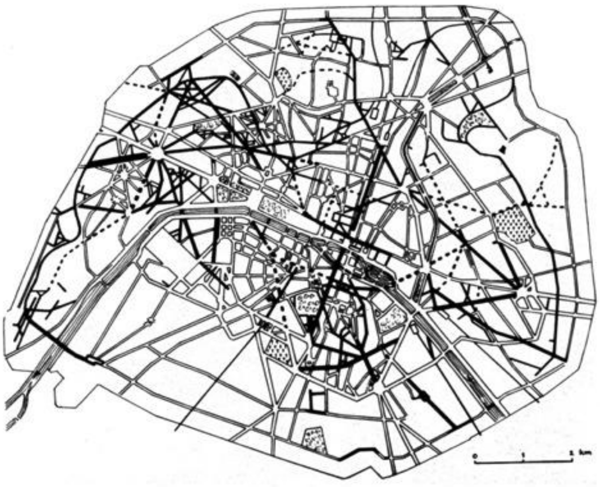
Shanghai: Gross urban density captures the total floor area on a given scale, here on a 800x800m scale

Compactness is complementary to density. Compactness informs on how scattered and spread out an urban fabric is at the city scale. Compactness can be captured through a gravity index, which rests upon a division of the city into fragments. The gravity index of a location j is proportional to the total amount of resources available to that location (W(j)) and inversely proportional to the travel cost of reaching them from other fragments I $e^{\beta d(i,j)}$. The gravity index for the fragment j is: $G_j = \sum_{i \neq j} \frac{W(j)}{e^{\beta d(i,j)}}$. The compactness of the city can then be measured as a weighted average of all gravity indexes.

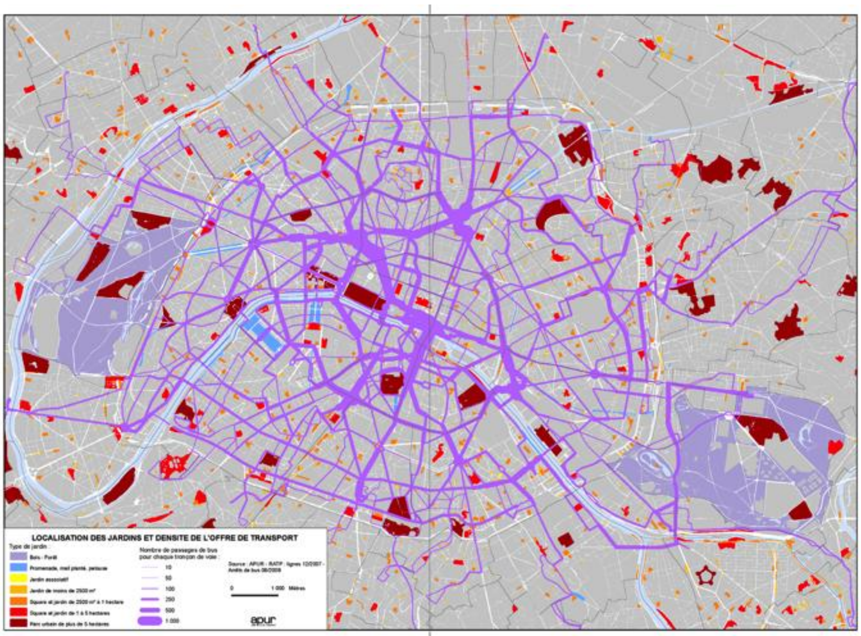
Principle 2: SCALING

Explanation of the principle

When we look at a district in Paris or Manhattan, we find the same relative distribution of large public parks, medium scale and pocket parks smaller than half hectare, than in the whole city. Each district is a reduced scale version of the city for the relative distribution of sizes of amenities such as public parks, health, education, and shops. When we look at the distribution of sizes of streets in Paris, we find at city scale and at district scale the same blend of 20 meters wide boulevards, 12 meters wide streets, 10 meters wide, 8 meters wide. Each sub pattern of streets at neighborhood and district scales presents the same distribution properties as the whole city. In the resilient order of cities one can observe, like in nature, the same level of complexity on several scales. The local and the global are linked by a successive series of connections that show structure and organization at each scale. This is called a scale-free structure. In such a structure, the global order emerges from local orders. A complex order is created from the bottom-up evolution of the small scale and its integration at higher scales.



Street patterns in Paris



Bus frequencies in Paris

Why it matters for and urban resilience

The spatial distribution and the intensity of connections in a resilient city obey a scale-free distribution. The more scale-free the city, the more it can absorb and even build new structures upon the perturbations to which it is subjected, without letting them upset the stability of its structure. It is in assimilating the fluctuations that an urban system becomes more complex. Hence, there is an ongoing dialogue between the city's capacities of resilience and the constraints to which it is subjected, between the fluctuations from the outside environment and its building structures to absorb these fluctuations.

