Universidade Federal do Rio de Janeiro

INSTITUTO DE ECONOMIA INDUSTRIAL

TEXTO PARA DISCUSSÃO Nº 142

MEGACITIES AND INNOVATIVE TECHNOLOGIES

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Dezembro/1987

UNIVERSIDADE FEDERAL DO RIO DE JANEIRO

INSTITUTO DE ECONOMIA INDUSTRIAL

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Dezembro/87

(*) Trabalho apresentado no XIº Congresso da International Sociological Association, Nova Delhi, Agosto de 86; publicado primeiramente em CITIES (Londres, maio de 1987).

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anpec Este trabalho foi impresso com a colaboração da ANPEC e o apoio financeiro do PNPE PNPE

FICHA CATALOGRÁFICA

Perlman, Janice E.
Megacities and innovative technologies /Janice E. Perlman. - Rio de Janeiro, UFRJ/IEI, 1987.
22 p.; 21cm (IEI/UFRJ. Texto para Discussão, 142)
1. Urbanismo - Inovações Tecnológicas. 2. Urbanismo - Aspectos Tecnológicos.

The purpose of this paper is to explore the dissemination of existing urban innovation and the applicability of new technologies to the problems of urban livability in the world's largest cities.

The extraordinary growth of cities around the world, rising demands for urban services, rising prices for provision of services and materials for basic human needs, inadequacy of existing systems and limited municipal budgets, have given new impetus to the search for urban innovations. By urban innovation, we mean the creative use of traditional technologies as well as relevant applications of new ones; they may be managerial, organizational or financial technologies as well as physical ones; and they may be decentralized (neighbourhood or household level) as well as centralized (city level) initiatives.

Different approaches are needed to examine successful in-place innovations in the world's cities and their applicability elsewhere; explore the possibility of adapting existing ("off the shelf") technologies to urban problems in ways that have not been addressed thus far; and invent new concepts and technologies to meet the needs of the urban future.

In all three cases, the point is to mobilize new or idle human and physical resources in the quest for better coping mechanisms for urban livability —whether bottom up or top down. This quest has become urgent in light of present realities and future projections.

The Challenge

The world is becoming predominantly urban. In 1800 only 3% of the world's population lived in cities; by the year 2000, according to the United Nations, the majority of the world's population will live in urban areas. Big cities are growing at unprecedented rates and reaching unprecedented sizes. By the year 2000, UN projections show that there will be about 78 cities of 4 million or over, and 22 megacities (over 10 million). The largest of these - Mexico City - is projected to have a population of 26.3 million (more than the current population of Canada). And UN data show that overall the megacities are growing faster than any other size city.[1]

In the process, the balance of urban concentration is shifting from the industrialized nations to the developing ones (see Table 1). Of the 22 megacities, 18 will be in developing countries —mostly in Asia and Latin America. Estimates are that from 1950 to 2050 the urban population in Third World countries will have increased almost 16 times from under 200 million to 3150 million people.[2]

Most of the discussion of megacities has focused on their problems and not on their opportunities. Rather than seeing the city as the source of economic progress, increased

1) Rafael Salas. "Super cities of the future". New Scientist, 15 May 1986, p.27.

2) The UN has since revised downward its projections for the year 2000, and the US census projections are lower still; but there is consensus that the top cities in the year 2000 will include those on this list with the addition of Seoul according to the UN and Osaka, Buenos Aires and Moscow, according to the USA.

choice, upward mobility, energy and creativity, attention has been drawn to congestion, pollution, disease, unemployment, homelessness and crime. Therefore policies to limit cityward migration have been promoted by national governments around the world. An extensive review of such policies shows that all three types —closed city policies, dispersion policies and rural or regional development policies — have had limited success in slowing the growth of the primate cities. Although in centrally planned economies the migration flows have been at least partially controlled.[3]

Even if renewed policy efforts are made to limit in-migration to the megacities and slow the rate of natural increase within them, and even if the projections are not soundly derived,[4] cities will none the less grow to sizes previously unknown in human history. This is partially because, as ILO studies have shown, people follow opportunity; and the larger the city, the more opportunity.[5]

While cities in the Third World are growing at 3-4% per year, the shanty towns, illegal subdivisions and low income neighbourhoods are growing at twice that rate. This means that

3) Janice Perlman and Bruce Schearer, Migration and population trends and policies and the urban future". UNFPA International Conference on Population and the Urban Future, Barcelona, Spain, May 1986.

