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### **Background contextualisation: Introducing the new paradigm**

Cities are the most durable institutions built by humans and come in all sizes, shapes and compositions, each one being a unique result of the local and regional environment, the availability of natural resources and transport corridors, the historical circumstances of its founding, and subsequent development. The importance of natural circumstances for the evolution of cities was reduced somewhat by the relatively recent invention of first the railways and then the automobile, but with global environmental change accelerating, natural conditions are once again powerful drivers of migration and urban development.

In a nutshell, cities are complex systems for managing environmental and resource flows in the most effective and efficient way in order to provide for the existence, social and cultural development, and economic activities of its inhabitants. The density of population in cities and their size can only be maintained because water, food, fresh air, energy and other natural resources are brought into a city, essentially without interruption, and because the waste produced in the city in the form of air and water pollution, solid waste, and heat are efficiently removed from the city.

Cities, their suburbs and wider surroundings are the most important enablers of modern lifestyle choices:

- On the one hand, cities stand for a resource-intensive hedonistic lifestyle, the “Atlantic lifestyle” (McGlade et al., 2016), with conspicuous consumption beyond a level that would meet normal needs. In this light, cities are the cause of the rapid erosion of the Earth’s carrying capacity for human population as measured by the Earth Overshoot Day (EOD) which falls earlier each and every year.
- On the other hand, cities are much more efficient at providing the resources necessary for any given standard of living, because the (technical) networks for the management of environmental, energy, resource, and transport flows are shared among the population and thus much cheaper to build and run than they would be for a more dispersed

population. Seen in this light, cities are the only hope for 10 billion people to share planet Earth without overtaxing its ability to produce the ecosystem services needed for human civilisation.

When it comes to experiencing and coping with increased environmental stress, the focus is often placed on existing cities, which are presumed to be at a disadvantage compared to newly built cities as agents of environmental efficiency and sustainability. This presumption is based on the idea that existing cities are somehow inefficient. While this may be true for some existing cities, especially those built up in the last 50 to 60 years with a transport system designed for individual auto-mobility, it cannot hold for all existing cities in their magnificent diversity. Some dense old cities, such as many mid-sized towns in Italy, are highly efficient in terms of land use, density, openness for social life and energy use, while some new towns are highly inefficient, badly located in view of global environmental change and patently unsustainable.

Nevertheless, the distinction between existing cities, which have to adapt to changing circumstances, and newly built cities, which can be designed – well or badly – from scratch, is useful in highlighting the fundamentally different options available.

A third category may be cities that cannot adapt to environmental changes but need to relocate. A historical example is presented in the box below. Recent data and information from observation of the earth indicate that sea-level rise is likely to be faster than previously thought, and accelerating (Jones, 2016; Fasullo, et al., 2016). The water levels in slow-flowing low-land rivers will rise approximately in line with sea-level rise, inundating ever larger areas of many fertile river plains. Groundwater levels and salinity will also be affected.

### **Relocating the ancient town of Winchelsea, East Sussex, south coast of England**

Winchelsea is a rare example of a town that survived its own death by hurricane. Around the year 1200, the town was the second largest seaport in Britain, the home of fishermen, merchants, sailors and pirates. Three decades later, heavy storms began afflicting the town again and again, over five decades. Ultimately, Winchelsea could not continue resisting – but it survived its own destruction by the waves. The citizens, who repeatedly decided to rebuild a living place in the exact same locality, eventually understood the futility of this approach. They finally rebuilt their town on higher land. From there they watched their old town being devoured by the sea in 1287. They could not rescue their former homes and churches but the economic foundations of the seaport remained, and thereby its political and military standing. The history is obscured by the sad fact that the town was ravaged by the Black Death two generations later and then lost and never regained its pre-eminent status. Otherwise, the town would be known today as the first to survive, by relocation, its own death by the forces of a changing climate (Kraemer et al. 2008; 122-124).

Wise Cities will anticipate the specific environmental change and the threats emanating in their locality. They will seek to reduce vulnerability and prepare for the abandonment of some areas while developing others.

To make an analogy with biology, there are cities with urban metabolisms dominated by anabolism – the growth in structure and size (like a growing child or teenager, or a bodybuilder on anabolic steroids); there are cities that cannot cope well with the stresses they experience and whose development is dominated by catabolism, a process of erosion, decay and shrinkage that comes with illness or old age. The third category of cities experiences decline in some areas and growth in others, catabolism and anabolism co-exist in proximity or at a distance in a more complex form of metabolism requiring substantial inputs of resources, energy, and human ingenuity.