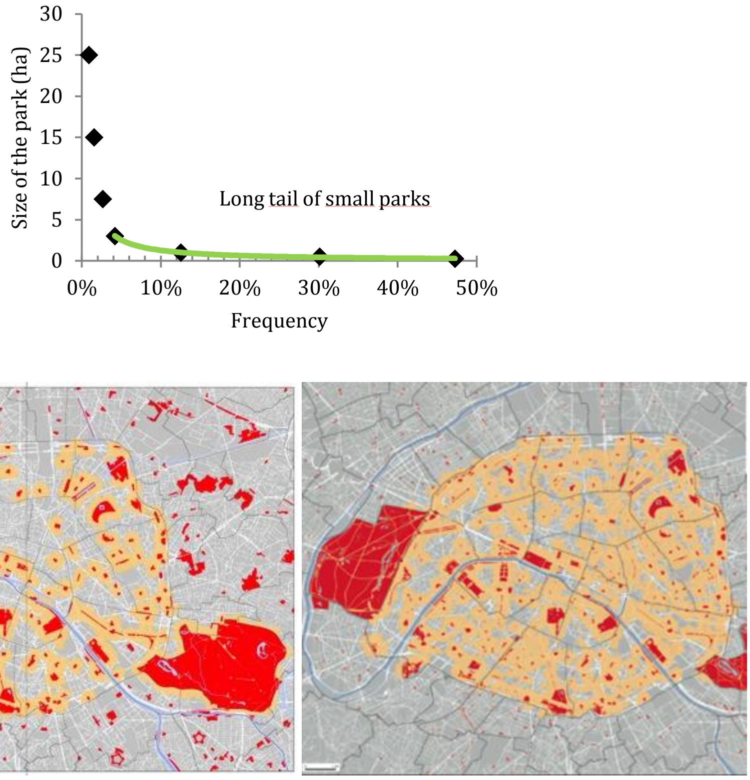
In a seminal paper, Herbert A. Simon (1962) introduced the topic of complexity architecture with a

parable that has since largely influenced complexity sciences. He told the story of two highly regarded watchmakers, who constantly had to pick up the phone to answer clients. One of the two fine watch businesses, run by Hora, prospered, while the other, run by Tempus went bankrupt.
The two watchmakers had to construct watches out of 1000 parts each. Tempus' watch was designed so that if he had partly assembled it and had to put it down to answer the phone, it immediately fell to pieces. The more clients he had, the more they phoned him, and the more difficult it became to have enough time to finish a watch. On the contrary, Hora's watch was designed so that he could put together subassemblies of about ten elements each, then put together ten of those subassemblies into a larger subassembly, and so on. Whereas a phone call caused Tempus' work to fall entirely into pieces, it only causes Hora a subassembly to fall into pieces. No need to argue further that the probability for Hora to finish a watch is much higher than for Tempus. This parable was meant by Herbert A. Simon to highlight the role of scale hierarchy within complex systems: a complex system made up of coherent subassemblies has a greater ability to evolve and adapt quickly to change, accident and fluctuation. Adaptability has crucial implications on climate resilience ability. For a property to emerge at a higher scale, smaller scales need to exist to foster its emergence. Each spatial scale supports the higher scales in the ascending hierarchy of an emergent complex order. These emergent properties allow the system to repair, stabilize itself and to evolve.

Metrics to assess the principle

Resilient cities present urban elements at all scales with a universal law characteristic of complex natural systems. This law links the frequency and the size of urban elements. The frequency of an element's appearance and the span of a connection are based on their scale hierarchy level: the smaller an element is, the more often it will be encountered in the system; the bigger an element is, the more rarely it must appear. In mathematical terms, a Pareto distribution, or inverse power law, relates the large, the intermediary and the small in measurable ways. It states that in a complex well-balanced system the frequency of an element of size x is proportional to the inverse of its size at an exponent m characteristic of the system $freq \propto \frac{1}{size^m}$. In other terms there are few big elements, a medium number of medium-scale elements and a very large number (a "long tail") of small-scale elements, and the relative frequency of each type is determined by the mathematics of the rank size distribution: the size of any elements is related to its rank within the distribution.

In Paris for instance, the distribution of public parks follows the following distribution: $size(ha) = \frac{487}{rank^{1.42}}$. This long tail spatial distribution of parks ensures an optimal accessibility to green spaces to Parisians, with a constrained area of green spaces on the city scale, as shown in the following map (orange areas correspond to a 10 minute walk accessibility).



5 min walk accessibility to large public parks in Paris (Left) and 5min walk accessibility to small public parks (right). The long tail of small public parks (top) ensures a generalized accessibility to green spaces.

