Curitiba: towards sustainable urban development

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I. BACKGROUND

CURITIBA IS BEST known for its innovative public transport system based on buses but this is only one among many initiatives which have improved the environment and quality of life in the city, limited pollution and wastes and reduced resource use. The public transport system has also been complemented by comprehensive initiatives in planning and land use management. This paper describes not only the development of the public transport system but also the planning and administrative framework that was needed to make it, and other initiatives taken in Curitiba, effective.

Curitiba is the capital of Paraná, a mainly agricultural state in the south of Brazil. Located 900 metres above sea-level, near the coastal mountain ridge, the city dates from the seventeenth century and has long been an administrative and political centre. It developed rapidly as a city in the second half of the nineteenth century, underpinned by the arrival of many (mostly European) immigrants and the expansion of urban services and the opening of new economic frontiers; Curitiba had a central location on roads and railways and became a key service centre for new economic activities. It was designated the state capital in 1854.

However, until the second half of the twentieth century, physical, economic and demographic growth was relatively slow. There has been rapid economic and demographic growth in the last few decades which has transformed the city into an important industrial and commercial centre and a centre for transporting and processing agricultural goods. Today, the city has 1.6 million inhabitants and covers an area of 431 square kilometres; in 1965, it had less than 500,000 inhabitants. Service and commercial activities account for about 80 per cent of employment. Average per capita income is approximately US$ 2,500 per annum.

Curitiba continues to be one of the fastest growing cities in Brazil. Despite this rapid growth, substantial improvements in the quality of life have been achieved - for example, the innovative public transport system, the preservation of the city's cultural heritage, the large expansion in the number and area of parks and green areas, the integration of social programmes and environmental education, the innovative "garbage that is not garbage" solid waste management system and the "garbage exchange" programme.

II. THE PLANNING PROCESS

DURING THE PEAK of Brazil's rapid urbanization in the 1960s, a decision was taken in Curitiba to concentrate on a planning framework which emphasized the integration of all the elements within the urban system and which centred on a transport system that gave primacy to meeting the population's transport needs - rather than primacy to those owning or using private automobiles. At this time, most Brazilian cities were being planned for cars and individual modes of transport. Initiatives undertaken by the local government in Curitiba allowed the city to plan, direct and control its growth process; it also avoided large-scale and expensive projects, but included hundreds of small modest initiatives.

In spatial terms, the key concept was to encourage Curitiba's physical expansion along linear axes which had at their centre a road with exclusive lane express busways. This sought to reduce the concentration of employment in Curitiba's traditional city centre areas and to return this central area to the pedestrian and permit the preservation of the city's cultural heritage. Through a coherent zoning programme, new developments in the central area were limited, and the commercial and service sectors expanded along structural axes towards north, south, east and west (see Map 1).

The original plan for Curitiba came out of a public competition and the winning plan was made available to the municipal authority in 1965. In this same year, the municipal authority created the Curitiba Research and Urban Planning Institute (IPPUC) and this was allotted the following functions: to develop the master plan, develop studies and projects for the integrated development planning of the Curitiba metropolitan region, create conditions for the implementation, continuity and flexibility of proposals and coordinate local planning with policies at a regional, state and national level.

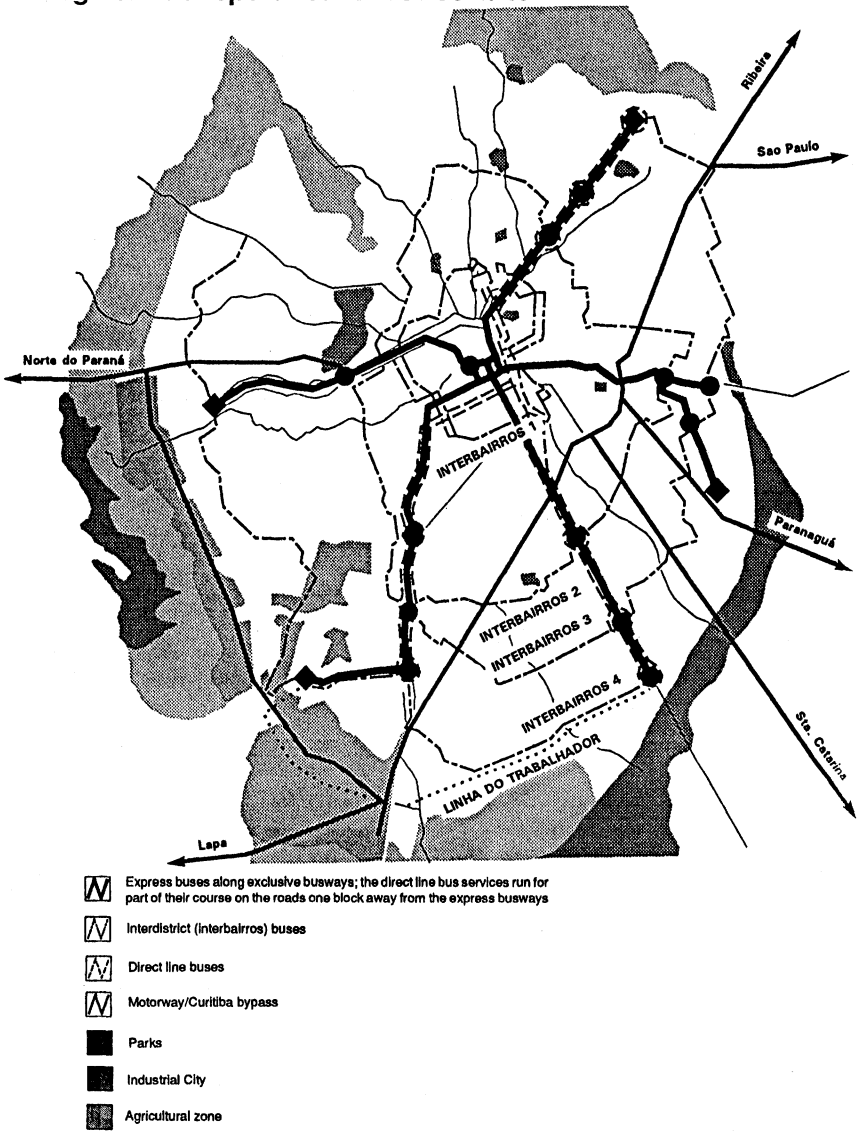
One of the key actors in the success of Curitiba over the last 25 years is Jaime Lerner, the current mayor who is serving his third term (he also served as mayor from 1970 to 1974, and 1979 to 1983). Prior to his first appointment as mayor of Curitiba, Jaime Lerner worked at the Curitiba Research and Urban Planning Institute and during his first administration, the IPPUC's powers and responsibilities were considerably enlarged.

