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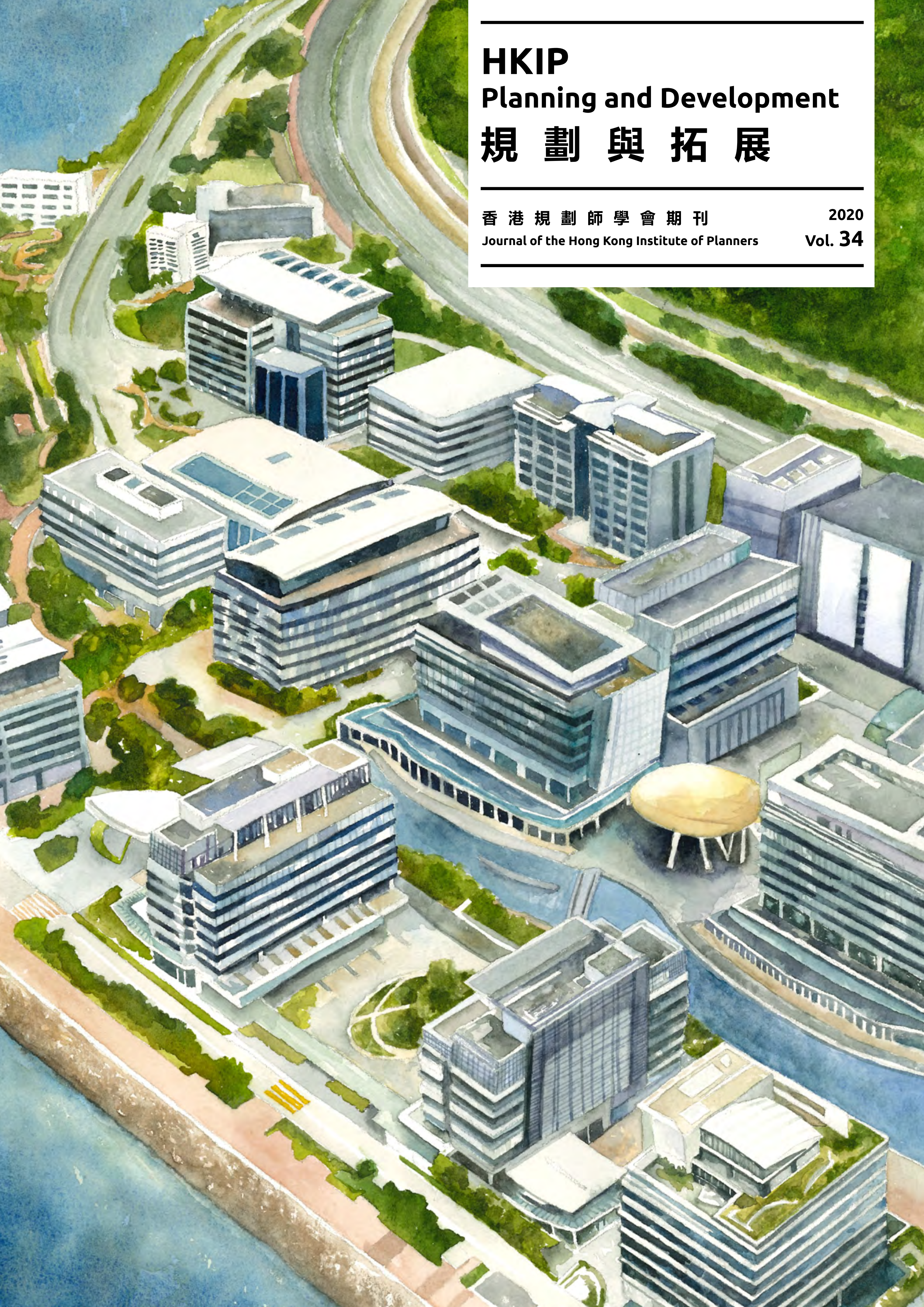

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*Feature*

# 'Wearable Infrastructure: an experimental demonstration'

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In the Eyes of the City Section of 2020 Bi-city Biennale of Architecture and Urbanism, a conceptual environmental management strategy, namely the Internet of Breaths (IoB) was introduced to increase cities' capacity for resilience against air pollutions (Lau *et al*., 2019). By infusing intelligence and data mining into everyday objects, the IoB leverages the power of real-time data to delineate an unambiguous picture of the critical socio-environmental issue.

