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PLANNING & GOVERNANCE
PETER HO

Peter Ho is Chairman of the Urban Redevelopment Authority (URA). This article is adapted from his keynote speech at the World Cities Summit 2021 webinar, Making Sense: Leveraging the Science of Cities, jointly organised by the Centre for Liveable Cities (CLC) and the Urban Redevelopment Authority.

Leveraging the Science of Cities to Solve Complex Urban Challenges

People and their interactions are part of the complex systems of cities.
Image: JC Gellidon / Unsplash

Cities are enormously complex.

In each city, every person, also referred to as an agent, interacts with each other and with the environment. These interactions are usually hidden from view and often unpredictable in nature. As a result, they can defy conventional analysis and produce outcomes that confound and astonish. How do we make sense of all of it?

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Cities as Complex Systems

To understand how a city works, we must understand not only the behaviour of each person living in it, but also how they interact with others, and how they behave as a whole. Given the state of science in the past, this would have seemed an enormous—even insurmountable—challenge. But the situation is changing.

The Challenge of Reductionism

For hundreds of years, the basic approach to understanding complex systems was *reductionism*. It reduces complex systems—like cities—into smaller and simpler parts that are easier to study, analyse and evaluate. Instead of studying cities as a whole, their complex problems are sliced and diced into digestible pieces such as functional areas like transport, environment, energy, public health, social dynamics, economics and so on. However, there is a flaw in this approach. The assumption is that when these smaller parts are reassembled, the whole will be approximate to the real world. Unfortunately, outside the realm of the hard sciences, reductionism has not been very useful in predicting the holistic behaviour of complex systems like cities, whether they will flourish or fail.

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Interdependency and Emergence

Chinese philosopher, Lao Tzu, once wrote that "everything is connected, and everything relates to each other". People as well as other agents are not independent. Instead, they are *interdependent*—interacting and influencing each other in ways that defy a deterministic or linear analysis. Their interactions lead to outcomes that are inherently unpredictable *ex-ante*, and are only revealed when they occur. In other words, we only know what is going to happen when it happens. This is the property of *emergence*, which characterises complex systems.

The Law of Unintended Consequences

As a result of emergence, complex systems are prone to the *Law of Unintended Consequences*. In other words, intervention in complex systems can lead to unforeseen and often undesirable outcomes.

In transport, for instance, traffic congestion, car accidents, air pollution and global warming are all unintended consequences of the advent and widespread adoption of the automobile.

Adopting an Interdisciplinary Approach

Thus, it is important to look at complex systems not just in terms of their component parts, but also as a whole.

However, for a very long time, investigating the features of complex systems like cities at a holistic level was eschewed

Rush hour traffic congestion—an undesirable outcome of complex urban systems.
Image: epSos.de / Wikimedia

in favour of investigating the properties of the components. It was easier and the scientific tools for analysis at that micro level were already available.

Part of the reason for this is that scientists have been conditioned over centuries of reductionism to dissect the complex world into smaller and less complex parts, and to favour explanations framed at the lowest level of scale.

However, in recent years, efforts to study the overall properties of complex systems have begun to attract interest. Pioneers in the field are now looking at problems of complexity holistically, acknowledging that the properties of higher-level entities like cities are often quite distinct and unrelated to those of the components that constitute them. This is a radical departure from studying problems within disciplinary silos. It is a holistic approach in which academic silos are collapsed in favour of interdisciplinary and integrative study.

Interdisciplinary study achieves a holistic understanding not by rejecting reductionism but by building on it. That combination of holism and reductionism makes it possible for interdisciplinary study to address the big challenges of today, including, of course, urbanisation.

In Singapore, as well as in countless cities around the world, the urban planning process considers the complexity of packing in housing, green space, industrial land, commercial and retail space, land for transportation needs, and other public infrastructure like hospitals and power stations. This process involves integrating the perspectives of economic, social and development agencies, as well as consultations with various stakeholders in the private sector and the general public. This Whole-of-Government approach is in essence an interdisciplinary approach to planning that enables all stakeholders to better understand interdependencies and implications of land use and strategic decisions.

