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Technology and Cities: What Type of Development Is Appropriate for Cities of the South?

Jean-Claude Bolay and Abigaïl Kern

ABSTRACT *This paper deals with technologies, catalysts for change, and their links to development. Indeed, particularly for developing and emerging countries, scientific and technological breakthroughs create wonderful opportunities, but they may also convey risks that should not be overlooked. This leads to crucial questions on the nature of technological innovation and its capacity to fulfill the specific needs of certain societies. Thus, the issue of investing in priority sectors to guarantee more sustainable development for the benefit of all is paramount, as is the question of the stakeholders' direct or indirect involvement in this scientific, technological, and socioeconomic development process. Access to technologies is one of the last vital issues to be addressed. The paper, therefore, explores the question of the existence of exclusively urban technologies and their adaptability to city-related territorial and societal issues in emerging and developing countries and the key factors on which this adaptability will depend.*

Introduction

Technological innovation—combined with scientific research—has always constituted a driving force of transformation in our societies. From the moment it turns into an industrial and economic tool, any form of societal innovation involves and produces change in production processes, in the creation and development of new lines of business, in the increased marketing of new products, and in the set-up of new organizational modes of social interaction, as much within as between societies across the world.

But technology is also a process, a social mechanism which becomes inclusive over time and brings individuals together, or drives some away; it creates special-interest groups, affects the natural or developed environments in which these individuals evolve, alters cultural patterns, the way we think and act, the way we see the world and understand it, whether we have taken ownership of these technologies or are marginalized by their development.

Technologies—their emergence, dissemination, transformation, development, and even disappearance for the benefit of more sophisticated ones—are, and increasingly rapidly so, catalysts for change within and between contemporary human societies. They are the fundamental constituents of what will determine the future and the reference points outlining the present.

We live in a world in which technologies play a prevalent role in the globalization of exchanges (of information but also of people and culture) and in the cre-

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ation of new living patterns (settling down, moving around, working, eating and staying healthy, communicating, enjoying ourselves, interacting, etc.), as well as the geographical distribution of the assets, knowledge, and products that are driven by growth. In fact, the world is no longer divided into self-contained hegemonic blocks, be they political or economic groupings. The world has turned into a throng of countries and regions constantly competing which each other. They have all adopted a similar vision of what progress means, both economic and material as well as cultural and social, teetering between aggressive behavior and cooperation, between living and working patterns that are either site-specific—and yet similar worldwide—or mixed.

In the future, developing and emerging countries, given their demographic and geographical weight as well as the potential for growth that some of them have unlocked, will face the major challenges that humankind is currently grappling with but will do so much more effectively than the old industrialized powers by offering the most fitting responses to solve them—providing they have the resources necessary and the capacity to do so.

In this light, generally speaking but for developing countries in particular, scientific and technological breakthroughs create wonderful opportunities but may also convey risks that should not be overlooked. In the future, only high-level human skills will provide the means of seizing these opportunities and forging them into development tools; and this, in sectors that international organizations consider to be key points for improving living standards in countries of the South, e.g., agriculture, health, access to water, the fight against the deterioration of the environment, and energy provision (Watson et al., 2003). It is, therefore, necessary to implement public policies that promote science and technology, most notably in favor of information and communication technologies—which clearly provide better access to knowledge—as well as educational policies that are in line with these priorities.

A study of the links between technologies and development should first address the contribution of modern technologies to sustainable development in all its environmental, social, and economic aspects, in order to cover the basis of this concept (Bruntland, 1987)[1]. Secondly, it is necessary to examine the relationship formed by individuals—and more globally, by contemporary societies—with present and future technologies.

This is a universal issue since technological innovation has been an evolutionary process through an increasingly widespread, complex, and sophisticated use of such technologies and their ever-growing dissemination. There is almost always a deep belief that technologies will improve the lives of individuals, whoever they are and wherever they live. However, it has also been proven many times that technologies have unfortunately only partially succeeded in eradicating socioeconomic disparities, both within and between societies.

The North-South relationship has long been a matter of debate, first in economic and then in political terms, and also from a sociocultural standpoint. From this point forward, the relationships between regions of the world, between nations, and between the populations of these countries must also be perceived in terms of technology. And here several lines of thought can be explored:

- Is technological innovation universal in nature or, conversely, is it specifically intended for particular sectors? Does it fulfill the particular needs of certain

societies in conditions inherent to each context, with particular reference to developing countries?