IoB sets out a holistic framework for the promulgation of smart objects and deep urban analytics to enable strategic planning of preventative measures against air pollution among other global environmental disasters. The 2018 State of Global Air Report revealed that over 95 percent of the world's population are breathing harmful air, contributing to 3.1 million deaths in 2016 (Health Effects Institute, 2018). In developing regions, the population are exposed to even higher risks, where PM2.5 concentrations easily exceed 35. In 2016, a population-weighted annual average of 101 μg/m$^3$ was recorded in Bangladesh and 56 μg/m$^3$ in China.

The Dutch planning practice associated with water management demonstrates city resilience against natural challenges is reliant on mass public participation and communications (Woltjer, 2000). With a common rationale, IoB proposes an implementation mechanism comprising features of central coordination and citizen-driven actions. The two platforms form a feedback loop, which facilitates information exchange between the public and government institutions to assure mitigations are carried out with minimum delays and in a concerted manner. The two-fold system of IoB consists of a package of software and hardware components. On the public user end, IoB relies on smart air masks and a mobile application to collect deep data mining and distribute system information such as disaster alert. The public administration end performs information management and analysis through a real-time IoT environmental sensing network, which collects and enables deep analytics on the data from mass sources. The two-fold system aims at combining bottom-up data collection and top-down environmental management, thereby enabling effective communications and information management.

A number of theories suggest healthy behaviour can be steered by guiding the decision-making process with cognitive prompts (Niedderer et al., 2016). IoB is strategically designed to prompt such behavioural change (Brown, 2009). The smart air mask is a detection, protection, and communication interface for the public users to measure ambient air conditions. The smart air mask's built-in MQ135 sensor monitors real-time airborne contaminants and alerts the user to wear a mask when pollutant is detected. At the same time, the sound sensor in the mask connects brightness of the light to the sound of the user's breath, creating a synaesthesia of sound and vision, making the mask 'a lighthouse in the smog', warning people around of the pollution (see Exhibit 1). These design features, combined with the data architecture, foster an urban culture that citizens would gradually develop attention and knowledge to take protective actions against air pollution and public health.

comprises multiple layers of information upon which the government can take immediate mitigative measures or strategic actions (see Exhibit 2). On top of a digital interactive base map which provides geolocation references on multiple scales, the system simulates the distribution of pollutants and severity of such damage in different regions by conducting deep learning based on the discrete pollution data. Based on these advanced analytics, the system provides different capability options. The system can plan routes for handling large traffic influx and outflow for personnel evacuation and material logistics. The system also identifies the available infrastructure network, including medical facilities, pollutant control devices, emergency shelters, relief material reserves. By integrating all this information, the system generates useful

**Exhibit 1: Synaesthesia of sound and vision in pollution**

*(Illustration: Team IoB, 2019)*

insights for disaster management and insights for wider urban planning strategies by automation.

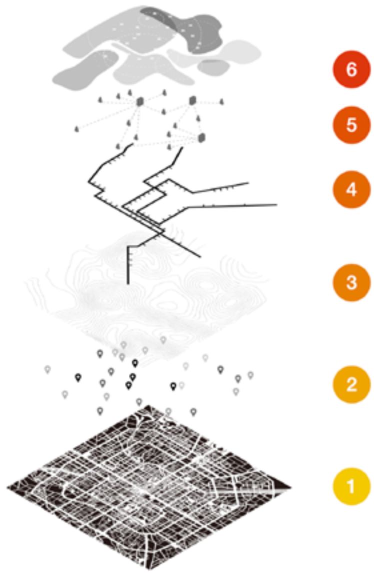
On the system-level, the masks serve as data nodes. Sensors on the mask transmit the AQI (Air Quality Index) information and the mask's GPS location to the cloud through the GSM (Global System for Mobile Communications) network, forming a real-time IoB environmental sensing network. The real-time air condition is then visualized on a digital map accessible to public users through a mobile app and a management interface accessible to the government to take strategic combating approaches.

