Urban Sustainability, Challenges, Paradigms and Policies

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Introduction

Cities emerged approximately 10,000 years ago when humans invented agriculture. Today, approximately fifty percent of the population of the world lives in urban areas and even a larger percent of the developed world population lives in the cities. This trend has been rapidly accelerating and is expected to continue for the foreseeable future, while the rural population is expected to correspondingly decrease. A particularly dramatic aspect of urbanization is the growth of the population in the larger urban agglomerations and the shifts in their ranking in terms of population. For instance, New York was second in 1980 in terms of population, but it is expected by 2015 to be the eleventh, while Mumbai, that did not even appear in 1980 in a listing of the top eleven cities, in expected to be the second in 2015.

Urban sustainability can be defined as the intersection of two enormous challenges: that of urbanization and that of sustainability, that is, of long-term urban livability and resilience. The trend is toward a closer and closer interpenetration of the two challenges (Fig. 1). Thus, urban sustainability has two contexts—the local context, that is, the conditions within cities that make them livable indefinitely, and the global context, that is, the impact of the urban phenomenon on global sustainability. The two contexts often clash, but ultimately one implies the other. Each context requires science (“what do we know?”), technology (“what can we do?”) and policies (“what do we want to do?”).

A most direct point of convergence of the two sustainability challenges is the reduction of urban footprints—the increasingly extended footprint of the material resources that flow into the city and of the spaces occupied by the city, and the outflow footprint, the pollution and other emanations from the city. The reduction of these footprints requires control of pollution, changes in psychology and social habits and the extraction from the city itself of many of the resources that it needs (“city mining”).

The physical and demographic impact of cities on the environment are exemplified by the temperature, higher by several degrees over cities, with impact on the temperatures of the surrounding areas, reduction of rainfall infiltration into the ground water blocked by pavements and structures, pollution of the water table from street washing and, most dramatically, the reduction of birthrates, which makes the cities effective instruments for demographic control.

Knowledge

Urban sustainability requires knowledge of both urbanization and of sustainability in general. Today we do not fully understand aspects of either phenomenon, nor their interaction. For instance, we do not fully understand the impact on sustainability of concentration *versus* that of dispersion. We do not quite understand whether megacities are ultimately desirable, and whether they are controllable in their growth. However, we have the knowledge necessary for addressing some sustainability challenges. We know how to supply water and energy; or how to control some aspects of health; we understand the importance of reforestation, of the potential of bioremediation and the imperative to control CO_2 and other emissions. But the fact is that often we have difficulties in implementation, as we do not quite know how to address many associated socio-technological challenges. Certainly we have not succeeded in solving a range of problems, from endemic poverty to traffic jams in cities, to the reduction of ecological footprints.

What Is a City?

A fundamental question in dealing with these challenges is: what is a city? In terms of urban sustainability the city is, in the first place, a concentrator of population, of genomic variety, of social capital, and of a large variety of social systems, processes and cultures. It is a concentrator of knowledge and information, of wealth, of services—in general, the larger the city, the more services—and of political power. Cities like Seoul, Karachi, Shanghai, Tokyo, London, Milan or New York exert tremendous political power in their countries because of their economic power. A city is also a concentrator of resources, materials, machines (that is, artifacts), buildings and infrastructures, land, and energy, and a place in which the quality of life is generally high. But inevitably, the city is also a concentrator of waste and pollution and of dysfunctionalities, such as pockets of poverty, transportation deficiencies, and crime. And it is a concentrator of risk. If in earlier times a city gave a certain sense of security, today it is ever more at risk and a primary target in war or for terrorism.

While being a concentrator, a city is also a disperser. In affluent countries, its inhabitants tend to increasingly disperse to suburbs and exurbs. This generates polarizations and conflicts between these areas and the central city because both draw on the same resources, because their infrastructural needs often contrast, because of different impacts on ecology and destruction of habitats, because of different political interests and attitudes, and because dispersion to the suburbs may contribute to the impoverishment of the central city.

Developed *versus* Developing World Cities

In addressing these problems, it must be recognized that there are profound differences between the developed and the developing world cities (Fig. 2). In the former, urban growth is slow, while in the developing world it is very rapid. The resources available are relatively abundant in the developed world but limited in the developing one. Demographic stability is high in the developed world and low in the developing world. The average age of the population is high in the developed world and low in the developing world. The tertiary sector, that is, the service sector, is strong in the cities of the developed world and weaker in the developing world. In the developed world, knowledge resources—universities, schools, libraries, data banks, etc.—are far more abundant. Ecological and environmental impacts are high in the developed world because its affluence and high consumption of resources place further burdens on the environment, but the developing world, as it becomes more affluent and increases its population, will have an ever greater impact. What can be called "plasticity," the ability of a city to adapt to new needs and conditions, should be higher in the growing cities of the developing world and lower in the cities of the developed world with their costly and long established configurations and infrastructures and their stationary populations. In effect, however, there are also impediments in the former that make it hard to assess where the plasticity is higher. A universal, both in the developed and the developing world, is traffic congestion.

