no.6 | September 2017

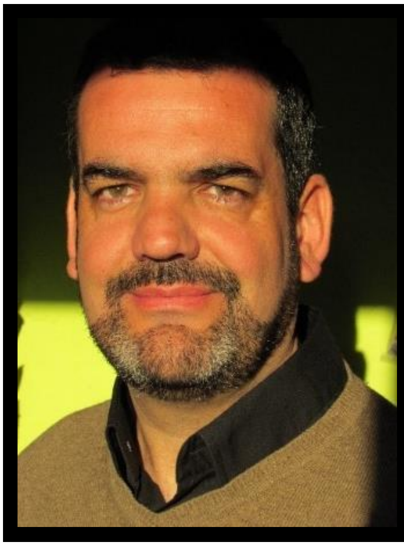
URBAN HEALTH AND WELLBEING
A SYSTEMS APPROACH

POLICY BRIEF

Advancing Urban Health and Wellbeing Through Collective and Artificial Intelligence: A Systems Approach 3.0

Franz W. Gatzweiler

1. Complex problems of urban health and wellbeing cause millions of premature deaths annually and are beyond the reach of individual problem-solving capabilities.
2. Collective and artificial intelligence (CI+AI) working together can address the complex challenges of urban health
3. The systems approach (SA) is an adaptive, intelligent and intelligence-creating, "data-metabolic" mechanism for solving such complex challenges.
4. Design principles have been identified to successfully create CI and AI. Data metabolic costs are the limiting factor.
5. A call for collaborative action to build an "urban brain" by means of next generation systems approaches is required to save lives in the face of failure to tackle complex urban health challenges.



About the author

Professor Franz Gatzweiler is with the Institute of Urban Environment at the Chinese Academy of Sciences, and Executive Director of the Global Interdisciplinary Science Programme with the International Council for Science, Health and Wellbeing in the Changing Urban Environment: A Systems Approach. Prof. Gatzweiler was Research Fellow at the Ostrom Workshop in Political Theory and Policy Analysis, Indiana University, Bloomington following his position as researcher at the Humboldt University of Berlin and Bonn University in Germany. Prof. Gatzweiler received his habilitation for independent teaching and research in the field of Resource Economics from the Humboldt University of Berlin. His research interests lie in institutional and resource economics, complex socio-ecological-technological systems, collective intelligence, science management, and science communication.

franz@iue.ac.cn

CHALLENGES OF URBAN HEALTH AND WELLBEING

> "As our world becomes more and more closely connected, through all kinds of electronic communication, it will become more and more useful to view all the people and computers on our planet as part of a single global brain. And perhaps our future as a species will depend on how well we're able to use our global collective intelligence to make choices that are not just smart but also wise." Malone 2015

Many problems of urban health and wellbeing, such as pollution, obesity, ageing, mental health, cardiovascular diseases, infectious diseases, inequality and poverty (WHO 2016), are highly complex and beyond the reach of individual problem solving capabilities. Biodiversity loss, climate change, and urban health problems emerge at aggregate scales and are unpredictable. They are the consequence of complex interactions between many individual agents and their environments across urban sectors and scales. Another challenge of complex urban health problems is the knowledge approach we apply to understand and solve them. We are challenged to create a new, innovative knowledge approach to understand and solve the problems of urban health. The positivist approach of separating cause from effect, or observer from observed, is insufficient when human agents are both part of the problem and the solution.

Problems emerging from complexity can only be solved collectively by applying rules which govern complexity. For example, the law of requisite variety (Ashby 1960) tells us that we need as much variety in our problem-solving toolbox as there are different types of problems to be solved, and we need to address these problems at the respective scale. No individual, has the intelligence to solve emergent problems of urban health alone.

COLLECTIVE AND ARTIFICIAL INTELLIGENCE

Collective intelligence (CI) is defined as the intelligence of a group created by sharing knowledge and working together toward the same end to solve common problems. This is essential for addressing the challenges that emerge from complexity and uncertainty since it exists beyond the reach of individual problem-solving. Design principles for CI have been referred to as "genes" (Malone et al. 2010). These "genes" are the principles upon which we can find answers to the questions of what needs to be done, why and how, and by whom. For example, the genes that drive motivation, e.g., love and glory, are principles that successfully operated in the collective development of the Linux operating system. Ostrom (2005: 258) referred to them as "design principles." Wikipedia, TEDx, or the Urban Health Collaborative at Drexel University and the Climate CoLab at Michigan Institute of Technology, are additional examples of CI.