Principle 3: FUNCTIONAL FLEXIBILITY

Explanation of the principle

A climate resilient city has to be able to evolve and to adapt to new conditions, which necessarily implies evolution of its initial plan. Resilient cities grow in a constant interaction between urban planning and processes of adaptive self-organization that make the regular aspects of the initial organization more complex. In functionally flexible cities, urban forms can easily adapt (with limited investment needs) to a redistribution of urban functions. In other words, office buildings for instance can be easily transformed into housing.

Monofunctional housing development (left) and functionally flexible urban block (right)

Why it matters for climate adaptiveness and urban resilience

Morphological dynamism is one of the characteristic traits of historical resilient cities. The capacity to have different successive functions fulfilled by the same forms or by gradually modified forms is the adaptation that characterizes resilient cities. Adaptation is not only a matter of the city's physical structures. It is a process of continually adjusting form and function – a matter of mutual transformation rather than the primacy of functions over forms. The fundamental persistence of adaptation is the basis of the evolution and continuity of climate resilient cities.

Metrics to assess the principle

Functional flexibility can be measured on the city, district, neighborhood and building scale. It can be measured as the ratio of « flexible floor area » over the total floor area:

$$Functional\ Flexibility = \frac{Flexible\ Floor\ Area}{Total\ Floor\ Area}$$

Functionally flexible floor areas or buildings are those which function can be changed (for instance from housing to offices) with a limited investment need, generally taken as 20% of the construction cost.

Principle 4: FINE GRAIN DIVERSITY AND ACCESSIBILITY

Explanation of the principle

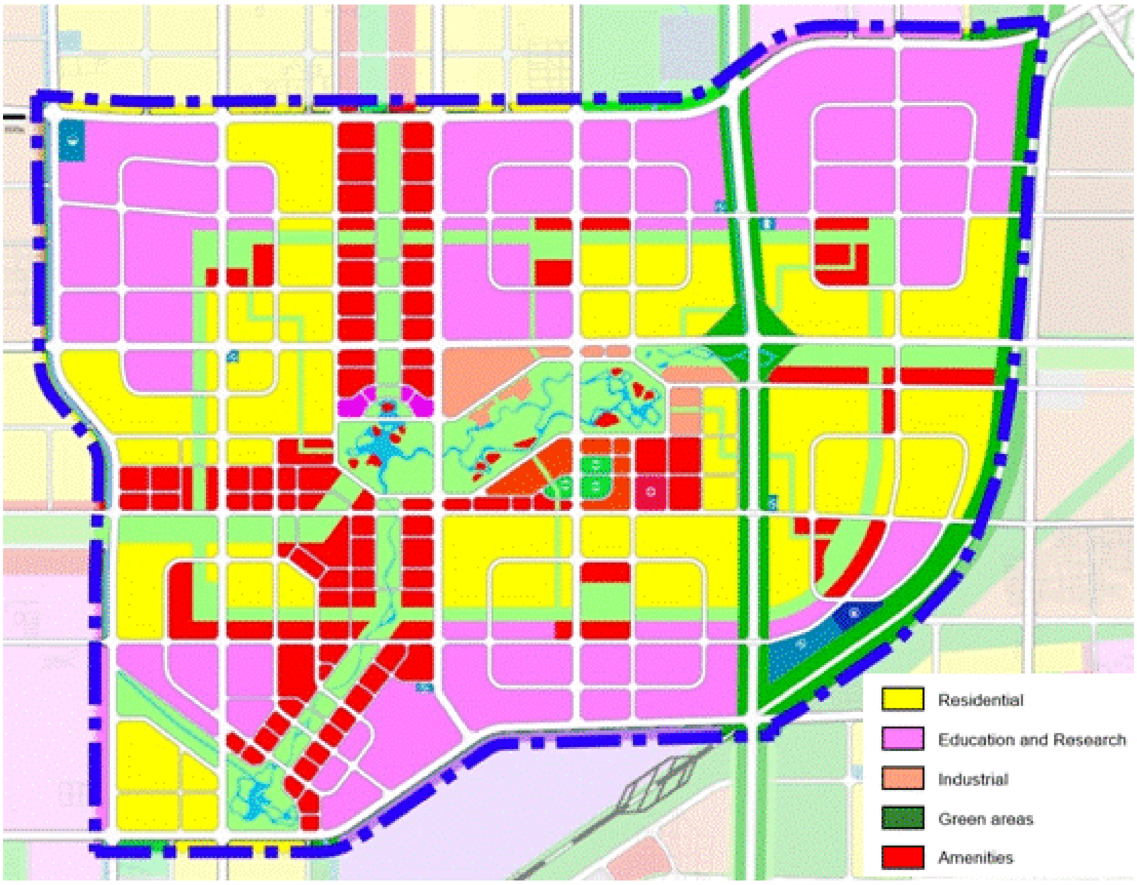
The amount of diversity inside resilient cities is enormous. This diversity has been created by myriads of different initiatives along a long period of time. In a resilient city, the smaller components can be changed without affecting the overall structure. Building the whole from the parts in an organic way leaves room for evolution. Starting from the whole creates structures that cannot evolve. Modifying the urban whole once it has been established from a technical blueprint involves destroying a great many components on very different scales. In a bottom up city evolving through a myriad of micro processes, it is, to the contrary, easy to modify smaller components.