4) For an excellent discussion of the problems of projections see David Satterthwaite and Jorge Hardoy, "Urban change in the Third World: are recent trends a useful pointer to the urban future?", Habitat International. Vol. 10, no.3, 1986.

5) See ILO Information Bulletin, "What size does to cities", Vol.10, No.5, December 1985, p.1. it reports on Bairoch's work which shows that employment, incomes and productivity rise with city size, while living conditions (including crime, traffic congestion, housing shortage and pollution) become increasingly worse.

any innovative solutions to livable, sustainable cities rust deal with the issues of massive urban poverty. Studies have shown, however, that the rural migrants who swell these ranks have an income and educational and motivational levels higher than their rural counterparts, find jobs in the city more quickly than other unemployed, and have lower rates of unemployment than other semiskilled or unskilled urbanites. In many cases they have created settlements on previously uninhabited marshes or hillsides and upgraded them to include paved roads, water, electricity, schools, clinics and commerce.[6]

The question then becomes how to meet the challenge afforded by this massive urban scale and level of needs and how to creatively use the full potential of the human and natural resources within these cities. It is illuminating that the Chinese symbol for "crisis" includes the symbol for both "danger" and "opportunity". The former has been much discussed, the latter largely ignored.

The opportunity

To start with, it makes sense to examine the existing coping mechanisms devised by city governments, grassroots groups, or private sector entrepreneurs in order to look at the sucessful innovations already in place and see whether they can be replicated. The questions then become: what are the innovations,

6) Janice Perlman,"The Myth of Marginality",University of California Press, Berkeley, CA, 1976.

how were they developed, what technologies are involved, what political, social, financial or administrative obstacles were overcome in implementing them, are they transferable to other situations, and what sectors of the population benefit?

Sachs has identified five fields of potential innovation for research:

1. new forms of organisation of economic activity;
2. untapped or underutilized resources in the urban ecosystem;
3. appropriate technologies;
4. institutional innovations; and
5. public policy instruments.

The criteria he proposes are social equity, economic viability, technical feasibility and ecological sustainability.[7]

The next question is what are the possible applications of the advances in science and technology over the past decades to addressing the quality of life of city dwellers. According to Eberhard,

> We don't know because there has been no attempt made to seriously explore the potential. The absence of technological research tradition the urban field, the assumption that private initiative will respond if there is a market, combined with the major alternatives for the high technology companies in space and weapons systems leaves no entry point for new developments.[8]

7) Ignacy Sachs, "Social innovation in the urban setting: scope and evaluation criteria", IFDA, Paris, November, 1985.

8) John Eberhard, "Technology and the future city", Lambda Alpha Biennial Congress, Washington, DC, October 1985, pp 1-7.

The work of BOSTID (Board on Science and Technology for International Development) at the National Academy of Sciences over the past years has fostered scientific research applied to food and fuel sources in rural areas of the developing world and the dissemination of findings, but has not focused on urban needs. Similarly, a recent ILO project on the "blending" of traditional and new technologies reports on 17 case studies, almost all of them rural.[9]

Although science and technology are clearly not the prime movers in urban life, inventions made and patented 100 years ago (in a brief 12-year time span between 1877 and 1889) did in large measure shape the city of today in the way they solved certain problems and created others. They include:

- steel; steel frame buildings; the skyscraper;
- elevators;
- indoor plumbing;
- electricity; the light bulb; the electric trolley;
- the internal combustion engine automobile;
- the subway; and
- the telephone.[10]

Thus, it is worth examining some of the new technologies which have emerged since the turn of the century (and especially in the past 25 years) to explore their potential for managing our cities and lowering both the costs and risks of

9) ILO, "New technologies and the Third World", Technological Change, the Tripartite Response, 1982-85, Geneva, 1985.