The real-time IoB management interface

The data insights and auto-generated action prompts are managed and distributed among government, communities and citizens through an omni-channel workflow during pre-pollution, during-pollution, and post-pollution stages (see Exhibit 3). Within each stage, stakeholders are connected via the dual platforms to support and facilitate the actions of each other, enabling continuum across each service function including, monitoring and evaluation, manufacturing coordination, data management, infrastructure

**Exhibit 2: IoB system architecture**

| | | |
|---|---|---|
| 1 | **Base Map:** | Digital interactive map providing geolocation references on multiple scales |
| 2 | **Sensor Data Input:** | Pollution data collected from the user end |
| 3 | **Pollutant Distribution:** | Simulation results for severity of damage in different regions |
| 4 | **Evacuation Route:** | evacuation routes that could handle large traffic influx and outflow (for personnel evacuation and material logistics) |
| 5 | **Infrastructure network:** | Medical facilities / pollutant control devices / emergency shelters / relief material reserves |
| 6 | **Planning Strategy:** | Auto-generated planning advices based on data analytics |




*(Author, 2019)*

planning, and citizen actions and that such actions are conducted in a concerted manner. All these processes are supported and further refined as new data are fed into the platforms.

*Wearables and participatory governance*

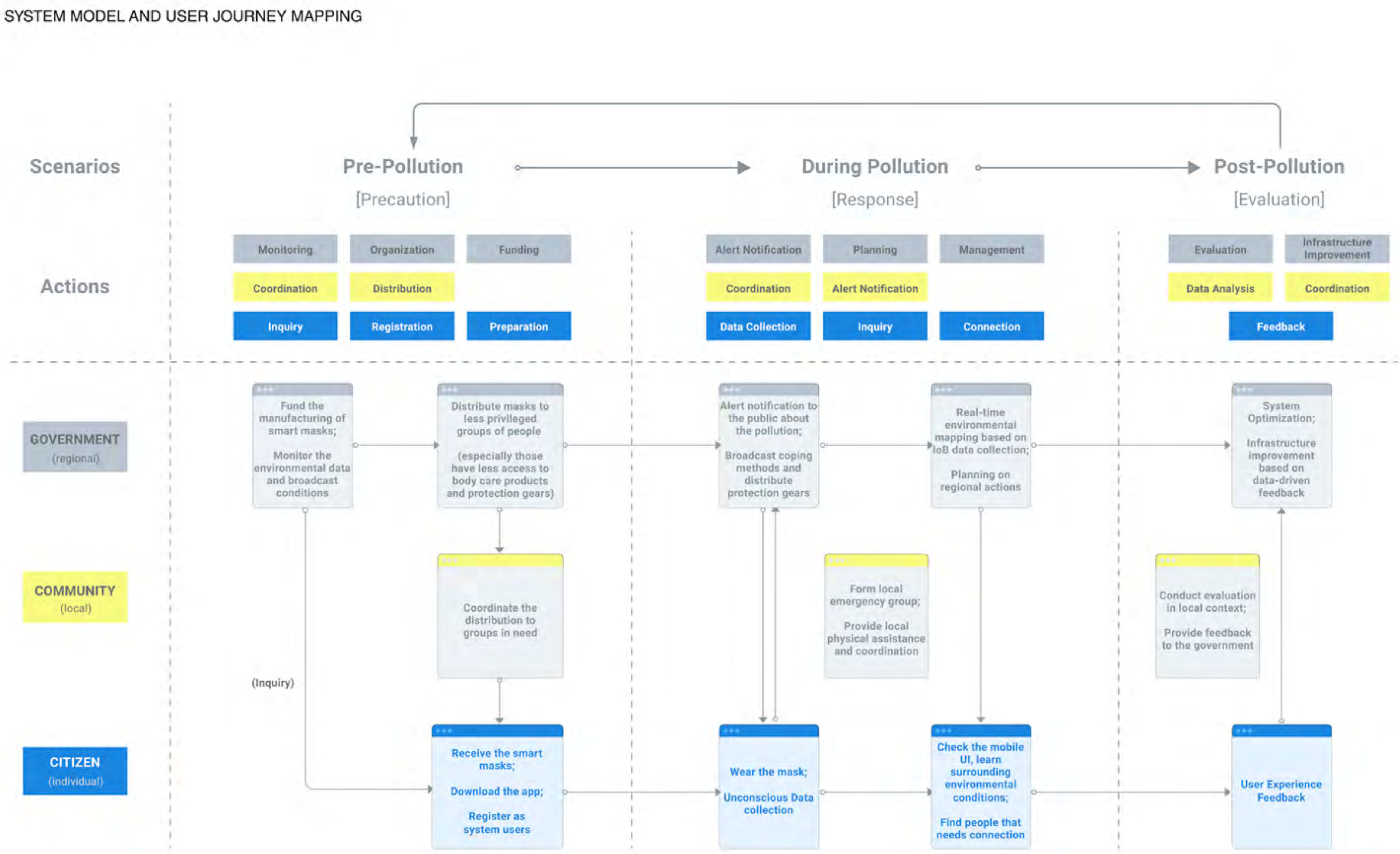
IoB is a demonstrator of the Goodchild's (2007) envisioning of "citizens as sensors" . It exemplifies how wearables are going to play a critical role in informing smart city development through tight integration of IoT and daily objects, promulgating a public-driven data culture and induce healthy behavioural change through thought design. These dynamic interactions make increased capacity resilience against natural disasters in a timely manner possible.