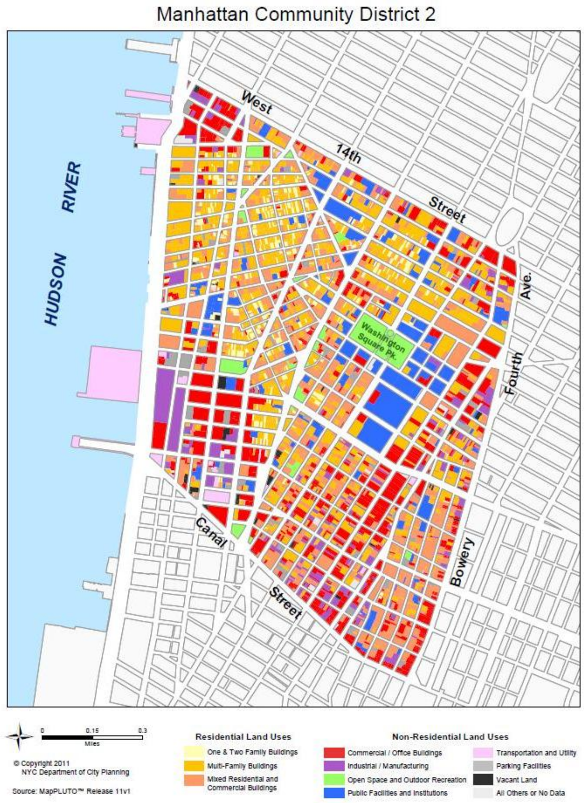
Cities with low mixed land use and low diversity are often found in North American cities and in many new urban developments in Asia. Large residential developments are separated from jobs or retail centres by long distances. Fine grain diversity refers to mixed use at the neighborhood and block scale. At the neighborhood scale, it refers to a "smart" mix of residential buildings, offices, shops, and urban amenities. At the block and building scale, mixed use consists of developing small-scale business spaces for offices, workshops, and studios on the ground floor of residential blocks and home-working premises.

Why it matters for climate change resilience

A number of studies of such single-use zoning show strong tendencies for residents to travel longer overall distances and to carry out a higher proportion of their travel in private vehicles than residents who live in mixed land use areas in cities. Single-use zoning is a low resilience urban development, because it is highly dependent to individual cars and fossil fuel energy.

Research on U.S. cities indicates that the presence of shops and workplaces near residential areas is associated with relatively low vehicle ownership rates and can have a positive impact on transportation patterns (Ewing and Cervero 2010). The impacts of mixed use on non-motorized commuting such as cycling and walking and the presence or absence of neighbourhood shops can be even more important than urban density. Fine grain mixed-use development shortens journeys and promotes transit/walking/cycling and adaptive re-use of buildings. As such it widely contributes to urban resilience.



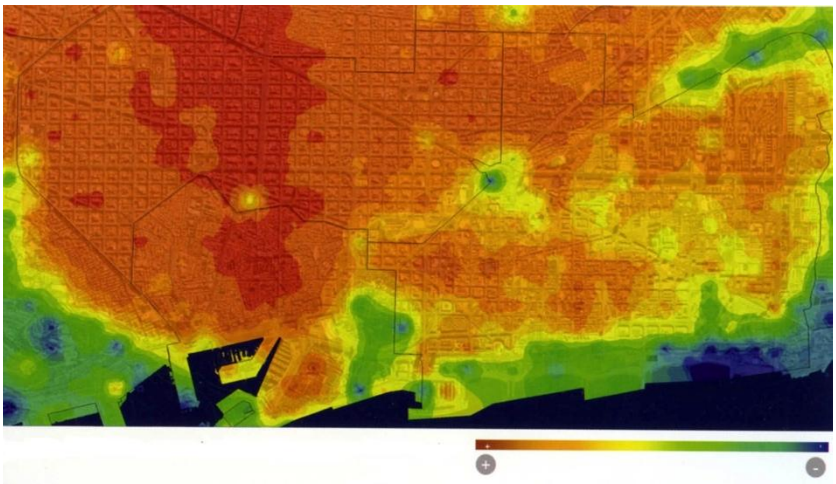


On the very same scale, diversity of building uses in Taiyuan Shanxi Science Town (Top) and Manhattan (bottom). Taiyuan Shanxi Science Town is zoned with mono functional areas. On the contrary, Manhattan displays a very diversified, fine grain, mixed use urban fabric: the buildings displayed in orange are mixed-use office-housing buildings.