- Focusing as a priority on developing countries, scientists and technologists of the North and South, as well as public and private decision-makers, are faced with great social, economic, and environmental needs that are not entirely or are only partially met and for which technological solutions must be created, implemented, and adapted to conditions prevailing in societies of the South. The issue of investing in priority sectors to guarantee more sustainable development for the benefit of all is paramount, as much on a political as on financial, economic, and societal levels.
- With this is mind, the issue of appropriate technologies and technological transfer opens up a vast debate on the choices to be made and their defining criteria. Although intrinsically there are no "poor" technologies designed for poor countries or innovating technologies designed for rich countries, societal contexts vary widely and so do human and financial resources. And these specific environments will affect the creation of technologies as well as their ability to offer solutions that fit the needs, of a particular society. Decision-making criteria related to future technological choices are, therefore, crucial and should a) meet the priority needs of the countries and regions concerned, b) concentrate on the nature of the innovations that are put forward, c) adapt to the specificities of users in all societies, and d) promote the full inclusion of these countries in international exchanges.
- The implementation of a technological innovation strategy raises the following questions regarding the stakeholders involved directly or indirectly in this scientific, technological, and socioeconomic development process: Who are the decision-makers? How are decisions made and in favor of whom? These questions are appropriate to cities of the South as well as the North.
- The last vital issue to address concerns access to technologies. It is clear that the development of research is generally very costly, as are transferring and implementing this research and then managing and maintaining it. But those in charge of managing technologies will also have to be watchful and ensure their development and sustainability, all the while guaranteeing the profitability of each innovation. Whatever their socioeconomic status, users will inevitably have to pay for this service, either fully or partially, with the risk—often demonstrated—that technologies adapted to a territorial and societal context can lead to segregation in society, as a majority of disadvantaged sections of the population cannot afford access to these innovations. It is, therefore, essential to identify pathways and means of fighting against these new forms of inequality (SDC, 1999) and to commit to scientific cooperation projects addressing these problems.

These fundamental issues will guide our reflection and ensuing proposals in order to address a *de facto* situation that is relentlessly deteriorating the terms of economic and technological exchange between industrialized or emerging countries on the one hand, and the vast majority of developing countries on the other hand.

The Role of Innovation and Technology in the World

The world has been undergoing radical technological transformation for the last two to three decades. From now on, the globalization of trade is setting the

course for a fully globalized economy. On that subject, Daniel Cohen recalls that from 1950 to 2000, the share of trade in Gross Domestic Product (GDP) has more than doubled (Cohen, 2004).

Yet, the opening of external trade is one of the three key factors in the dissemination of technological advances, along with direct overseas investments and contacts established between emigrated populations and their families of origin, in particular through remittals (World Bank, 2008a).

Technological advances have, therefore, led to the implementation of telecommunications and information system networks that are continuously linking up, in real time, all the inhabited areas of the world. This technological revolution and the globalization of economic exchanges on an international level have not, however, significantly reduced the poverty that is still rife in many regions of the world (Bolay, 2004; Stern et al., 2002). Whether at an international level or more narrowly, within each country's own internal structure, globalization is not consonant with a widespread reduction of inequalities On the contrary, as highlighted by Williamson (1998), there are growing disparities among countries and among individuals.

Technological progress also contributes to these disparities. Thus, the technological gap between rich and poor countries remains significant: on the one hand, because rich countries own resources that less advantaged countries do not possess, and on the other hand, because rich countries have more individuals and companies with the skills needed to make the most of available technologies. However, developing countries have achieved remarkable technological advances, sometimes even twice as fast as developed countries. Such progress was notably rapid in lower-income countries, with some catching up with high-income countries: e.g., in Chili, Hungary, and Poland, the level of technological development increased by more than 125 percent during the 1990s (Gerster and Zimmermann, 2003).

Alongside the expansion of international trade and the globalization of economies, the pace of technological dissemination has also increased dramatically over the last two centuries. At the onset of the nineteenth century, an average of 84 years were necessary to introduce new technologies in all developing countries; in the 1950s, the delay was reduced to 26 years and in 1975, it dropped to 18 years (Gerster and Zimmermann, 2003).

Technological progress is dividing fast-growth economies (South-East Asia and developing European countries) and slow-growth economies (Latin America, the Middle-East, and Africa). The measurement of technological progress remains flawed: it is based entirely on total factory productivity, namely the efficacy with which an economy produces goods and services, given a particular level of manpower and capital, and attributes to technology that portion of revenue growth that cannot be attributed to investment or available manpower. Nevertheless, in absolute terms, it is now widely recognized that technological progress has largely contributed to reducing poverty in developing countries which has dropped from 29 percent in 1990 to 18 percent in 2004 (World Bank, 2008a).

Although there seems to be an established link between information technologies and economic productivity, the more complex relationship between these technologies and social development has attracted less attention (Corea, 2005). Several studies have pointed to a positive correlation in the most industrialized countries between new information and communication technologies (NICTs) and socioeconomic development. However, this link is not so straightforward in

developing countries, thereby encouraging them to invest in both material and human resources, as they lack the skills to embrace these new technologies.

Indeed, public authorities can take various measures to promote technological progress, most importantly: openness to trade; continuous improvement of the investment climate to enable businesses to flourish; reinforcement of infrastructures; improvements in the quality and quantity of education; and enhancement of R&D guidelines and delivery programs.

Yet investment in R&D—the driving force of innovation—remains highly clustered (Mustar and Esterle, 2006). Therefore, the world devoted 1.7 percent of GDP to R&D in 2007, a share that has remained stable since 2002 (UNESCO, 2010). As official data on R&D investment are based on retrospective surveys, the discussion of cross-country R&D spending patterns is currently limited to the end of 2008. While this makes possible an initial analysis of the impact of the financial crisis and economic downturn on R&D and innovation, attributing movements in the data to responses to this recession call for caution (OECD, 2010). Nevertheless the financial crisis and economic downturn "has for the first time challenged the old North/South technology-based trade and growth models" (UNESCO, 2010:12).