We now know that people are more successful at solving common problems collectively than in hierarchies, states, or markets. Interaction, communication, and perception of commonly-faced problems are essential prerequisites. Smaller group size and homogeneity tend to be supportive, yet, broad participation in decision-making and strong interpersonal skills, as well as female presence and diversity in group composition (Malone and Klein 2007), are more closely associated with CI. Speaking a common language and sharing mental models and conceptions (Dyball and Newell 2015) to define the challenges and understand how they are interrelated lead to better solutions. Success of individual or expert intelligence depends depends solely on context when either first-time decisions are made or decision-makers learn from past mistakes. Katsikopoulos and King (2010) found that groups were generally more intelligent decision-makers whereas individuals were only successful when relying on previous decision outcomes. Thus, in order to arrive at a different paradigm, by definition, we must look to CI.

Artificial intelligence (AI) has emerged in an attempt to improve knowledge creation by processing big data with high performance computing, and machine learning. As a result of the evolution of intelligence we have reduced the costs of data processing and learning. AI makes transforming data into knowledge faster and more cost effective. Large groups of people can better communicate and act collectively if facilitated by AI. Multiple examples now exist to show us how CI and AI, operating together (CI+AI), enable people to understand and address complex problems of urban and planetary health on a global scale (Weld et al. 2014).

Essential for creating CI and AI are the costs of exchanging and processing information. Data processing, interaction, and collective action are factors that pose the greatest obstacle to building CI+AI because the costs are essentially determined by group size. As the group increases, the more unmanageable and costly become information exchanges, data flows, processing of data, and coordination of collective action.

In the past, the evolution of hierarchy (and modularity within hierarchy) developed out of the need to problem solve on a large social scale. It overcame the same obstacle of decreasing marginal intelligence with increasing group size (Powers and Lehmann 2017) when population size increased by becoming an important driver of network performance and adaptability (Mengistu et al. 2016).

In today's rapidly changing environments and growing societies, hierarchies continue to face increasing costs of information processing. As a result, they have turned to heterarchical-participative networks to solve problems characterized as complex, uncertain, and dynamic. Similar to polycentric organization (Aligica and Tarko 2012), the heterarchical organization has multiple command centers to accommodate the increasing participative cultures, autonomy, and high levels of self-determination, as well as ongoing dialogue – a structure more conducive for building CI. "The power of heterarchies lies in their flexibility and capacity for innovation" (Schwaninger 2006:31).

EVOLUTION OF THE SYSTEMS APPROACH

The systems approach (SA) to urban health and wellbeing (Gatzweiler et al. 2017, Bai et al. 2016) has been developed to better understand and solve complex problems of urban health. It combines both systems methods and models to understand problems emerging from complexity and the engagement of stakeholders. Participatory modeling of complex urban health problems, like resilience, has been successfully developed by the Ecological Sequestration Trust. In principle, the SA is an adaptive, recursive, cognitive mechanism at work in nested systems of various social, ecological, territorial, technological, or cyber spaces. The SA is a co-evolutionary process of, let's call it, a "data metabolism," transforming data into knowledge and knowledge into procedural and structural change (referred to as "action" among human agents) in response to external system changes. The mechanism of the SA is a driver of evolution.

The SA operates, for example, in biology, knowledge generation, or in social organization and action. It can be seen as analogous to the process of the adaptive cycle described by the concept of panarchy (Gunderson and Holling 2001) – a mechanism that is driven by two mutually reinforcing processes: a catabolic process which breaks down complex wholes into smaller parts; and an anabolic process which rebuilds. The process at work can be portrayed as intelligent and as self-creating intelligence. It facilitates the building of collective and artificial intelligence and, in turn, requires both types of intelligence for data processing, knowledge creation and action (Komninos 2008).