Metrics to assess the principle

Diversity and mixed use can be assessed through different mathematic formulas. The most commonly used are Simpson's and Shannon indexes. Both capture the local diversity of the urban fabric and of urban activities. The diversity of building types on the neighborhood scale for instance can be assessed using these two indexes. If the floor area of each building use i (office, residential, shop, retail, etc.) is $\mathrm{F_i}$, the respective proportion of each use, noted $\mathrm{p_i}$ is equal to the ratio of $\mathrm{F_i}$ over the total floor area. The two diversity indexes can be computed using the following formulas:

- Simpson's diversity index: $\mathrm{D_{Simpson}} = 1 - \sum_i {p_i}^2$
- Shannon's diversity index: $D_{shannon} = -\sum_i p_i \log{(p_i)}$



Diversity of economic activity in Barcelona (Shannon's index). Agencia d'Ecologia Urbana de Barcelona

Principle 5: HIGHLY CONNECTED NETWORKS

Explanation of the principle

With 37 million inhabitants, Tokyo-Yokohama is both the largest city in the world in terms of population and a giant leaf-like urban structure containing many smaller leaves. Its extraordinary fractal leaf structure (leaves within leaves within leaves) provides both local human scale fine grain connectivity and global complex order and connectivity. Instead of collapsing under the weight of its gigantic scale, the leaf structure of Tokyo provided the city and extraordinary resilience and adaptive potential. Tokyo street patterns grew inwards organically with smaller and smaller twigs while the subway and urban rail system by far the longest in the world (6 fold longer than the second one in Seoul) is also by far the most complex and the most fractal like structured. This fractal complexity ensures the stability of Tokyo urban system and its resistance to minor or major perturbations such as the tsunami and fire of 1923.

More generally, the fundamental notion that defines the stability and resilience of systems is that states are only stable if perturbations reinforce rather than destroy them. Dynamically stable urban systems are those that display, like Tokyo, an enormous number of geometric and functional connections structured in a scale-free manner. That means that connectivity exists at all scales with a distribution of connections adapted to the functional needs of each scale, but with no connective scale dominating the others. In simple terms, resilient cities must not have only lanes, neither only highways but a full spectrum of streets of various lengths, width and spans adapted to different speeds and to different flows. When some connections are cut, others are created to compensate for the cuts and maintain the urban system in operation.

Hierarchical trees in nature or in many engineered systems such as road or energy distribution networks are entirely disconnected on a given scale: even if two twigs are spatially close, if they do not belong to the same branch, to go from one to the other implies moving down and then up all the hierarchy of branches. Urban highways, car-oriented infrastructures, centralized energy infrastructures are trees: they separate urban elements and don't connect them at local scales. They make distant parts accessible trough mobility upward and downward the hierarchy but they don't relate close urban elements; they are organized along a command hierarchy where one cannot access close elements without ascending or descending part or the whole command structure of the system.

Counteracting the vulnerability of contemporary Chinese cities requires a real paradigm reversal, and a shift from a mono-scale conception to a scale-free conception of cities. Only multi-connected scale-free structures, similar to natural leaves, can secure optimal efficiency and resilience of variable flow networks, while limiting the propagation of local perturbations. A scale-free distribution of connections, where one can find a complex web of streets of different widths at any degree of resolution, creates a high connectivity at all scales. The most local levels of the city are as densely connected as the intermediary and global levels. Each level of resolution (when one zooms in and out) reveals street patterns that connect densely with the appropriate width and range.

The street network should include a variety of street types based on adjacent land uses and character of streets. Street connectivity should be promoted and accessibility should be enhanced, using a balanced street network:

- A human scale, highly walkable, dense, fine grain and connected network of narrow streets that improves accessibility, recognizing walking access, instead of speed of travel, as a priority
- A network of wider streets that rapidly connect distant parts of the city and connect the city to neighboring jurisdictions, while making good use of public transportation systems (i.e., tramway, bus rapid transit).

Why it matters for climate adaptiveness and urban resilience

A series of connections whose intensity obeys a scale-free distribution (that translates mathematically into an inverse power law or a Pareto distribution) increases resilience by preventing rapid and catastrophic fluctuations from spreading quickly through the system and disorganizing it. There should be few long-range connections and these connections should be weak enough to prevent the spread of disrupting fluctuations. On the other hand, a great many strong short-range connections ensure the system's resilience though local clustering and multiplicity of alternative paths.