R&D budgets, especially, tend to be vulnerable to cutbacks in times of crisis. Patents and publications will in turn be affected by the drop in R&D expenditure, but this will probably occur in the longer run and affect scientific output less directly, owing to pipeline effects that smother sharp fluctuations.

While investment in R&D is growing globally (in volume) emerging countries are clearly gaining strength in science and technology. Led mainly by China, India, and the Republic of Korea, Asia's share increased from 27 to 32 percent between 2002 and 2007. Over the same period, the three heavyweights, the European Union, the United States, and Japan, have registered a decrease. In 2002, almost 83 percent of research and development was carried out in developed countries; by 2007 this share had dropped to 76 percent (UNESCO, 2005).

The investments in R&D have usually been taken into account as GERD (growth in domestic expenditure on R&D). Then the United States is in the lead with close to a third of the world's share of GERD (32.6 percent), followed by the European Union (23.1 percent), Japan (12.9 percent), and China (8.7 percent). Other countries around the world—all regions combined—account for only 18 percent of R&D expenditure. This is a very low figure. As a result, the most disadvantaged regions of the world fully depend on innovations produced elsewhere, a situation which turns them into consumers of high value-added products. Similar discrepancies can also be observed in the number of researchers involved in the scientific sector, be it public or private. Although the proportion of researchers in developing countries increased from 30 percent in 2002 to 38 percent in 2007, two-thirds of this increase is due to China alone. In 2007, China, with its 1,423,400 researchers, was on the verge of overtaking the United States and the European Union. Today, Europe, the United States, and China each contribute 20 percent of the world's researchers, followed by Japan (10 percent) and the Russian Federation (7 percent) (UNESCO, 2010).

The 2006 UNESCO Science Report (UNESCO, 2005)[2] highlighted once more the great divisions in our world: 77.8 percent of R&D investment takes place in developed countries, which bring together 70.8 percent of the world's researchers, while developing countries—with 69.5 percent of the world's population and 39.1 percent of the world's GDP—allocate 22.1 percent of investment to the scientific

field and account for 29.1 percent of researchers. As regards less-developed countries—that is, 11.1 percent of the world's population and 1.5 percent of the world's GDP—funding of R&D amounts to 0.1 percent of the total world figure, with a corresponding 0.1 percent of the world's researchers. These figures signal a total and alarming marginalization of the poorest countries in the face of the technological changes dominating our modern economies, where education, science, and technology serve as drivers in societies that are increasingly fed by information and knowledge as significant factors of production.

Africa is probably the continent that is the most symptomatic of such socio-spatial disparities. For the nations on this continent, R&D amounts on average to 0.3 percent of GDP, though South Africa alone represents 90 percent of the 3.5 billion dollars invested every year in this sector across Africa (Science and Technology Department, 2008/09)[3]. The remaining African countries share a tiny fraction of research funding.

This is a dramatic situation since many international experts recognize that science and technology are prime drivers of development (UNDP, 2001 and OECD, 2007). Whatever the region, the modern world is now plugged into and driven by the information and knowledge economy, a "virtual" world which is nonetheless an integral part of our daily lives. Since global economic growth and the underlying technological explosion do not fuel social equality and a fair distribution of the fruits of growth, the only remaining way to manage the "challenges of globalization" (Thimonier, 2005) is through cooperation.

Urban Growth in Developing Countries

In 2009, for the first time in the history of mankind, over half of the world's population—more than three billion inhabitants—was living in an urban environment. According to forecasts, this rate will reach 55 percent in 2015 and more than 60 percent in 2025 (UNFPA, 2007). This growth concerns developing countries foremost. Thus, according to the United Nations, 81 percent of the world's urban population will be living in developing countries in 2030, with 70 percent of this population based in Africa and Asia. (See Figure 1.)

Given its structural nature and its contribution to a country's economic, social, and cultural development, it is now widely agreed that the global urbanization process should be supported rather than fought. "Cities concentrate global directional, productive and managerial functions, the control of the media, the real politics of power, and the symbolic capacity to create and diffuse messages" (Castells, 1998:461). The second UN Conference on Human Settlements "Habitat II" (Istanbul, June 1996) highlighted the scope of this process as well as its knock-on effect on all territories, and on rural settings in particular.

However, the overall growth of urban populations is reaching a historical high in many developing countries (5 percent on average per year). In coming years, it will result much more from the natural population growth of urban areas than from migration or the shift of small rural communities to the status of urban centers, as well as their absorption when located on the outskirts of expanding cities (United Nations, 2008). Therefore, by 2020, a majority of metropolises—agglomerations in excess of one million inhabitants—will be located in developing countries (Bolay, 1995); there were already 424 in 2000 (CNUEH,