Increasingly, in some countries, a trend that also might affect negatively urban sustainability is the diminishing sense of community. In the United States, for instance, club and church attendance has decreased dramatically since approximately 1960, coincidentally with the widespread use of television (Putnam). Furthermore, in the U.S., the number of inhabitants per dwelling has decreased almost by one third from 1960 to today, requiring one third more housing units for the same number of inhabitants.

There are several essential consequences of these differences between the developed and the developing world cities. The developed world cities are not a model for the developing world. They have resources but are harder to change, at least in theory (that is, have less plasticity) and have more of the needed knowledge, while the developing world cities experience growth so rapid that it overwhelms resources. They need different technologies from those of the developed world cities and they need fast action in planning, in infrastructure, design and construction, in public health, in education.

The Need for New Technologies

To address these conflicts, some urgent technological challenges include rapid construction in order to keep up with the rapid growth of the demand for services and infrastructures, the development of high performance buildings that can provide security, reliability, flexibility and environmental benefits, e.g., through the use of reusable or recyclable materials and the reduction of energy consumption, the development of new approaches to urban mobility to make it available to all citizens—indeed, not only the poor of the developing world, but also the increasing number of elderly in the developed world—and reduce in turn the energy demands and the pollution generated by transportation. There is a need everywhere to enhance urban resilience to make the cities more protective of their inhabitants and more able to rebound after disasters—tsunamis, earthquakes or floods, like Katrina in New Orleans—to enhance opportunities for the disadvantaged, to provide them with housing, access to transportation, information technology and other services. And there is a universal need for technologies to reduce the footprints of resources, pollution and waste, a most complex socio-technological set of challenges that often leads to conflicts with business economics and embodies on a global scale the "tragedy of the commons" (Hardin).

The Biosoma Paradigm

To address the issues of urban sustainability, it matters how a city is viewed. The view discussed earlier of the city as a concentrator/disperser is useful, but not sufficient. There are typically two other families of paradigms used in describing the urban phenomenon. One can be called geo-physical-ecological, in which the city is viewed as a physical and demographic reality. It is exemplified by the recent book, *Cities Transformed* of the U.S. National Research Council (National Research Council). The second paradigm is a sociological one viewing the city as an institution and a culture. In the United States, it is exemplified by the book *The Ungovernable City,* about New York and one of its mayors.

The two paradigms describe two different, albeit complementary, aspects of a city, but neither is operational in intent. What is needed is a new socio-technological-environmental paradigm combining and enhancing the combination of the two paradigms. Such a bio-socio-technological (or biosoma, for short) paradigm considers the city as a biosoma entity (intending by machine, in the broadest sense of the word, any physical artifact or any modification of nature created by humans (Fig. 3)).

In this paradigm, the biological components—the biological capital—are the humans and the other species, animal and vegetable, in the city. The social components—the social capital—encompass the culture, religion, customs, organizations, from government to business to health care to families, and the very important intangible of trust that makes such a profound difference to the functioning and effectiveness of a city. The machine components—the machine capital—range from housing to the physical infrastructure—transportation and utilities—and to other machines. The environment enveloping the city obviously encompasses geography, climate and natural resources. The balance among these three components and the environment manifests itself visually in very different forms in different cities. In the United States, for example, Levittown, a dense section of mass produced and originally indistinguishable individual houses in Long Island, is a manifestation of both individualism and conformity, and Manhattan is a manifestation of social concentration. Special complexes such as, in New York City, Rockefeller Center or Metrotech—the university-industry urban park created by Polytechnic University—are a manifestation of intense co-location of functions and structures quite distinct from the surrounding urban fabric (Bugliarello, 1993).

The articulation among the three components of the biosoma can be exemplified by a major concern in some developing countries as how to achieve birth control: biologically by monitoring the biological cycles of reproduction, by social pressure to limit births, or by the use of machine devices, that is, contraceptives. Another example is the increasingly pressing urban problem of solid waste disposal, which can be carried out by people acting individually, by a special social group within the city, or by machines. The choices and the synergies among these three components profoundly affect how a city operates and is sustainable. For instance, the introduction of machines for solid waste disposal in certain cities has dislocated the social groups that for generations had performed that function and that now find themselves deprived of their livelihood.