This network organization increases its robustness against random failures. Such failures might be small-scale failures (local transport network disruption, local energy supply disruption, etc.) or large-scale ones. London or New York subways are for example resilient as there are alternative paths when one connection between stations is randomly cut. For the same reason, the channeling of car traffic into a very reduced number of very large channels (the urban highways and ring roads) is responsible for the congestion problems in Beijing and will lead to a complete disruption in case of natural disaster due to climate change. Too many connections of the same type in a single channel may overload the channel's capacity. In constrained hierarchical systems, collector roads gather the traffic from lower-level paths and end up congested. Non-constrained connections of a wide variety of types create a less hierarchical network that is connected in a much more diversified way. This prevents the saturation of a single channel or gridlock caused by congestion at a node where all paths converge. The different networks, on different scales, need not coincide. If they do, network saturation will take place faster. A good example of a resilient network is the Tokyo subway, which consists in multiple superimposed and intertwined networks.

The multiple connectivity and scale hierarchy that leaves and cities have in common enhance both their efficiency and their resilience. Firstly, the loops that these structures contain, as Francis Corson has demonstrated, (Corson, 2010) manage variable flows more efficiently. One of the characteristic features of urban flows is their extreme variability, both in time and in space. The leaf structure absorbs these variations by distributing flows along different possible paths. This is impossible in a tree-like structure, where there is only one path between two points.
Secondly, the leaf structure imparts greater resilience to a network. When a branch of a tree is cut, all those that grew from it will die indeed. In a leaf, if a vein is interrupted, the redundancy of the network will allow the flow to get around the interruption via secondary paths, so that it will only be partly slowed down by the degradation of the network. This is why cities structured like leaves are more resilient. Just imagine that a path is blocked by an accident: the flow (of energy or of cars) is simply deviated onto other paths to irrigate the side beyond the perturbation. A part of the leaf's network can be amputated and the leaf will go on living and converting solar energy into nutrients. Thanks to scale invariance, nature has provided for redundancy on all scales to ensure the permanence of its structures. Resilient cities are those whose networks, like the veins of leaves, display a large degree of redundancy. If there are many ways of getting from one point of the city to another passing through different nodes, then cutting a connection between two nodes will not keep the network from working.

Metrics to assess the principle

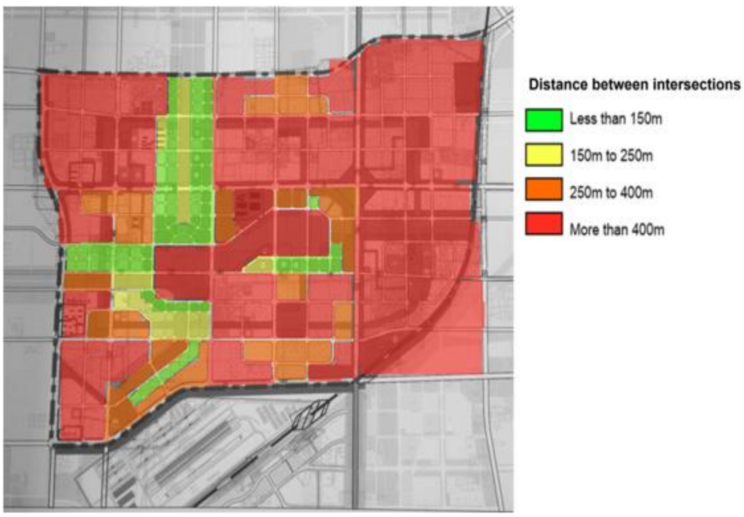
The multiplicity of connections enhances the resilience of a city and its adaptive evolution. The more connections there are, the more likely they are to be redundant.

Social networks as well as street networks in resilient urban systems show characteristics that are summarized in the term of "small world" properties. In particular they show a high level of clustering, meaning that neighboring nodes are also linked in a high proportion. Complex evolved street patterns show this small world property when a street is considered as a node and its intersection with another street as a link. Complex subway systems, such as the ones in Tokyo, London, Manhattan, tend to evolve with a long time and multiple decisions towards the same structure as social networks. From the "small world" properties a number of measures of efficiency can be derived such as characteristic path length, global and local efficiencies.

These characteristics can be measured and assessed using metrics from graph theory:

- Number of intersections per km²
- Distance between intersections
- Cyclomatic number
- Clustering coefficient
- Betweenness centrality

International benchmarks for street network connectivity: number of intersections per km² (left) and average distance between intersections (right)