The SA itself is evolving. Its evolution (Figure #) is characterized by data collection and processing mechanisms. These processes are most likely to happen where and when the costs of information exchange and flow are lowest. The lower the costs, the lower the resistance to the data-metabolic process and the better the SA works/performs, thus, the SA not only drives the evolution of systems, it evolves. The path of its evolution leads along avenues of least resistance, similar to the way electric voltage in lightning follows a path through the atmosphere.

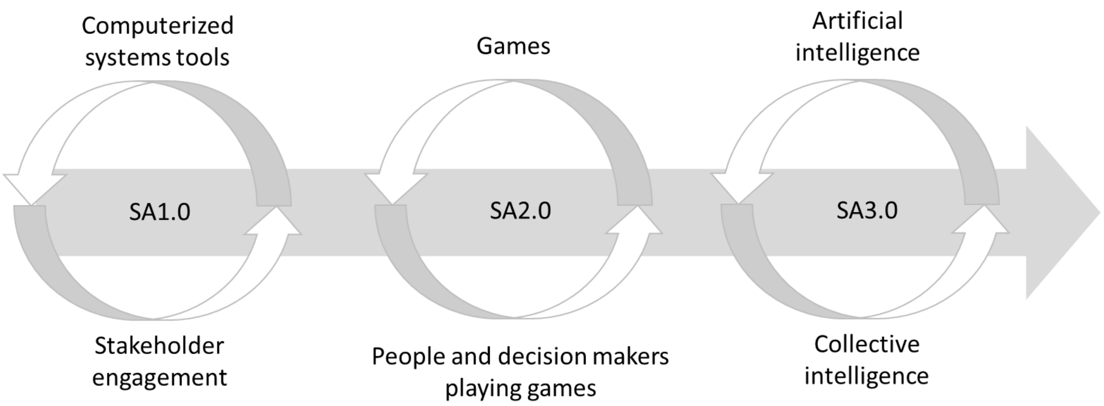


Figure: The evolution of the systems approach from SA1.0 to SA3.0

In the evolution of the SA, it is the SA1.0 that tackles problems of complexity in socio-ecological-technological systems (SETS) as it combines complexity modeling with stakeholder engagement. The process can be very costly, particularly when bringing together engaged experts and citizens, creating a common understanding of the problem, and communicating common goals and outcomes.

SA2.0 then emerges from any other alternative approach as the most cost effective with regard to its data-metabolism. It integrates engaged citizens into the model which simulates the environment in which urban health problems emerge. What was a "virtual model' in SA1.0 now enters the real world where the engaged citizen plays the game. By playing repeatedly, the human agent learns how to solve complex problems better than before. Individual and collective intelligence can improve and new skills develop. For example, city developers can learn by playing games like Sim City, City Skylines or IBM's City One, or nation state managers can learn by playing 'Ecopolicy'.

A CALL FOR ACTION: SA3.0 and the URBAN BRAIN

Today, the best players of the Chinese boardgame GO have lost against Google's AI's Deepmind machine using intuition, something once believed to be a uniquely human trait. AI developed by Elon Musk's Open AI team recently won against a world champion of the online multiplayer game DOTA2 showing us that machines can outperform humans. Humans are not simply teaching machines, they are learning from them.

SA3.0 is the next phase in the evolution of the SA. It would advance the human learning process even further by applying (utilizing, integrating, incorporating) AI. In the SA3.0, CI and AI, mutually supporting each other, would produce better solutions in complex problem-solving processes for solving problems of urban health and wellbeing. The algorithms of AI would improve the data processing and learning process, while the rules and regulations in society would support the building of CI. The SA3.0 would be the mechanism at work to drive the mutual enhancement CI+AI to shape the collective brain of a city:

$$(CI+AI) \times SA3.0 = \text{collective urban brain}$$

Working together with CI and AI innovators would advance the urban brain's learning curve by applying variations of the SA in order to build urban intelligence – intelligent cities that are resilient and able to adapt to change for the health and wellbeing of its inhabitants. Facing millions of premature deaths each year is a clear indication for collaborative action to build the SA3.0 urban brain in order to overcome the increasing risks of urban health and wellbeing that exists in our world today.