In the rapid rise of new generation 5G networks, cities are evolving as platforms of AI applications which fundamentally changed humans' way of life through deep integration of IoT and daily objects (Beroche, 2011). increasingly play a role in the management of societies driven by individual movements and actions. As much as the automobile has changed the way and the right of the way humans move around places, smartphones, and wearables such as smartwatches and trackers are fundamentally transforming the mechanism of information flow, human social networks and way of governance. Institutions such as Harvard Berkman Klein Centre, Oxford Internet Institute are making efforts to unleash the socio-economic value of new media and data technologies while mitigating their potential impacts through experimental with novel governance models.

Amid the increased occurrences of global disasters including global warming or the outbreak of pandemics, global governance is subject to new uncertainties that a centralized approach may expose the governance to greater risks of failing due to the lack of resilience against various risks including goal misalignment organisational misbehaviour (Lau, 2020). Furthermore, in the age of "connected societies", bottom-up input is perceived as an essential component to policy formulation and evaluation processes. Bottom-up led governance provides an opportunity for dynamic alignment of processes, goals and human labour, namely human-centres or distributed governance (Lau and Wang, 2020).

*In the rapid rise of new generation 5G networks, cities are evolving as platforms of AI applications which fundamentally changed humans' way of life through deep integration of IoT and daily objects*

**Exhibit 3: Omnichannel disaster management**




(Author, 2019)