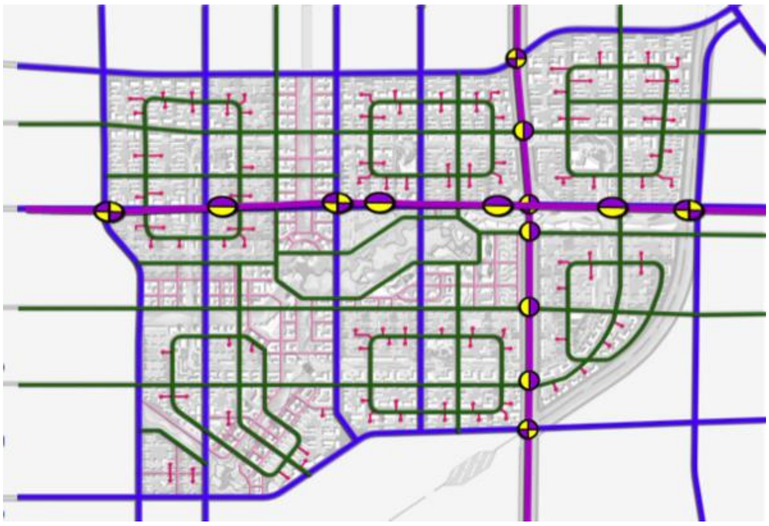
Distance between intersections in Taiyuan Shanxi Science Town

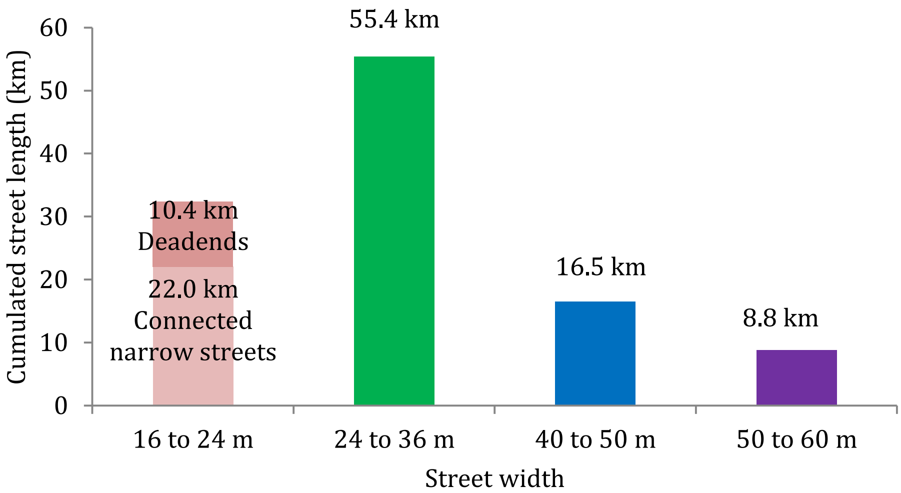
For the World Bank, the Urban Morphology Institute has carried a comprehensive assessment of the core area of Taiyuan Shanxi Science Town, including an extensive street network analysis.

The street network of the master plan displays four street width:

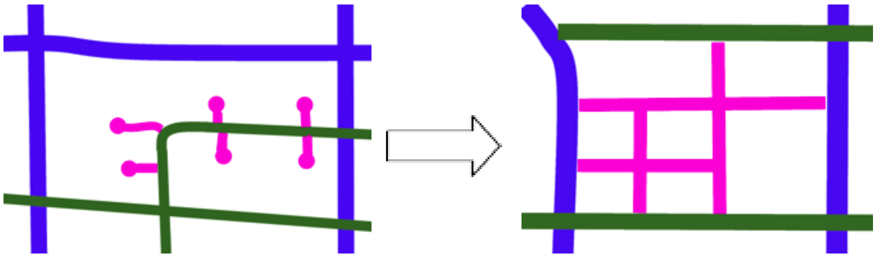
- Large arterials (purple), 50 to 60 m wide

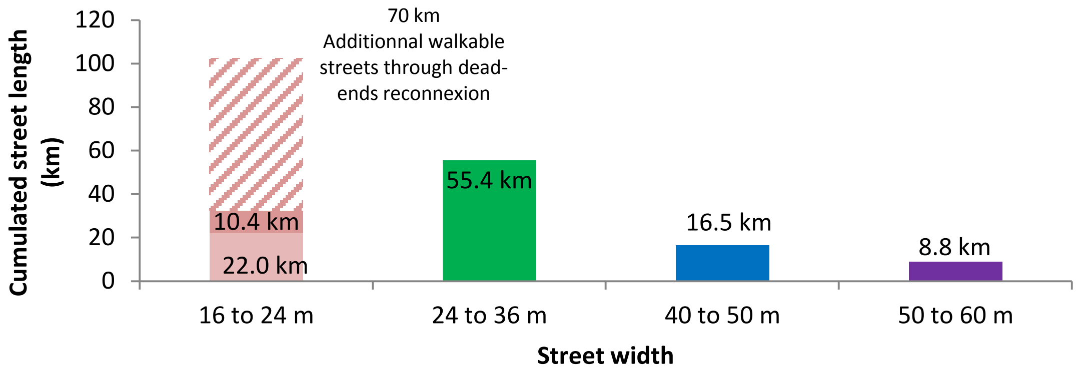
- Secondary arterials (blue), 40 to 50 m wide,
- Connectors (red), 24 to 36 m wide
- Two types of distributors of 16 to 24 m wide: dead ends (pink) and connected narrow streets (light pink). The connected narrow streets correspond to the above mentioned small block fine grain areas.