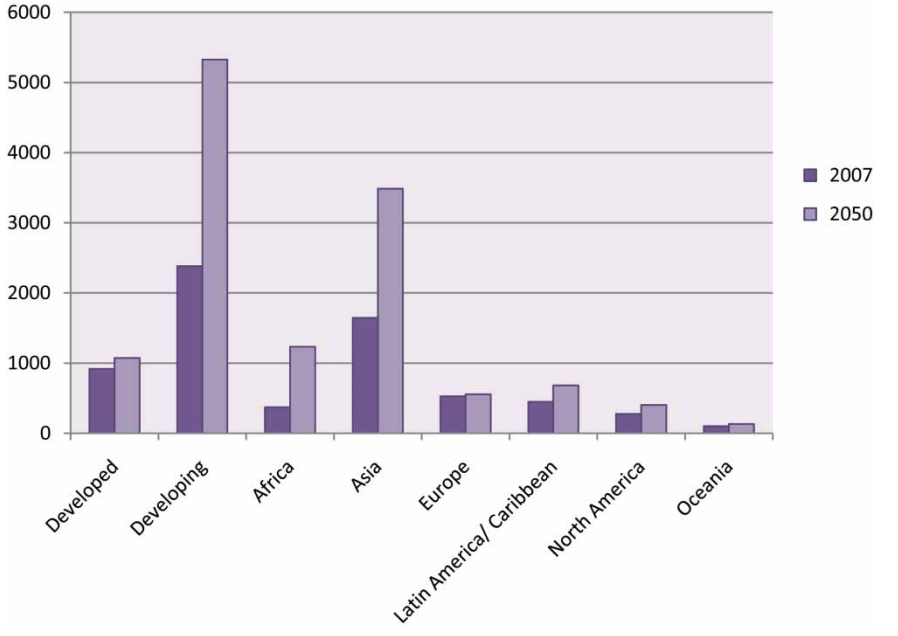

Figure 1. Urban population by region 2007-2050 (in millions of inhabitants)
Source: UN-Habitat, 2009

2001). By 2015, there should be 23 megalopolises of more than 10 million inhabitants, 19 of which will be located in developing countries. (See Figure 2.)

This pace of urbanization will make it difficult for these megalopolises to raise questions about whether these cities can be sustainable, either socially, economically, or environmentally. The poorest populations will grow the fastest in the megalopolises of the developing world. Already there are more than one billion people living in the slums of these cities. (UN Habitat, 2006), and as the

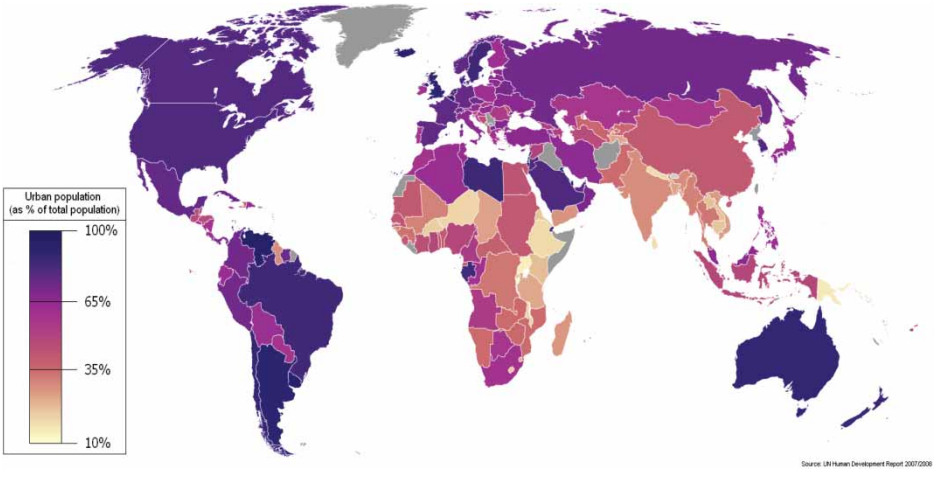

Figure 2. World map showing the percentage of citizens living in an urban environment in 2007
Source: United Nations Human Development Report, 2007

numbers grow, there will be more and more social and spatial segregation (Bolay et al., 2000).

While the new urban dwellers view the city as a place of hope, these cities face many disadvantages and structural constraints (such as the lack of infrastructure or the proportion of informal employment) that will thwart economic transformation and the development of companies (Kessides, 2006).

Finally, the populations of these cities are the most vulnerable to the effects of climate changes because of the density of the cities and their lack of adequate infrastructure. (World Bank, 2008b). Urban development in developing countries has now become a major challenge for the international community, as evidenced by the United Nations Millennium Development Goal 7, target 11 (United Nations, 2000), which aims to significantly improve the lives of at least 100 million slum dwellers by 2020.

Given this trajectory, this paper asks the questions: What is the possible role of technology in the face of the new challenges confronting Southern cities? To what extent can technology contribute to the sustainable development of the cities of the developing countries of the South?

Appropriate Technologies for Urban Development

Post-modern or post-industrial civilization (Katzenstein, 2010) is today characterized by technology or the application of scientific knowledge to the production of goods and services. The application of innovation has also led to breakthroughs in many areas of technological development (Puech, 2009). Developing countries led the way in producing technological progress within the last several decades. Meanwhile, the broad adoption of technologies has decreased the proportion of people living in poverty from 29 percent in 1990 to 18 percent in 2004 (World Bank, 2008a).

In this context, the city plays a major role in the dissemination of new technologies. Technological innovation is both the cause and effect of urban development, playing a decisive role in the structuring of cities but also representing a means of fulfilling emerging needs (Dupuis and Prud'homme, 2010).