10) John Eberhard, "Advanced urban systems: a world wide opportunity", Habitat International Journal, Vol.2, no. 1/2, 1977, pp 5-12.

doing so. This has been especially evident in the wake of the earth-shaking disasters of Bhopal and Chernobyl.

Currently, however, less than 1% of worldwide research and development (R & D) spending is geared to development issues at all, while 32% is devoted to defence and space research.[11] Furthermore, of all multilateral and bilateral development assistance, only about 8% is targeted to urban problems. We are not so naive as to expect any technical "quick fix" to urban problems, but wonder whether the research and development that has gone into the space age defence system and the consumer age product system may have some spin-offs for urban livability.

According to Eberhard[12] we are ripe for these, as we are now into the third generation of urban systems (the first going back to 3000 BC in Egypt and continuing until the new Industrial Revolution and the set of inventions mentioned above). In his view the promising technologies would include such things as:

- continuous process robotics (which might be used, for example, in fire-fighting equipment);
- satellite communication (which could be used for education and research);
- photonics (the combination of laser light and fibre optics) which could be used for global town meetings;
- computer-aided design (which could permit testing of city planning and service delivery options);

11) Norman Meyers, ed. GAIA: An Atlas of Planet Management, Anchor, New York, 1984, pp 266 ff.

12) Op cit., Ref. 8.

- microprocessing with electronic memory (could give every school instant access to the entire Library of Congress);
- hi-tech ceramics and new materials (for housing and building); and
- biotechnology and genetic engineering (with numerous applications for food sources, health, sanitation, water treatment etc).

The question then becomes how to transform the massive unmet needs of the urban populations into effective economic demand such that off-the-shelf technologies can be adapted and applied to cities, and new prototypes and R and D work in this vein can be supported. The market has not worked by itself in aggregating demanda, and perhaps a broker role needs to be created to facilitate communication between public sector clients and private sector suppliers in such a way that urban needs become marketable demands.

But there is another set of questions, perhaps even more telling. How would these benefit the majority of urbanites in the developing countries who are struggling with survival rather than enhancement issues? How would they contribute to self reliance rather than increased dependency (especially in this age of crippling foreign debt)? How would cities which cannot even collect water tariffs or run a telephone system cope with the managerial, administrative and financial aspects of such innovations? Would jobs ultimately be created or destroyed and resources conserved or expended?

Technology blending

Another part of the opportunity, then, has to do with precisely those points raised above — equity, self reliance, capacity building and resource conservation. It involves innovation in the productive use of non-utilized or underutilized resources (often waste, sewage, wind, sun or earth). This entails serious research into the creative blending of traditional and new technologies.

As Jorge Wilheim, former planning director for the city of Sao Paulo calculates it, the "social debt" (ie the combined deficits in schools, health facilities, jobs, housing, water, sanitation and street paving) that has accumulated over 15 years of neglected maintenance and population explosion amounts to a total of US$ 16.782 billion (at 1984 rate). In his calculations this is roughly divided into equal thirds for operating existing equipment, building new equipment and operating the new equipment. This social debt represents the present equivalent of 30 municipal annual budgets. He concludes, "One of the only modes of tackling this situation is through mobilization of human resources and through innovation technologies which are less expensive than traditional approaches".[13]

In these areas the technology transfer is not generally North-South, as in the high technology examples above, but often South-North, since developing country cities

13) Jorge Willheim, "Innovations in human resources: case of Brazil", Discussion notes prepared for the NYAS workshop, 11 April, 1986, p 1.

(especially in China and India) have been forced by their already dense populations and scarce resources to be innovative. In such cases the innovations are not generally "invented" through an organized R & D effort in a research lab but by local "tinkerers" working at the grassroots, decentralized level.