To further elaborate the consequences of the interactions among these three components of the biosoma, the forms and functioning of government are the result if bio-social interactions, urban society is shaped by socio-machine interactions (for instance through transportation and industry) and the bio-machine interactions determine the nature and configuration of human-machine interfaces, and impact the citizens= health, psychology, performance and way of life (Fig. 4). The three biosoma components have different configurations in the city than in the suburbs, but they interact. For instance, the social organization—e.g., the governance—of the suburbs affects that of the city (as in the issues of taxation or of voting preferences) and the biological component in the suburbs affects that in the city, for instance, the different possible or allowable interactions of the inhabitants with vegetation and animal life.

Within the city, biosoma interactions occur among households, neighborhoods, other parts of the city and special complexes. A set of examples demonstrates their importance. The number of individual connections made possible by societal interactions and telecommunications affects the affluence of a city—its Gross Domestic Product (GDP) *per capita*—dividing the world and the cities in different groups according to whether the number of connections is small, medium or large. When the connections are numerous, the GDP *per capita* has increased over time, but when they are few, it has tended to stagnate, perpetuating the endemic poverty. Another example of the relation between the GDP per person and the acceptance of pollution is the Kuznets curve, which indicates that, as affluence increases beyond a certain point, the acceptance of certain kinds of pollution decreases (Van Zanden).

Of particular usefulness in addressing the interaction among the biological, social and machine components of a city are *biosoma matrices* characterizing each component in terms of factors such as materials, energy, information and systems (e.g., in terms of energy provided by biological organisms, by social synergies, and by machines (Fig. 5)) (Bugliarello, 2003). The trajectory over time of a city is shaped by trade-offs and synergies within the matrix, such as those between information and energy, information and materials, or between biological organisms and machines. Thus, in what can be called information cities, information is the predominant theme, e.g., in biotechnology activities (the *bio* component of the biosoma), in information activities, such as education or financial services (the *so*), and in information and telecommunications technology (the *ma*). Different societies in different times have had different emphases. In the Egyptian, Greek, Roman and Mayan cities it was materials; in the industrial cities after the Industrial Revolution it was energy. Well functioning cities are manifestations of the key role of systems and so are cities which are dysfunctional.

The biosoma paradigm leads to a number of questions. How can the biosoma components of a city be better integrated to deal with these dysfunctionalities and to enhance beneficial synergies? What are the consequences of enhanced urban biosoma interdependencies in terms of global competitiveness? of birth rates? of the availability and access to services and jobs? of the reduction of urban poverty? of security? of governability? of the balance between individual and community? of the all important trust among citizens? Also, are there desirable limits to the enhancement by machines of the bio-social component of a city, including the dysfunctionalities created by the excessive power of machines (such as, to make a trivial example, excessive sound)?

The Nexus Science, Technology and Policies

The connection of science and technology with needs, goals and policies usually does not receive as much attention as economics or urban politics (Fig. 6). A reason may be that some overarching principles and policies necessary for effective science and technology intervention may not clearly be agreed upon and followed by those in the realm of science and technology, as well as by those in the realm of politics.

One such principle is political realism, that is, the acceptance of irrationality and emotion in the dynamics of a city, of different modalities for resolution of urban conflicts, and of the need to harmonize urban, regional, national and global policies. The latter is particularly urgent because urban needs, goals and policies cannot be addressed only locally, as exemplified by regional decentralization, relocation of industries and business and the possible commonality of services among neighboring communities.

A second set of principles has to do with graduality, flexibility, accessibility and affordability. As pointed out earlier, the developing world needs different solutions to its urban challenges. It needs solutions that are less intensive in capital, in materials and energy, solutions geared to the dynamics of rapidly evolving cities, so that their infrastructure can grow in synchrony with the growth of the city rather than as a step function that keeps or years needs unfulfilled. Also needed are solutions providing accessibility and affordability for all citizens. All these solutions require new socio-technological approaches, which must be based on a clear understanding of the possibility offered by well designed biosoma interactions.

A third set of principles and policies is coordination of different jurisdictions within a city, and the elimination of a large number of contradictory specific policies, such as indiscriminate subsidies for all, efficiency *versus* employment, and taxation *versus* incentives.

The last set of principles is development of inter-urban synergies, to facilitate innovation for common problems by assembling more resources and creating bigger markets, for instance, by joint research and development, by creating new urban mobility systems, and by remanufacturing in one city the products of another city.

Conclusion

Purpose of this rapid review of the complex issue of urban sustainability has been to call attention to their bio-socio-technological nature, and to a paradigm—the biosoma paradigm—that can help identify systematically conflicts, synergies and trade-offs among the components of the urban fabric. A set of principles to enhance urban sustainability underscores the importance of the nexus between science and technology and policies.

The challenge is particularly urgent because if the demographically exploding cities o the developing world, global sustainability will be ever more difficult to achieve. Ultimately, globally, the unanswered questions are whether the urban concentration process will abate and can be sustained.

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