References

Aligica P and Tarko V 2012. Polycentricity: From Polanyi to Ostrom, and Beyond. Governance 25(2): 237-262

Ashby RW 1960. Design for a Brain. The Origin of Adaptive Behavior. London:Chapman and Hall

Bai X, Surveyer A, Elmqvist T, Gatzweiler FW, Güneralp B, Parnell S, Prieur-Richard A-H, Shrivastava P, Siri JG, Stafford-Smith M, Toussaint J-P, and Webb R 2016. Defining and advancing a systems approach for sustainable cities. Current Opinion in Environmental Sustainability 2016, 23:69–78, DOI: 10.1016/j.cosust.2016.11.010

Dyball R and Newell B 2015. Understanding Human Ecology. A Systems Approach to Sustainability. London and New York: Routledge

Gatzweiler FW et al. 2017. Advancing Health and Wellbeing in the ChangingUrban Environment. Implementing a Systems Approach, Hangzhou: Zhejiang University Press and Singapore: Springer

Gunderson L and Holling CS 2002. Panarchy: Understanding Transformations in Systems of Humans and Nature. Washington,Covelo, London: Island Press

Katsikopoulos KV, King AJ 2010. Swarm Intelligence in Animal Groups: When Can a Collective Out-Perform an Expert? PLoS ONE 5(11): e15505. https://doi.org/10.1371/journal.pone.0015505

Komninos N 2008. Intelligent Cities and Globalisation of Innovation Networks. London, New York: Routledge

Malone TW and Klein M 2007. Harnessing Collective Intelligence to Address Global Climate Change Innovations: Technology, Governance, Globalization 2(3): 15-26

Malone TW, Laubacher R, Dellarocas C 2010. The Collective Intelligence Genome, MIT Sloan Management Review; Cambridge 51.3: 21-31

Malone TW 2015. Building better organizations with collective intelligence: Webinar MIT, Accessed Aug 14, 2017 at: https://www.youtube.com/watch?v=hu4ZXr40bSA

Mengistu H, Huizinga J, Mouret JB, Clune J 2016. The Evolutionary Origins of Hierarchy. PLOS Computational Biology 12(6): e1004829. https://doi.org/10.1371/journal.pcbi.1004829

Ostrom E 2005. Understanding Institutional Diversity. UK and New Jersey: Princeton University Press

Powers ST and Lehmann L 2017. When is bigger better? The effects of group size on the evolution of helping behaviours. Biol. Rev. 92: 902–920. doi: 10.1111/brv.12260

Weld DS, Lin CH, Mausam, Bragg J 2014. Artificial Intelligence and Collective Intelligence. Accessed Aug 14, 2017 at: https://homes.cs.washington.edu/~weld/papers/ci-chapter2014.pdf

WHO 2016. Global report on urban health: equitable, healthier cities for sustainable development. Geneva: World Health Organization

URBAN HEALTH AND WELLBEING
A SYSTEMS APPROACH

The *Urban Health and Wellbeing: a Systems Approach* (UHWB) programme, is a global science programme, of the International Council for Science (ICSU). The vision of the programme is: cities functioning as integrated complex systems which sustainably provide benefits for the health and wellbeing of its residents. It aims at (1) promoting and coordinating research, (2) developing and identifying data needs, (3) building and strengthening capacity and (4) communicating new knowledge.

The UHWB programme is sponsored by the InterAcademy Partnership (IAP) and the United Nations University (UNU). Financially it is supported by the Chinese Academy of Sciences (CAS), the Chinese Academy of Science and Technology (CAST) and the City of Xiamen.

The international programme office of the UHWB programme is hosted by the Institute of Urban Environment (IUE), Chinese Academy of Sciences (CAS) in Xiamen, China.

The Policy Briefs of the UHWB programme aim at highlighting and drawing attention to policy relevant findings and insights from research and researchers and communicating them with decisionmakers at all levels of society in order to encourage the co-creation of knowledge for healthy urban environments and people.

INTERNATIONAL COUNCIL FOR SCIENCE

iap SCIENCE RESEARCH HEALTH
the interacademy partnership

UNITED NATIONS UNIVERSITY

Editor: Franz W. Gatzweiler
Tel: +86-592 6190 761, franz@iue.ac.cn

Design: Studio COSICO, Berlin

Publisher: Institute of Urban Environment (IUE)
Chinese Academy of Sciences (CAS)
1799 Jimei Ave., 361021 Xiamen, China