Programmes and networks to explore these opportunities have been established in many countries and international institutions including the UNU Food-Energy Nexus. USAID's MEREC project (Managing Energy and Resource Efficient Cities) the Asian Institute of Technology in Bangkok, GRET, in Paris, the IFDA Urban Self Reliance Project, IIED in London, the Institute for Local Self Reliance in Washington, DC, The Earth Project in NYC, The Center for Science and Environment, Lokayan and Development Alternatives in New Delhi, and many, many more. Some of the technologies with which these and others have been working include biogas, adobe, solar energy, wind energy, aquaculture, sewage treatment, water filtration and composting.

Biogas (methane) is a renewable source of energy which can be generated from garbage (eg rice husks, slaughter house waste, market refuse, etc) and can be used for cooking, lighting and heating. As landfills become exhausted it becomes an increasingly appealing way to deal with sludge and garbage. For example, in Sao Paulo, the city is running 40 buses using methane gas produced by waste from the favelas.[14] Another

14) Ibid.

example is in Patna (Bihar state), India, where borehole pit latrines produce methane as a source of energy for cooking and electric lighting for the household.[15]

Adobe utilizes widely available local clay and earth mixed with other abundant local materials which are ordinarily waste products (such as rice husk, ash and lime) to create durable, wheather resistant and even earthquake stable houses which can be user built on site. Peru, Egypt, Morocco and Mali all have experiments with adobe constructions and an Electronic Encyclopaedia is now being developed by the Earth Project which will catalogue the techniques and their connections to rooftop rainwater harvesting, "solar silos" for fish and vegetable production and modified borehole pit latrines mentioned above.

Solar energy uses natural sunlight to transform or capture energy for household use, particularly for water and space heating, cooking and food drying. Solar energy systems can be active or passive. Photovoltaics use sunlight to produce direct current, and although presently too costly for wide application, research is being carried out on a "paint" which can be applied to surfaces and hooked up directly to storage batteries as a home energy source.

Wind energy farms have enormous potential for electricity generation and can vary in scala from tiny to enormous. For example, the Indian Secretary of the Department of Non-

15) "Two examples of shelter innovation in India", in Bulletin of the International Year of Shelter for the Homeless. HABITAT, Nairobi, Kenya, April, 1986.

Conventional Energy Sources has just won the "Energy for Mankind Award" for conducting a national programme on renewable energy. One of the experiments is an integrated energy system in Mosoodpur (near Delhi) which combines community biogas plants, wind energy used for water pumping, solar photovoltaics for radio and TV, fast growing biomass and gasifiers for production of power and charcoal.

Lest this be seen as of purely Third World interest, the Southern California Edison Company is running four huge solar plants and three wind farms. The wind farm in San Gregorio is the largest in the world with 3974 privately owned turbines of 15 different models. As a proof that these technollogies are potentially profit making, the US Department of Commerce is now pushing renewable energy technologies as part of its Foreign Buyer's Programs.

Integrated systems involving aquaculture, sewage treatment, water filtration and composting, use plants such as water hyacinths (which grow wild all over Asia) to clean sewage run-off water while growing fish and leafy vegetables. Later the hyacinth can be harvested, chopped up and composted for fertilizer while the water, if properly treated, can be made into drinking quality. There are numerous examples around the world including well known projects in Sao Paulo, Southern France and Mali. As an instance of South-North technology transfer, the city of San Diego is currently using water hyacinth ponds to treat its sewage. The scientifically exacting research being undertaken by John Todd on this area is highly

promising.[16] Water filtration and treatment can be accomplished through slow sand filters, aeration, sedimentation (using plant coagulants rather than chemicals), open reservoirs etc. For example, a two stage filter made of coconur fibre and burnt rice husks was developed by the Asian Institute of Techonology and is now being used in Bangkok, the Philippines, Thailand and Vietanam. It removes 60-70% of suspended solids and 80% of coliform organisms from raw surface water.