In the recent past, the era of industrialisation and global urbanisation, the development of towns and cities was based on the often unstated premise of infinite growth potential, if not of the settlement itself then of the economy within it and surrounding it. Much of the current economic and infrastructure policies are still based on the growth paradigm.

Wise Cities will base their development planning and investment on a very different outlook, recognising both the limits to growth imposed by planetary boundaries, and the need to transform practically all of the technical, social and institutional systems that make a city. Chief among those are the technical networks that manage energy and resource flows, because they are uniquely vulnerable to changes in the environmental and resource conditions of the city, and they provide leverage in implementing solutions for society to live within the ecosystem constraints currently experienced by industrial civilisation as a whole.

## **Challenges in urban resource and energy flow management**

Physical and technical networks or grids serve a number of essential functions, with most having to be provided without interruption or only with short interruptions, in particular:

- Public sanitation, in the form of water supply and sewerage, including rainwater removal through physical networks of pipes and canals, waste collection, separation, recycling and disposal using a system of interrelated but distributed installations and rolling stock forming a logistical network;
- Energy, in the form of electricity supply, including street lighting, gas supply, or the provision of heat (as hot water or steam) or cold, providing economic and technical support to public and individual transport, housing and commerce;
- Transport below, on and above the ground, on roads, rails, waterways or on cables, including provisions for the separation of and complementarity between different modes of transport, from cars, buses and trams to cycling and walking;
- Information as an enabler of rational and efficient use of shared spaces and infrastructure for managing resource and energy flows, from physical cable networks for (fixed-line) telephony to wireless access to the internet in public spaces. Cities' information services go beyond the provision of physical infrastructure and extend to the provision of enabling information content for inhabitants, from hazard warning to entertainment of local interest.

All of these networks share a number of characteristics. They are capital-intensive and have a long technical and economic life, and thus they generate path-dependencies with the effect that any design decisions affect the shape and functions of a city for a long time. The quality of the networks and the services they render often vary between parts of a city, and differences in quality often cause or reflect differences in property prices.

As a consequence, the management and development of the networks affects the distribution of economic and social opportunities in a city. Denial of network services to parts of a city generates health risks for the whole city and leaves room for exploitation of the inhabitants of unserved areas, for instance by resellers of bottled water or gas tanks.

Most of the networks are “natural monopolies”: For economic or physical reasons they cannot be duplicated, so competition is restricted to what can be achieved by regulation concerning access, conditions of services, prices and profits. Regulation can be provided by (central) government or by city authorities, especially if the latter are also owners of or in other ways control the physical networks.

Regulation is a key challenge that determines the long-term economic viability, social acceptability and distributive effects of the networks and the services they provide, and the environmental footprint of a city in terms of resource consumption, energy use, pollution caused or avoided, and resilience or vulnerability to environmental and other hazards.

## **Trending solutions in the adaptive management of city networks**

From the perspective of natural resource use and environment protection, the key trends in the management of physical and technical networks in cities are:

- **Efficiency and reuse:** City-driven (public) policies tend to spur efficiency in operation, e.g. by reducing losses and the networks' own consumption, and in the form of lower water and energy consumption by end users, be they industrial, commercial, public or private. Lower throughput in networks can have the effect of increasing unit prices (for water or energy), which can in turn negatively affect poor households or neighbourhoods. Reuse of goods (e.g. bottles) reduces waste, and the recycling of materials from waste streams can reduce the environmental footprint of a city significantly.
- **Smart grids and electrification:** Advances in information and communication technology enable cities and their inhabitants to manage networks and the energy and resource flows on them in smart new ways. Traffic flows, the collection of waste, the flow of rainwater through the sewerage system, and the stability of the electricity grid can all be managed better and at lower cost than before. Smart-grid technology is an enabler of efficiency, and is coupled with a parallel trend towards more electrification. Trams and light railways are mostly driven by electricity, and a shift from individual mobility towards mass transit is a shift towards electric

mobility. More recently, air pollution, for instance in cities in China, is a key driver for a push towards electric mobility, a trend that is likely to be replicated everywhere in the world and eventually drive polluting internal combustion engines out of most uses in urban areas. There is an emerging co-transformation of electricity grids and transport systems with electric cars being integrated into the urban energy network.