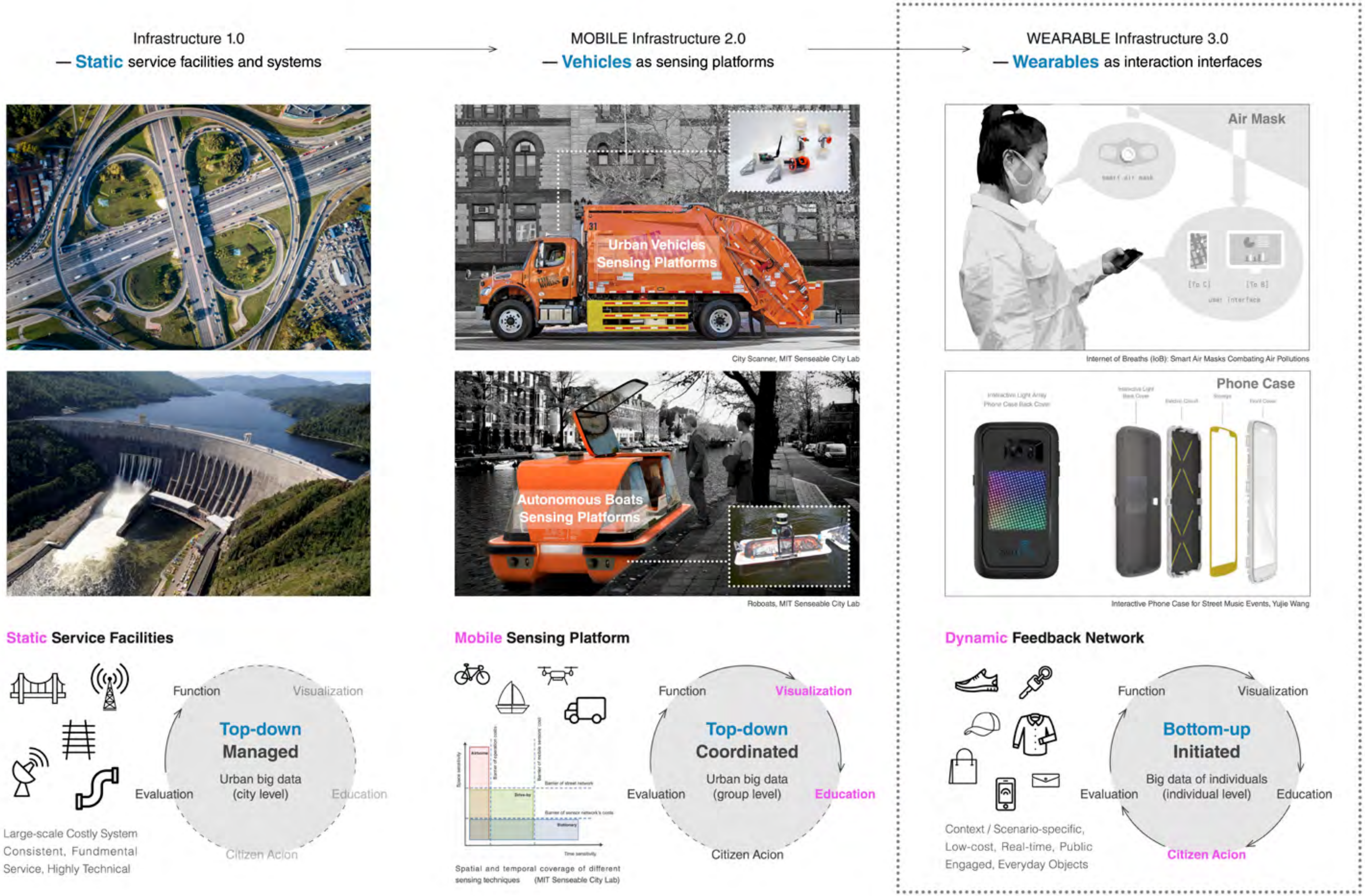
The authors interpret global infrastructural development in three phases (see Exhibit 4). The first phase, namely Static Infrastructure, is a top-down managed system and a linear process focusing on evaluation and functions. It attempts to transform cities through ubiquitous computing and embedding digital sensors into mega infrastructure such as large roadworks or tunnels (Gabrys, 2016). Because of the large scale, first phase projects are largely costly, consistent and highly technical.

The second phase, namely Mobile Infrastructure, leverages on vehicles or other forms of mobility as sensing platform. It relies on top-down coordination while also enjoying a higher degree of mobility. It inherits the linear process for evaluation and function from the first phase. However, it is equipped with visualization and education capabilities. Resembling cases include the 'City Scanner' project developed by the MIT Senseable City Lab which experimented with utilizing garbage trucks as moving data nodes to collect environmental data and to conduct sensing analysis (Anjomshoaa *et al.*, 2018).

The third phase, namely Wearable Infrastructure, leverages mobile devices (e.g. air mask, phone case) such as wearables as interaction interfaces. It is bottom-up initiated that it forms a dynamic feedback network. Its process grew into a loop of evaluation, function, visualization, education, and citizen actions. As it involves bottom-level inputs from everyday objects, it is context-and-scenario specific, more immediate and more extensive. The third phase also provides the opportunity to directly affect behaviours of an individual as the sensing functions are embedded within portable and sometimes personal items.