In addition to these technological innovations, many of the most interesting examples of urban innovation are actually creative ways of organizing existing systems. For example, the land sharing scheme in Bangkok, the public transport system in Curitiba, the "feito em casa" programme in Sao Paulo or the "arisan" system of savings in Jakarta. There is also enormous scope for the use of information management innovations in lowering the cost and improving the efficiency of billing systems and revenue collection, cadastral surveys, equipment inventory and maintenance and urban service management.

In all of these areas, the benefits of exchanging "sucess stories" are obvious. As David Morris puts it,

> Cities are by definition resource short. They are finite pieces of land with high population densities. Therefore, it is conceivable that as municipal self-reliance takes hold in the United States, the vast scientific and technological know-how of urban areas will be focused on developing techniques for doing more with less, for extracting the maximum amount of useful work from meager resources.

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16) John Todd, Bioshelters, Ocean Arks, City Farming: Ecology as the Basis of Design, Sierra Club Books, San Francisco, CA, 1984.

> The technologies that Arizona developes to generate wealth from its abundant resources of sand and sun, or that St Paul developes to generate wealth from its abundant resources of cold, water and biomass may be useful to the rest of the world. The rise of the new city states may give rise to a technological dynamic which makes the technological products of the United States more attractive and compatible with other nations and other cultures.[17]

The five critical questions then become:

1. Regarding appropriate technology: what mix of hi-tech, low-tech and organizational tech is appropriate for what circumstances?

2. Regarding local implementation: how can scientific or management experts work with the local governments, the community and the private sector to develop, adapt and implement innovative technologies?

3. Regarding scale and scope: how can local decentralized innovations reach a significant portion of the population in need? Small is beautiful, but it is still small. With the massive problems of the megacities there is little room for romantic solutions reaching the international press, but benefiting only a handful of local users.

4. Regarding technology transfer: how can cultural historic, social and even religious differences be overcome in transferring a successful innovation from one place to another? What is involved in terms of differences in local resources,

17) David Morris, "Local self-reliance in the United States", SID World Congress, Rome, July 1985.

economic level, institutional capacity etc?

5. Regarding self reliance: what are the limits to self reliance in an age of increasing interdependence? Is it really a viable trend or only an interim coping mechanism?[18]

Lessons learned

From the accumulated experience with bringing technology to cities and transferring it between cities, certain lessons have been learned. These lessons are most succintly summarized in two works: Toregas, "Putting Science and Technology to Work for the Cities of the World"[19] and The Urban Institute, "The Struggle to Bring Technology to Cities"[20]. The first is based on worldwide experience; the second on case studies of trash pick-up systems in Scottsdale, Arizona, slippery water introduced by RAND corporation to the New York City Fire Department and a computerized traffic control system.

Regarding the obstacles faced by cities, scientists and industry in working together on applying technology to urban needs, the problems must be seen from each partner's viewpoint. City governments worldwide tend to favour familiar

18) These questions are elaborated in personal correspondence from Pablo Gutman, Centro de Estudios Urbanos y Regionales, Buenos Aires, Argentina, 14 March 1986.

19) Costis Toregas, "Putting science and technology to work for the cities of the world", Ekistics, No.292, January/February 1982.

20) The Struggle to Cities, The Urban Institute, Washington, DC, 1971.

procedures and equipment, be constrained by very tight budgets, be distrustful of industry experts and unsophisticated about science and technology. In addition there is generally little incentive for government officials or civil servants to risk their reputations on innovative programmes since they will be blamed for the initial costs which are generally high and the rewards of successful cost saving may be reaped after they are out of office.

In terms of obstacles for industry and research, R and D scientists generally perceive no obvious market in urban needs. They are faced with tight budgets themselves, the urban market is fragmented and they are generally as unsophisticated about urban needs as the city officials are about science. As the saying goes. "We can get a man to the moon but not downtown".

In addition, when analysing reasons for the failure of urban innovations from the two studies, there was a lack of prototype of the innovative trial demonstration, lack of clear cut cost-benefit criteria, unsuitability of the product offered to the actual needs and poor communication between the various parties. It was found time and again that new technologies need to be user driven. It simply does not work to fit a nifty new technology into an urban need; the process has to begin with the need.