If technologies are to be transferred from the cities of developed countries to those of developing countries, and if there is to be the joint creation of adapted technologies, those technologies will have to respond to the major problems confronting the public authorities, economic stakeholders, and end users of these urban technologies (AUTM, 2010). There are five areas that are especially appropriate for technology transfer: water, energy, transport, sanitation, and habitat.

However, in light of the new challenges that Southern cities are confronting, the field of application for the transfer and joint creation of technologies is being expanded in an attempt to better contribute to the sustainable development of these cities. Globalization, demographic change, mobility needs, access to basic services, and the mitigation of climate change are new avenues to explore for the implementation of adapted and appropriable technologies for and by urban territories in developing countries.

Two major questions arise in discussions about technology and development in urban centers:

- Can contemporary technologies contribute to the sustainability of urban development in all its environmental, social, and economic aspects?

- Can urban technologies that are advanced according to sectors, needs, and access allow for ownership for all and by all?

These questions are especially pertinent in regard to those urban technologies created in developing countries to work in the five areas already mentioned (water, energy, transport, sanitation, and habitat) in the face of new challenges that urban centers must tackle (globalization, climate change, etc).

Many emerging technologies do not need large infrastructures (microgeneration, photovoltaic energy, etc.), and current research seeks to explore the potential of these technologies to improve urban living conditions and reduce urban poverty. Part of that research must consist of analyses of the social, economic, and environmental effects of these technologies and their long-term implications for slums, cities, and metropolitan agglomerations.

The study of these new technologies must also examine issues related to local knowledge in the identification and development of technologies, such as the interactions between technologies and social and organizational structures, and reflections on ways to extend the ownership of these technologies across the entire urban territory.

Risks Related to Technologies in Urban Environments: Towards a Diversified Technological Approach

Urban segregation—as much in its spatial as in its socioeconomic aspects—is a consequence of an urban growth in developing countries that has led to the implementation of a market economy, resulting, among other things, in mass rural exodus. This phenomenon is not only a threat to the traditional agricultural economy, where it has survived, but also to the sustainability of a modern economic sector that has to cope with a growing urban population. This urban economy is a direct replica of capital-intensive technological models imported from industrialized countries. The concentration of industrial development in the metropolises of developing countries has a negative impact as rural populations relinquish the primary sector of the economy in favor of employment in the city (Schumacher, 1989). As a result, developing countries suffer from particularly high rates of unemployment, a continuous rise in poverty, growing social disparities, and increasingly difficult access to basic services.

When cities adopt "appropriate technologies" some of these problems are obviated. The term "appropriate technology" became popular in the 1970s with E.F. Schumacher's bestseller *Small Is Beautiful: Economics as if People Mattered* and had a significant impact at the onset of the oil crisis, the emergence of globalization, and the gradual development of political ecology. A renowned economist who collaborated with J.M. Keynes and J.K. Galbraith, Schumacher focused his work on a new idea of decentralization while advocating a reorganization of economic tasks on a smaller scale.

"Small-scale operations are always less likely to be harmful to the natural environment than large-scale ones, simply because individual force is small in relation to the recuperative forces of nature" (Schumacher, 1989:37). Elsewhere, he refers to local technology as "technology with a human face" that mitigates "the greatest danger [that] invariably arises from the ruthless application, on a vast scale, of partial knowledge as we are currently witnessing in the application

of nuclear energy, of the new chemistry in agriculture, of transportation technology, and countless other things" (Schumacher, 1989:36).

Mohandas Karamchand Gandhi, the father of Indian independence and staunch defender of non-violence, was another pioneer of this type of technology. The works of the American Henry David Thoreau greatly influenced his philosophy of development, in particular his critique of the economy of the industrial society in his book *Life without Principles* (1854). A large number of authors who have written on appropriate technology often refer to Gandhi as the "father" of appropriate technology and the "first appropriate technologist" (Betz et al., 1984). Gandhi referred to the need to promote "industrial villages" in India: "the poor of the world cannot be helped by mass production, only production by the masses" (Schumacher, 1989:163). Thus, the development of a modern industrial sector within an urban environment equipped with significant technological capital was to go hand in hand with the promotion of small companies and of agriculture in hinterlands in order to enable all individuals to reap the benefits of technological growth.

Appropriate technologies are technologies that need little capital; they use materials available locally, require less manpower than traditional techniques, are accessible to families or community groups, can be understood, supervised, and maintained by local individuals without high skill levels, can be achieved in villages or small workshops, may be adapted to different environments in different circumstances and are environmentally-friendly (Darrow and Saxenian, 1993).

Then "as a convenient shortcut for modeling 'appropriateness,' we index technologies by capital intensity, where in the definition of capital we include both human and physical capital. Each technology is thus appropriate for one and only one capital-labor ratio."(Basu, Weil, 1998, 1026)

Over the years, the concept of appropriate technologies has met with a number of criticisms, including these:

- Technology is not the sole growth factor; appropriate technologies cannot possibly solve all problems faced by developing countries.
- Appropriate technologies can jeopardize worker productivity in countries where endemic unemployment rates genuinely threaten the survival of individuals and families.
- The efficiency of appropriate technologies remains to be proven against that of capital-intensive technologies.
- The term has a negative connotation and seems to imply that appropriate technologies are somehow inferior.