Street network distribution in Taiyuan Shanxi Science Town





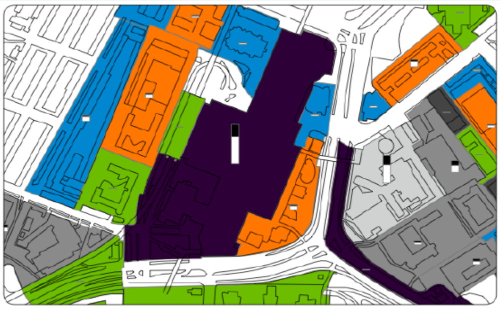
Design strategy to increase connectivity in Taiyuan Shanxi Science Town core area, Urban Morphology Institute ©

Principle 6: SYNERGY

High density and mixed use can be considered as key strategic assets of urban areas that help to use energy more efficiently through synergy approaches resting upon energy systems integration and compact energy-efficient housing. As they reinforce urban density and mixed use, infill redevelopment strategies make it possible to implement new strategies to decrease the energy and resource intensity of urban communities. The local diversity of building uses and building types induces a local diversity of demand loads. A key issue in improving the efficiency of urban energy systems is an optimal matching of various energy-demand categories with energy-conversion processes. Housing, office, shop, retail or public buildings have very different load profiles. This diversity of load profiles supports the implementation of synergy strategies such as:

- Peak shaving strategies: as consumption peaks in different buildings types do not happen at the same time of the day, high levels of local mixed use contribute to shaving consumption peaks
- Cascading strategies consisting in recycle energy flows according to their quality (electricity, mechanical, thermal) to improve the energy process overall.

Synergy strategies increase the resilience of urban energy systems. Indeed, cascading and recycling energy flows according to their quality (electricity, mechanical, thermal) improves the stability and the resilience to unexpected events (flood, drought, storm, peak load, etc.) of energy networks.



Energy mix on the district scale (REAP)

Principle 7: GREENING AND WATER RECYCLING

Changes in extreme rainfall could cause the amount of sewage released to the environment from combined sewage overflow spills and flooding to increase by 40% in some cities. Responses include strengthening wastewater, stormwater and runoff infrastructure. Risks to freshwater resources, such as draught, can cause shortages of drinking water, electricity outages, water-related diseases, higher food prices and increased food insecurity from reduced agricultural supplies. Responses include encouraging water recycling and grey water use, improving runoff management and developing new/alternative water sources; storage facilities and autonomously powered water management and treatment infrastructure. On the one hand, the city's green infrastructure helps reduce GHG emissions by serving as a carbon sink, enhancing the pedestrian and cycling environment, regulating energy consumption, enabling environmentally sustainable nutrient recycling and local food production. On the other, it improves resilience through flood mitigation, erosion control, and maintaining water availability.

Principle 8: URBAN-RURAL INTEGRATION

All aspects of food security are potentially affected by climate change, including access to food, food utilization and price stability. Local responses include preserving arable land by limiting sprawl and by efficient land use, support for urban and peri-urban agriculture, and immersion of compact urban nodes (less than 10 minutes walk) within accessible continuous green spaces.

AUTHORS' PROFILE

Serge Salat

Founding President of the Urban Morphology Institute, Serge Salat is a practicing architect, urban planner and designer. He is a graduate of École Polytechnique and ENA and holds 3 PhDs in Economics, Architecture and Art History. His most creative designs have been exposed in prestigious places (Triennale di Milano, Centre Pompidou) and featured by major media (Architecture Now!, Frame or the Wall Street Journal). He is recognized as a leading expert and central figure in the field of urban morphology, urban policy and complexity science. He advises leading international institutions in the field of urban planning and urban policy, among which the United Nations, World Bank, IPCC, CDC and AFD. As a project director, he supervised large projects such as international airports, high speed train stations and Eco-cities. He is the author of two major books on urban morphology, published numerous peer-reviewed publications and is often invited to give keynote speeches at international conferences.

Loeiz Bourdic

As an engineer and economist, Loeiz Bourdic is co-founder and project manager at the Urban Morphology Institute. His main focus is on bridging the gap between hard science and urban policies. He works on the transposition of quantitative data analysis into urban strategies to support urban investments and policy decision making processes. He is the author of several peer-reviewed papers. He holds a Master in Engineering from École Polytechnique and a Master of Science in Environmental Economics & Policy from Imperial College, London and is preparing a PhD at EHESS.