The ingredients of success turn out to be user driven impetus plus the full cooperation of all necessary groups including users, policy makers, administrators, researchers,

experts, manufacturers and funders.

Change strategies, whether within one city or in the transfer of technology between cities, appear to require:

1. specific prototype development to address the specific local circumstances;

2. a market aggregation mechanism (such as joint purchasing arrangements, standard specifications, contracting for public services etc);

3) a "climate for innovation" whereby bold urban managers are willing to work with their own employees in seeking technical advice as well as grassroots impact;

4) intensive technical assistance over a fairly prolonged period; and

5) long-term financing needs.

The following criteria are particularly important for technology transfer from North to South:

1) an equity strategy which provides access for the poor;

2) the need for labour intensive solutions such that jobs are created, not lost;

3) local needs identification and participation at all stages;

4) the development of local information systems to track costs and services and management capacity; and

5) the necessity for ultimate self reliance (in terms of both expertise and currency).

An agenda for action

With these lessons in mind, how can the megacities of the world create the opportunity for innovations to emerge and for the majority of the population — the urban poor — to have access to them?

Clearly, new partnerships between the public, private and voluntary sectors and the science and technology community are essential. The user driven approach to innovation requires joint work on needs assessment and priority setting as well as in the later adaptation, implementation and management stages. Furthermore, intercity and international networks can help. They help not only in avoiding replication of mistakes or avoiding costly re-invention of the wheel, but also in legitimizing the innovation and providing credibility for its proponents. Information exchange, face to face meetings, site visits and joint workshops are all helpful in this process.

What is needed is the international equivalent of PTI (Public Technology Inc.), which could be a central clearing house for research, information exchange, hands-on technical assistance and networking. This four-tiered approach has worked well domestically and is supported by subscriber fees as well as grants. The megacities should be challenged to develop an international research and development funding network to define the unique problems of size, density and complexity and furnish the risk capital to encourage the application of human ingenuity to these problems. Morris has calculated that if the top ten megacities each contributed 1% of their municipal budgets for this purpose, they would generate approximately $700 million. If that were used as pure R & D or venture capital, it could leverage in the order of $3-7 billion in loan capital and private investment.[21]

In conclusion, we return to the fundamental issues of any change process. Political will, institucional commitment, citizen pressure and financial underpinning — in short, not technology itself but the context and system within which it is embedded — will determine the outcome. As Norman Myers puts it:

> The management of city problems cannot be separated from wider issues of income distribution (both between social groups and between nations), the international economy, sustainable development, and human values. There may well be many innovative schemes to improve life in cities, but they nearly all hinge on economics strength, on cities having the resources and the will to pay for their infrastructure and services.[22]

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21) David Morris, correspondence with the author, 21 April 1986.

22) Norman Myers, ed, op cit, Ref.11, p.222.

TABLE 1: Ten largest cities in the world in 1950, 1985 and 2000

1950	Population (millions)	1985	Population (millions)	2000	Population (millions)
1. Greater New York	12.3	Mexico City	18.1	Mexico City	26.3
2. London	10.4	Greater Tokyo	17.2	Sao Paulo	24.0
3. Rhine-Ruhr	6.9	Sao Paulo	15.9	Greater Tokyo	17.1
4. Greater Tokyo	6.7	Greater New York	15.3	Calcutta	16.6
5. Shanghai	5.8	Shanghai	11.8	Bombay	16.0
6. Paris	5.5	Calcutta	11.0	Greater New York	15.5
7. Buenos Aires	5.3	Buenos Aires	10.9	Seoul	13.5
8. Greater Chicago	4.9	Rio de Janeiro	10.4	Shanghai	13.5
9. Moscow	4.8	Seoul	10.2	Rio de Janeiro	13.3
10. Calcutta	4.6	Bombay	10.1	Delhi	13.3

Source: Estimates and Projections of Urban, Rural and City Populations 1950-2025, United Nations, New York,1985.

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