This is why we are now witnessing the emergence of a new concept; a diversified technological approach (Akubue, 2000), taking into account some of the criticisms related to appropriate technologies while retaining their basic principles: technologies that are embedded and differentiated according to territories and their idiosyncrasies and to the people using and affected by those technologies.

This concept seems particularly useful when reflecting on technologies within urban environments and the current challenges posed by their implementation in developing countries. On one hand, if you consider the term appropriate from a purely technical and technological angle, context could be the first key of analysis for appropriate technologies. A technology could consequently be appropriate with regard to a given context and adapted according to clearly

identified needs. On the other hand, the second key of analysis could focus on the beneficiaries of these technologies by viewing the term appropriate from an ethno-sociological perspective: in what manner can the users of a technology take ownership of it and how will it, therefore, be adapted to persons?

Although there are many differences between developed and developing countries—the latter require technologies to address primary needs such as drinking water, electricity, or habitat, for instance—innovation also includes many similarities among regions of the world, be they in terms of communication, safety, or sustainable preservation of the environment. It is with an eye on the major differences between countries and by examining the societal impact of these appropriate and diversified technologies that we will be in a position to assess whether or not they have successfully been adapted to the context.

Technology for Urban Development: A Societal Issue

The definition, design, and implementation of technologies for a more harmonious development of Southern cities still raise many issues, in the decoding of their content and their purpose and in the assessment of the particular contexts inherent to emerging and developing countries.

By linking these major issues to urban debates about which avenues to explore to guarantee the spatial and socioeconomic development of cities, we pose a series of questions and then attempt to outline a few answers:

- To which urban areas and sectors should appropriate technologies be primarily assigned?
- What are the characteristics of designed and/or implemented technologies?
- What societal needs do these technologies target?
- How do they differ and how innovative are they compared with modern scientific and technological choices?
- How do these technologies adapt to the geopolitical context in which they are introduced?
- How do they contribute to sustainable development through their environmental, social, and economic compatibility?
- What role do they play in scientific and technological cooperation for development?

If the existence of purely urban technologies begs debate, we deem it interesting to define urban specificities. Indeed, scenes of production, innovation, exchange, and identity, urban territories cannot be described from the sole viewpoint of poverty, insecurity, or pollution. On the contrary, the concentration of populations, activities, and economic, social, and cultural wealth that characterize them can represent a tremendous momentum for development. A line differentiating purely urban technologies from other technologies could take root in this concentration.

Admittedly, a majority of technologies have been invented and implemented far from any urban influence. However, it appears that beyond a certain level of concentration of activities, persons or even powers, certain technologies have been either improved or completely created in response to the needs engendered by cities. By way of example, technologies for the treatment of wastewater have gradually evolved from the environmental impact of the pouring out of wastewater into riverbeds and other substrata, these natural resources proving to be unable to recycle by themselves the quantities of contaminants that have

caused their original balance to degenerate. Equally, in the domain of transport, neither buses nor cars were specifically created for cities. Yet, the latter having in many cases reached high levels of concentration of both inhabitants and activities, said technologies had to be adapted so as to create smaller, less fuel-greedy cars, or still, for public transport, tramways or undergrounds using clean energies which do not cause a deterioration in air contamination (Raisson, 2010).

"*The machine, or technology, does not belong exclusively to the City; but the City, more than any other form of social organization, has developed and elevated it to almost divine, or demonic, levels. Controversy, as it has throughout the history of cities, yet rages as to whether the compact between mankind and machine is, or is not, a Faustian bond*" (Clapp, 2007:94).

As previously stated, five fields are of the utmost importance in the implementation of new technologies that are capable of both solving the problems encountered and adapting to the territorial and societal context inherent in Southern cities while adding nuance according to the history of each agglomeration, its human and geographic specificities, its position within urban networks as well as within regional, national, and international dynamics. These key areas are water, sanitation, energy, transport, and habitat. They constitute the backbone of environmental as well as social and economic sustainability and have a strong impact as much within the private sphere as within community and public life. Serious shortages have been observed in a number of cities in developing countries, in terms of listed requirements, in terms of physical access and infrastructure for accessibility, and often, most importantly, in terms of socioeconomic accessibility.

Water and Sanitation

Water is most certainly the basic natural resource without which individuals cannot survive; its potability is, therefore, essential to maintain both health and hygiene, which is why water is often presented with its corollary, sanitation. In the cities of poor countries and in arid areas, water is still unevenly distributed in fringe neighborhoods, forcing users to call on private distributors with unacceptably high unit costs or to connect their homes to unofficial water supplies, with significant water losses and a severe depreciation in its intrinsic quality, as observed in Buenos Aires, Argentina (Catenazzi, Kullock et al., 2000) or Ho Chi Minh City, Vietnam (Randin et al., 2000). Appropriate technologies must address the main deficiencies identified, namely the lack of water supply in some cities, as well as shortcomings in terms of water access and quality. Sanitation is a corollary of water supply, and wastewater treatment is often ill-organized in the poorest fringes of Southern cities. In most agglomerations, urban water recycling is still non-existent, sanitary wastewater is released in downstream water courses, lakes, or seas without any purification of biological, chemical, and heavy metal waste, producing a pollution beyond urban borders that can contaminate as much table water as surface water, as much soil as individuals using such untreated water. Urban sanitation also involves the collection, sorting, recycling, and processing of solid, household, industrial, and hospital waste, etc. Here again, there are countless examples in developing countries showing that sanitation technologies are in their infancy compared to the systems already being applied in high-income cities (UNSHP, 2006). Besides, as the costs of traditional solid waste treatment systems are too high, individuals

and public authorities are tempted to deny the problem, at best moving waste towards uncontrolled dumps, at worst dumping the waste in the streets or in streams, with immense risks to soil and water tables—and this despite existing alternatives, as observed in Ho Chi Minh City, Vietnam (Tran et al., 2002).