Development of wearable infrastructure also has important implications for public administration. The mobile platform provides a reliable connection between the government and its citizens, thereby offering a chance to radically shorten the processing time between an occurrence, and its follow-up actions including detection, notification and mitigation, with an implication for improvement in public health and reduction in related government spending. By incorporating personal objects, the infrastructure also extends its sensing area to previously untapped urban territories such as indoor environment, implying a more comprehensive data collection process and thus insights and action prompts of higher fidelity as well as a more extensive scope of urban management. On the strategic level, the platform approach would enable a more informed design and renewal mechanism for different kinds of standards and protocols. Wearable infrastructure also opens up the possibility for personalizing insights for each registered user, i.e. each citizen, when integrating his/her personal attributes in the analytic process. For example, the government can offer individualized special support or early alerts to high-risk individuals when serious air pollution occurs by interpreting his/her health risk factor alongside wider environmental observations. Personalization also makes possible to introduce new features for urban management and regulation such as health rewards.

**Exhibit 4: The emergence of wearable infrastructure**




*(Illustration: Author, 2019; source: Anjomshoaa et al., 2018)*

The likelihood of wearable infrastructure's adoption and successful development will mostly rely on the cost, technological readiness and policy support. Generally, the wearable market has already achieved economies of scale, which allows the technology to fully marketize. In the fourth quarter of 2019, the global market for wearable devices grew 82.3%, reaching 118.9 million devices shipped (International Data Corporation, 2020). Consultants estimate the prices will drop as the competition in the field intensifies further (Suematsu, 2020).

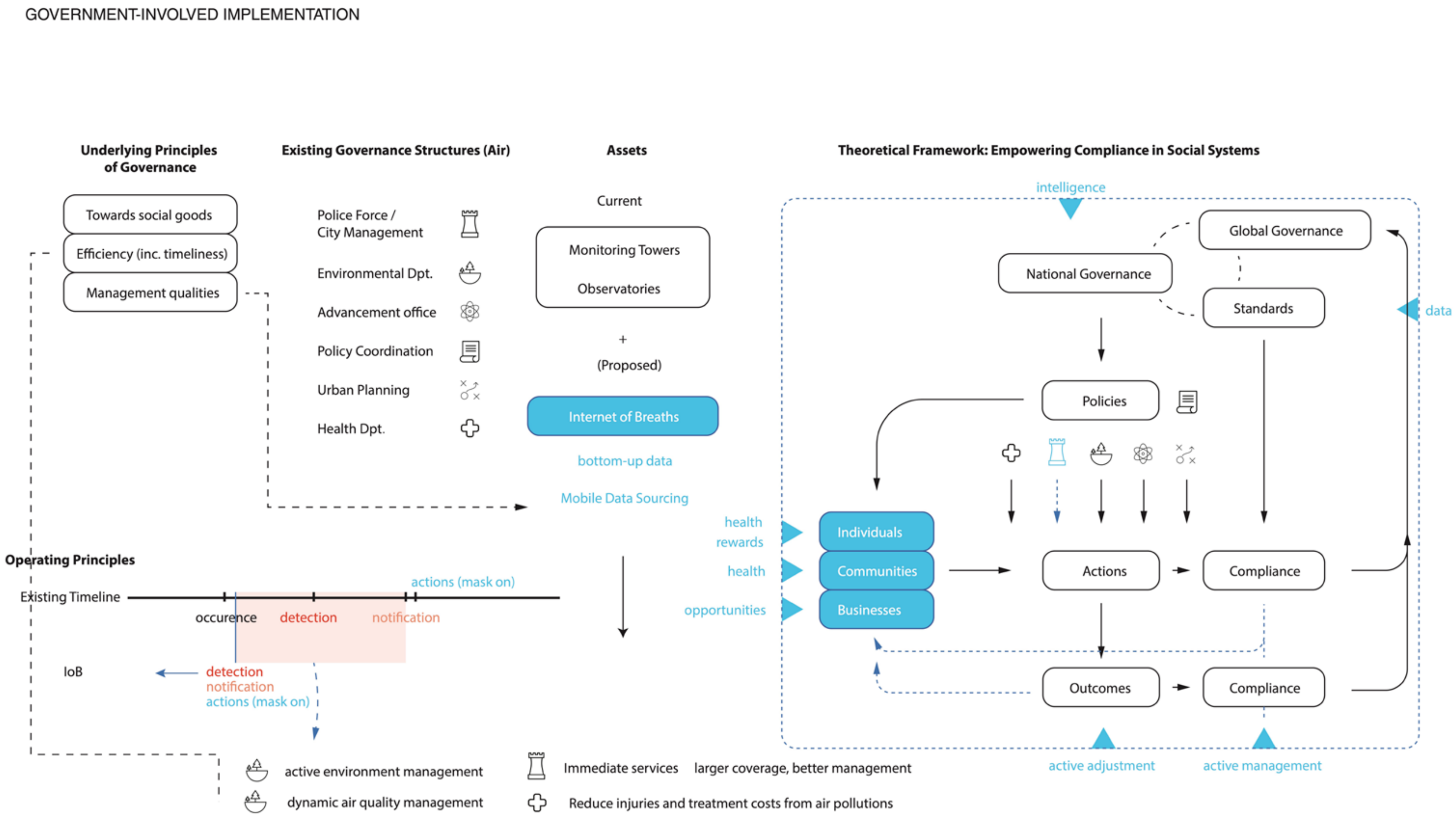
However, there are still certain roadblocks particularly associated with technological readiness and policy support that need to be addressed before such technology can be fully promulgated.