- **Integrated management:** Many cities integrate the management of their networks. In some cases, this may mean that one legal department in the city government manages the contracts with private services providers that operate the networks, in other cases, a works unit is in charge of several of the networks. Joint billing and the management of customer relations also provide synergies through the integrated management of networks. The most advanced form of integrated city management is in the form of specialised agencies or city-owned business units for the management, maintenance, and adaptation of networks to new technologies and needs. Increased professionalism in integrated network management is helped by more trends.
- **Full cost recovery and financial capacity:** The capital-intensive nature of city networks and the reduced capacity of central governments to provide subsidies is pushing policies towards achieving full cost recovery for urban network services from the users. Full cost recovery is a precondition for good financial capacity of the service to maintain the network and plan re-investment, expansion or replacement of outdated plants.
- **Good tariff principles:** The development towards full cost recovery is not without social consequences, but if well-managed the overall effect on the equitable treatment of all users and the social cohesion in a city is positive. Successful reforms are based on principles such as:
  - **Inclusion:** everyone can be a user, and all users pay a share. This is a specialised application of (egalitarian) universality in citizenship;
  - **Fairness:** every user pays the same, no-one exempt, non-payment is tolerated only temporarily and in extreme circumstances. Implementation of this principle presupposes admission that network service provision is not a good instrument of (redistributive) social policy;
  - **Quality of service:** The quality of the service is good and tends to improve, not deteriorate;
  - **Incrementalism:** There are no sudden changes in prices, cost or quality of service;
  - **Non-appropriation of any surplus:** There is either no (financial) surplus accumulated on the back of service users, or any surplus arising remains in the service or returned to the community in a transparent manner, and is not appropriated, e.g. by overstaffing, overpay, lavish buildings, entertainment of politicians, etc.
- **Managerial independence and legal standing:** The increased complexity and interconnectedness of city network management has resulted in a need for higher levels of professional competence and less interference of non-professionals in operational decision-making. As a consequence, there is a trend towards more independence and autonomy of network management, from political oversight on behalf of and often elected by the city population. Legal independence or “standing”, with the right to sign contracts, and sue or be sued in court, is becoming more widespread among network operators, both

as a consequence of involving private contractors in service provision, and by more city-owned private-law enterprises being formed for the purposes of network management.

- **Social embeddedness:** The service providers are local companies employing local labour, paying taxes in the city and practicing good corporate citizenship. This principle is important where private contractors are entrusted with the provision of network services.

Together, these characteristics and trends allow cities to adapt to environmental change and other developments, from more frequent and more intense extreme weather events and relocation needs in response to changes in water levels and regimes to changes in the number and composition of urban population as a consequence of climate-induced migration.

The extent to which these characteristics improve the management of environmental resource and energy flows in city networks varies between cities and depends on legal traditions in countries and the general power balance between cities and central government. As a general global trend, however, there is a resurgence of city power in the face of government weakness, leading to an eroding financial standing of central government, or even state failure. The growth of city or city-mayoral initiatives at global level is evidence of this trend, and it is particularly remarkable in the areas of climate protection, energy system transformation, urban mobility, and the evolution of “smart cities”.

## Lessons learned and/or policy recommendations

From an environment and resource perspective, the need for efficient and rational management of energy and resource flows in technical or physical networks is paramount, because they determine the environmental footprint of a city. The quality of service provision and professional management are enhanced by managerial independence and autonomy of the network operators in their day-to-day work, including recruitment and investment, while they must obviously also remain under political control concerning strategic decisions tied to the long-term interests and development of a city. Such control is usually exercised by elected (or unelected) city officials, under varying conditions of transparency and accountability.

The most successful network operations are those that combine high levels of service with broad (or even complete) coverage at lowest cost for total system operation and thus affordable prices for all users. Such successful operation cannot be achieved overnight but is the result of established traditions in management and supervisory control. In many cases, the most suitable institutional arrangement is the establishment of city-owned private-law companies with managerial independence, commercial cost-accounting standards, and legal standing. City representatives of the population can (and will) exercise supervisory oversight, using ownership (or shareholder) rights they exercise as trustees for the city and its population. The division of roles and the clarity of responsibilities, the accounting standards and accountability thus created, along with the strategic oversight all combine to enable city network management to be professional, efficient, and adaptive in the light of changing needs.

Not all countries and legal systems allow cities (and other small territorial units) the right to establish, buy, hold, expand, control, or sell private-law companies as described. The “Plan B” solution is then often an imperfect public-law organisation open to political interference from many sides, or privatisation as investor-owned utilities which require additional and very complex layers of regulation and high levels of legal expertise in city government.

Given the advantages of entrusting city network operations to city-owned private-law enterprises, all countries should allow, enable and encourage their cities to become engaged in “municipal enterprise” and contribute to reducing their ecological footprint for the benefit of future generations.

## References

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