Energy

Energy remains the driving force for economic activity and for the minimal levels of comfort needed in urban homes, for heating, food preparation, lighting, and electronic appliances. Although electricity now reaches 93.4 percent of urban households worldwide (100 percent in industrialized countries, but only 66.8 percent of African urban dwellers and only 63 percent of the world's rural population) (IEA 2010), a significant number of marginalized households live outside public networks and must continue to heat, feed themselves, and provide lighting with fossil, non-renewable, highly-polluting energy or with a negative impact on the ozone layer, be it through coal, wood, or oil. Similar questions arise regarding units of production, notably in the traditional sector, with no possibility for individuals to resolve these issues on their own. And it is not unusual to see cities experiencing regular and repeated black-outs, with a symptomatic impact on economic productivity and profitability. (See Figure 3.)

Transport

In most cities in emerging and developing countries, adapting public transport to the needs of ever-growing communities remains one of the main tasks facing city-dwellers, most particularly the poor and those located on the outskirts of large urban centers. In the vast majority of agglomerations, the expansion of inhab-

	Population Without Electricity *million*	*Electrification Rate* *%*	*Urban Electrification Rate* *%*	*Rural Electrification Rate* *%*
Africa	**587**	**41.9**	**68.9**	**25.0**
North Africa	2	99.0	99.6	98.4
Sub-Saharan Africa	585	30.5	59.9	14.3
Developing Asia	**798**	**78.1**	**93.9**	**68.8**
China & East Asia	186	90.8	96.4	86.5
South Asia	612	62.2	89.1	51.2
Latin America	**31**	**93.4**	**98.8**	**74.0**
Middle East	**22**	**89.5**	**98.6**	**72.2**
Developing countries	**1,438**	**73.0**	**90.7**	**60.2**
Transition economies & OECD	**3**	**99.8**	**100.0**	**99.5**
World	**1,441**	**78.9**	**93.6**	**65.1**

Figure 3. Electricity access in 2009: regional aggregate
Source: IEA, 2009

ited territories was not matched by an increase in public transport networks. The majority of people's travel needs, in particular journeys from home to work, are met by either resorting to individual modes of transport (walking, cycling, or driving, according to financial resources) or by using privately-run, low-capacity transport (such as taxis and minibuses). Public transport is lacking where quantity, quality, and accessibility are concerned, rarely reaching areas away from the city center. Once again, poor populations living in the fringes of the city are disadvantaged and spend a high percentage of their family budget funding their traveling both within the city and beyond. In the most prosperous countries, agglomerations are experiencing a growing, wealthier middle class, and the mix of public and private transportation is leading to continuous traffic congestion, with increasing traveling times and air pollution. Fortunately, alternatives are starting to emerge such as BRT systems (Bus Rapid Transit) that are less polluting and less costly than expanding road infrastructure or building underground rail networks. Yet again, adapted technologies should help reduce the pollution and noise from these modes of transport, increase their speed, and make them accessible to large numbers of people. But technology should support better planning for mobility and intermodal transfers (Kaufmann, 2005); this would also have an effect on connectivity within urban regions and the revival of public spaces and urban centers.

Habitat

Habitat is an obstacle for the development of socially-inclusive cities. Property is a booming sector in many urban environments, providing many direct or subcontracted jobs; it is the economic powerhouse of the city. Generally, the habitat of the poor remains outside this sector's traditional modes of operation and management because of the poor's lack of financial resources; ill-adapted official regulations; and because of the lack of financial and technical support institutions—as highlighted in Bolivia for example (Bolay and Taboada, 2011) and elsewhere in the world (UN Habitat, 2006). The main consequence of the expansion in informal housing is that it enables the poor to find accommodation—in normal market conditions—although generally in precarious and often unsanitary circumstances, but enabling all family members to have a roof over their heads and a place to sleep. Questions remain regarding urbanistic and infrastructure integration. Indeed, many deprived neighborhoods are not recognized by local authorities and suffer from limited access to basic networks such as water, electricity, sanitation, etc. Modes of construction are still rudimentary, with no assurance of sustainability, often using second-hand or very low-quality materials which do not guarantee salubrious and "climate-proof" accommodations. Though it pertains to the private sphere and is enmeshed in legal and administrative complications, housing is most probably one of the urban sectors in which appropriate technologies can most easily succeed, as long as they remain affordable for low-income families and have a real impact on the physical and material conditions of urban living; choice of materials, modes of construction, connection to networks and urbanistic integration are all elements paving the way for new technologies.