Artist's impression of Singapore's first smart and sustainable town in Tengah.
Image: Housing & Development Board (HDB), Singapore

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New Tools for the Science of Cities

Paving the way ahead are complexity science tools, such as agent-based modelling, which examine how agents in a complex system interact with one another and influence system behaviour. These tools, when applied to cities, are beginning to provide fresh and useable insights that deterministic models have failed to produce.

To explore how such tools can be used in Singapore's context, government agencies are conducting research and acquiring confidence in the utility of these tools. This is a major step towards establishing a science of cities as a foundation for urban planning.

The Emergence of Big Data

Furthermore, the availability of data to assist in the quantitative study of cities has grown significantly in recent years. There is so much data being generated now that the amount of data created over the next three years will be more than the data created over the past 30 years.

The agents within a city—the people, public and private institutions, markets and networks are all contributing to what we now refer to as *big data*. The key difference is that we now have the technology both to capture big data, as well as to process it.

Artist's impression of Singapore's pilot polder development at Pulau Tekong.
Image: HDB, Singapore

Singapore's Smart Nation initiative is in essence an exercise to systematically capture this big data. When combined with high performance computing, increasingly powerful data analytics, and Artificial Intelligence, such big data can be converted into useful insights into new patterns and trends. This is a truly powerful capability that is vital to the development of the science of cities.

The tools of complexity science combined with the insights from big data can help us to "see" the city through new lenses. What then are the fresh possibilities to imagine and shape a different and better city for the future? More importantly, if we can imagine a different city of the future, we can take active steps toward realising it. This is what a good science of cities should be able to achieve.

Emergence of a Science of Cities in Singapore

In Singapore, there is no shortage of research into urban matters. The Lee Kuan Yew Centre for Innovative Cities, the Singapore-ETH Centre's Future Cities Laboratory, the Lee Kuan Yew School of Public Policy and a host of other university-based centres, laboratories and institutions study aspects of the urban setting. The next step is to integrate such research—combining the reductionist with the holistic. In time, this will evolve into the science of cities. Already in Singapore, the Centre for Liveable Cities (CLC) is taking the lead to integrate the efforts of these various research institutes, using new tools of complexity science.

Embracing Experimentation

With complex systems like cities, exploration and experimentation are often more valuable than relying

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on predictions of analytical models. There needs to be a willingness to try things out, to experiment with new approaches and solutions. The approach is to probe, sense patterns and to act, even in the absence of complete information. Pilot programmes, demonstrators, prototypes and "beta versions" should be embraced as a foundational approach to deal with complex systems. If they work, they are evidence that the hypothesis can be scaled up. If they fail, the damage is mitigated.

In Singapore, this approach is adopted for some complex urban challenges. For instance, polder development is being piloted at one of its islands, Pulau Tekong, where land is being reclaimed in a sustainable manner and at lower cost. The polder technology can also be an adaptation measure for future sea level rise due to climate change. Elsewhere, whole districts such as the Punggol Digital District for the smart digital economy and Tengah for sustainability will be living laboratories for researchers and companies to pilot new ideas and solutions, and for people to explore and embrace new lifestyles.

In 2016, a floating solar farm was test-bedded at Tengeh reservoir in western Singapore. With its success, the pilot was scaled up 60 times to create one of the world's largest floating solar farms. This will power our local water treatment plants, making Singapore's waterworks one of the very few in the world to go 100% green.

Punggol Digital District is designed to enable collaboration between industry and academia through the sharing of each other's spaces and facilities.
Image: JTC

Floating solar farm at Tengeh Reservoir.
Image: Sembcorp Industries

Conclusion

As Geoffrey West, the distinguished theoretical physicist at the centre of efforts to develop a science of cities, observes, the future of humanity and the long-term sustainability of the planet are inextricably linked to the fate of our cities. This is a compelling reason to develop a science of cities that provides a framework for understanding how they work, as well as what drives their growth sustainably.

Many of the building blocks for the science of cities are already in place. The tools of complexity science are steadily improving; big data, as well as the technology to collect and analyse it are now available. With the long experience in studying cities at the component level, the next step to take is to study them holistically.

Lastly, beyond taking an interdisciplinary approach, fostering partnerships among companies, government agencies and communities in pilots and strategically-directed research funding are also key.

With the assembly and integration of these different building blocks, we can look forward to discovering new possibilities and knowledge that can lead to the development of better plans and policies to ensure Singapore's future liveability and sustainability.