In terms of technological readiness, the major challenge lies within the interoperability among product components. There is currently lack of common connectivity protocols, standard data formats and common software interfaces (Manyika *et al*., 2015). Policy makers, industry associations and suppliers can join forces to agree on industry standards and protocols to ensure information can be extracted from devices of different manufacturers.

Challenges for public policy include privacy issues and regulatory process for technology. Increasingly, consumers demand for a greater control over the use of their own personal data privacy. A 2020 survey indicates over half of consumer respondents identify location data as a 'very important' data type (Anant *et al.*, 2020). Some governments have already introduced regulations to assure data privacy. For example, the General Data Protection Regulation (GDPR) in Europe, the California Consumer Privacy Act (CCPA) and the LGPD (General Data Protection Law) in Brazil requires or will require companies to collect, store, share and delete consumers' data in specific ways, failure to comply with which will result in arduous penalty. New clauses designated to data privacy of wearable technology can be introduced to ensure personal privacy and that institutional application of such technology are culturally accepted by the public. Furthermore, approval bodies such as health regulation authorities are running out of capacity to catch up with regulating wearable devices due to the rapid development of the wearable market (Junata and Tong, 2018). New processes can be introduced to streamline approval process for the introduction and application of wearable technologies.

As the international society is increasingly exposed to more uncertainties of unanticipated forms (Flaxman and O'Rourke, 2020), including environmental disasters, diseases, and complicating international relations, limits of existing urban governance systems around the world are being tested. Global governments are challenged to respond with governance strategies. Under these intersecting realities, new norms such as work from home and social distancing have already emerged, with some international governmental organizations claimed that there will be no return to 'old normal' (United Nations, 2020). Wearable Infrastructure, the third wave of sensing based infrastructural development, as the authors identified, provides an opportunity to deconstruct some of the uncertainties, with its capability of naturally allowing exchange of information among individuals and government authorities with minimal delay. As a result, the platform can respond to different types of uncertainties with immediacy, enabling new way of life where public participation becomes an integral part of urban management. As wearable technologies continue to grow in the consumer sector (International Data Corporation, 2020), the arrival of wearable infrastructure is foreseeable and practicable given government support and adequate incentivization.

## Exhibit 5: Wearable enhanced governance




(Author, 2019)

**References**

Anant, V., Donchak, J., Kaplan, J. and Soller, H. (2020), The consumer-data opportunity and the privacy imperative, McKinsey and Company. Available at https://www.mckinsey.com/business-functions/risk/our-insights/the-consumer-data-opportunity-and-the-privacy-imperative

Anjomshoaa, A., Duarte, F., Rennings, D., Matarazzo, T., deSouzza, P. and Ratti, C. (2018), "City Scanner: Building and Scheduling a Mobile Sensing Platform for Smart City Services", IEEE Internet of Things Journal, 1-12, DOI 10.1109/JIOT.2018.2839058. Available at http://senseable.mit.edu/papers/pdf/20180522_Anjomshoaa-etal_CityScanner_IEEE-IoT.pdf

Beroche, H. (2011), Urban AI, Smart World, 144-147.