Conclusion

In developing cities of the world, especially in the South, new inventions are springing up daily and gradually being translated into new products, into

different types of innovation, which come in various shapes and sizes and for specific purposes. These inventions often manifest themselves as, and are categorized as, urban technologies. This raises a series of questions: How are these innovations—in their technological application and use—genuinely urban? Is it because they are rooted in a social and environmental context? Is it through their participation in solving the problems of contemporary cities, or more essentially because they emerged in urban societies, were created and developed in harmony with their stakeholders, in the culture and history which they sprang from? Admittedly, since little has been rigorously written on the subject, it is difficult to discuss which criteria to follow or indicators to apply, and more generally, which gateways to establish among sectors concerned, technologies used, and methods adopted. This work remains to be carried out and it is certainly fascinating, starting with tried and tested technology and set goals. It challenges urban planning in a very direct fashion, both in its intentions and its modes of action, and it also questions the players involved in these present and future endeavors. As George Bugliarello said about contemporary megalopolises: "In effect, most megacities present a dual reality. They have many modern and efficient buildings and infrastructures, and, at the same time, they have slums in which much of their poverty is concentrated. Megacities grow because they are increasingly powerful instruments of economic and social development for the country in which they are embedded and because the opportunities they can offer to their citizens outweigh their dysfunctionalities" (Bugliarello, 2009:152). Similarly, he contends that urban efficiency—to which technology evidently makes a significant contribution—will tend to reduce dysfunctionalities and respond to economic and social changes in a flexible manner for a better quality of life.

In concluding this reflection on urban technology, it appears that the adaptability of such "appropriate technology" to city-related territorial and societal issues in emerging and developing countries will depend on a few key factors:

- First of all, let us not forget that any human establishment, agglomeration, or city, whatever its size, population, and location in the world, cannot survive and expand without a number of technological tools to develop these environments inhabited by continuously growing populations and to facilitate social living. The purpose of technologies has remained the same. Embedded in urban environments, they have considerably evolved in their sophistication and connectivity, and information and sharing are now at the heart of any developments in this complex field.
- Technological innovation cannot simply be a replication in Southern cities of solutions adopted by Northern cities, with transfers from other societies with no consideration of how to adapt to alternative spatial and social contexts. Innovation is a creation, an authentic, original product, which meets genuine requests drawn up from the needs identified in these cities and expressed by their stakeholders.
- Technologies will be designed and implemented with a transdisciplinary perspective resulting from various scientific and technical contributions but also, and just as importantly, resulting from the interaction between the designers of these new instruments, their urban promoters and the users and beneficiaries of these technologies. There will, therefore, be a shift towards a sociotechnical creative process, where not only are technologies adapted to given urban situations but where there is a clear sense of ownership by all the different

players involved in these technologies regarding their use, their added value. and their development.

- Beyond the contributions of technology, urban societies continue to change and such transformations do not always take place in an isolated and consistent manner. Technological transformations reflect territorial tensions and conflicts, as well as the environments and the social and political settings that the societies in all cities experience. They take part in these changes and can sometimes trigger them or exacerbate them. One of the central issues that will cling to the debate on urban technologies will be the accessibility of technology to all city-dwellers, whatever their position, both spatial (territorial marginalization or inclusion within equipped areas) and socioeconomic (real and symbolic integration in urban society, or disparities and segregation). On a wider spectrum, the debate may focus on the meaning of the democratization of urban societies in a world that is ever more global and technological, in which this space for dialogue is no longer solely political but also questions the fields of science and technology.

Thus, there are no exclusively "urban" technologies. However, the city and its characteristics do play a significant role in the redefinition of technologies and their adaptation to needs, both from a social and material viewpoint. We will continue to explore more efficient and cleaner energies, the most solid and "climate-proof" construction materials or faster and less polluting means of transportation, etc. It will not be possible to pigeonhole as strictly "urban" those technological efforts designed to enhance performance and yield in these sectors. Nevertheless, for the most part, they will come from an urban environment and will have attempted to solve issues raised by contemporary life in an urban society. To that effect, technologies will essentially follow the world's evolution thanks to scientific breakthroughs as well as the globalization of both communications and economies, in this ongoing radical transformation on each continent, at varying paces and timescales, towards an increasingly urbanized world.

When urban technology is endorsed, adapted to all urban contexts and needs, it becomes the mainspring of an enhanced "urban life," a togetherness and a feeling of belonging to a community, highlighting potential synergies between individual fates and social inclusion; between inhabited territories and environmental protection; and between individual security and socioeconomic integration. In this light, urban technology would thus primarily be a human technology, in its deepest sense, created by humans for their development as well as their material, social, sanitary, and even spiritual wellbeing.

Notes

1. There is a spatial—and cultural—dimension to sustainable development that must also be considered.
2. UNESCO (2005), UNESCO Science Report, UNESCO, Paris: the same figures were not included in the Unesco report 2010.
3. Joint government and business R&D spending rose by 2.1 billion rand (around US$280 million) between 2006–07 and 2007-08. But this increase did not keep up with the country's economic growth with the result that R&D spending dropped from 0.95 percent of GDP in 2006–07 to 0.93 percent in 2007-08 (South African Science and Technology Department 2008/2009).

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