Brown, T. (2009), Change By Design, HarperCollins, New York.

Flaxman, A.D. and O'Rourke, K. (2020), "Uncertainty and the COVID-19 Pandemic", Think Global Health, 3 June [Online]. Available at https://www.thinkglobalhealth.org/article/uncertainty-and-covid-19-pandemic

Gabrys, J. (2016), "Citizen Sensing in the Smart and Sustainable City", Program Earth: Environmental Sensing Technology and the Making of a Computational Planet, University of Minnesota Press, Minneapolis, 177-178.

Goodchild, M.F. (2007), "Citizens as Sensors: The World of Volunteered Geography", GeoJournal, 69 (4), 211-221.

Health Effects Institute, Boston MA (2018), State of Global Air 2018 [Online]. Available at https://www.stateofglobalair.org/sites/default/files/soga-2018-report.pdf

International Data Corporation (2020), "Shipments of Wearable Devices Reach 118.9 Million Units in the Fourth Quarter and 336.5 Million for 2019", IDC Media Centre, 10 March [Online]. Available at https://www.idc.com/getdoc.jsp?containerId=prUS46122120

Lau, A.Y.C. (2020), "The Value of Design Thinking for China's Planning and Development", MSc thesis, The University of Hong Kong, Hong Kong.
Lau, A.Y.C., Ruan, J., Wang, D., Wang, Y., Zhang, Y., Zhao, J. and Zhu, Z. (2019), Internet of Breaths, Eyes of the City [Exhibition], 2020 Bi-city Biennale of Architecture and Urbanism, Shenzhen. Available at http://eyesofthecity.net/internet-of-breaths/

Lau, A.Y.C. and Wang, Y. (2020), "The Implications of Design Thinking to Regional Development and Institutions", lecture notes distributed in the topic design thinking and regional governance, Jindal Centre for the Global South, New Dehli, 23 May. Available at https://www.linkedin.com/feed/update/urn:li:activity:6669990803869442048/

Junata, M. and Tong, R. K.-Y. (2018), "Wearable Technology in Medicine and Health Care", in Tong, R. (Ed.), Wearable Technology in Medicine and Health Care, Academic Press, US, 1–5.

Manyika, J., Chui, M., Woetzel, J., Robbs, R., Bughin, J. and Aharon, D. (2015), The Internet of Things: Mapping the Value beyond the Hype, McKinsey and Company,100-107. Available at https://www.mckinsey.com/~/media/McKinsey/Industries/Technology Media and Telecommunications/High Tech/Our Insights/The Internet of Things The value of digitizing the physical world/The-Internet-of-things-Mapping-the-value-beyond-the-hype.pdf

Niedderer, K., Ludden, G., Clune, S.J., Lockton, D., Mackrill, J., Morris, A., Cain, R., Gardiner, E., Evans, M., Gutteridge, R. and Hekkert, P. (2016), "Design for Behaviour Change as a Driver for Sustainable Innovation: Challenges and Opportunities for Implementation in the Private and Public Sectors", International Journal of Design, 10 (2): 69-72.

Suematsu, G. (2020), "Op-ed: The potential of wearable health technologies on the future", Berkeley Fung Institute for Engineering Leadership: News, 14 February. Available at https://funginstitute.berkeley.edu/news/op-ed-the-potential-of-wearable-health-technologies-on-the-future/

United Nations (2020), "COVID-19: No return to 'old normal', says UN health chief, as cases top 15 million", UN News, 23 July [Online]. Available at https://news.un.org/en/story/2020/07/1068941

Woltjer, J. (2000), Consensus planning: the relevance of communicative planning theory in Dutch infrastructure development, Aldershot, Hampshire, England.