During the 1970s, three important elements influenced Curitiba's development: the rationalization of the integrated transport system, the development of the road network system, and land use legislation which allowed environmental preservation, cultural services and the meeting of human needs. These initiatives were later complemented by the development of the industrial city (a specially designated industrial area to the west of the city), which at present generates one-fifth of all jobs in the metropolitan area without resulting in significant environmental problems, such as industrial pollution. What makes Curitiba unusual is not so much having a coherent plan but the fact that it was implemented and that this plan was integrated with an effective public transport system and with various other initiatives to improve the quality of life in the city.

Box 1: The Evolution of Curitiba's Public Transport System

1974: Implementation of the first two express bus lanes along the structural axes to the north and south
1978: Three new express busways added along structural axes
1978: Introduction of a new computerized area traffic control system
1979: Introduction of the social fare: a standard fare paid by all bus users which meant major benefits for bus users who lived on the city periphery (predominantly poorer groups) as shorter journeys subsidize longer ones
1979: Introduction of inter-district bus lines to complement the existing public transport system
1982: Opening of a new connection between the city centre and the industrial city and improvement of the inter-district routes
1991: Introduction of the Rapid Bus System (Direct Lines) using boarding tubes

Map: The integrated transport network of Curitiba



III. THE BUS CENTRED PUBLIC TRANSPORT SYSTEM

CURITIBA'S PUBLIC TRANSPORT system has developed over some 20 years; Box 1 outlines the main changes and modifications made over this period. During the 1970s, the city authorities began the implementation of an urban design structure which emphasized linear growth along structural axes (see Map 1). It also implemented the land use legislation that was required to make this effective. Curitiba's planned road network and public transport system are probably the most influential elements accounting for the present shape of the city.

Over the years, urban growth has been encouraged along five main axes with "structural" roads (see Map 1). Each axis is designed as a "trinary" road system. The central road has two exclusive bus lanes in the centre for express buses flanked by two local roads. Each side of this central road, one block away, are high capacity free-flowing one way roads, one for traffic flowing into the city, the other for traffic flowing out of the city. In the areas adjacent to each axis, the land use legislation has encouraged high density occupation, together with services and commerce.

The whole of Curitiba is zoned according to the kind of use to which the land can be put and the density of development permitted - although mixed land uses are allowed. On the land sites located along the structural axes, this legislation permits buildings to have a total floor area of up to six times the plot size. Developments close to other kinds of road well served by public transport are also permitted relatively high coefficients - with floor space up to four times the plot size. This coefficient decreases the further a land site is from public transport. This has encouraged new commercial developments outside the central city, along each structural axis, and also high density residential developments so there is a match between high density residential and commercial areas and the availability of public transport. This has taken the commercial pressure off the central city which has permitted the central city areas to be returned to the pedestrians. One important complementary activity to the road system was the municipal government's acquisition of land along or close to the new transport axes, prior to their construction. This permitted the government to organize high density housing programmes close to the transport axes; in all, some 17,000 lower-income families were located close to these.

Another important element of Curitiba's road network is the hierarchy of roads. Each road is assigned a function in relation to its location and importance. There are the "structural" roads along the five axes described above and "priority" links which connect traffic to the structural roads. "Collector" streets have commercial activity along them with all forms of traffic, and the "connector" streets linking the structural roads to the industrial city. These four types of road form the skeleton structure of Curitiba.

Despite having 500,000 cars (more per capita then any other major Brazilian city), Curitiba does not have a traffic problem. When the present transportation system was initiated in 1974 under the first term of Mayor Jaime Lerner, the city decided to continue to restrict the city-wide transport system to the bus. The use of "express buses" on exclusive busways is far cheaper than subways or light railways and represents a more practical and affordable solution to public

Box 2: The Relative Costs of Different Public Transport Options

Public transport option	Capital cost per kilometre
Underground metro system	**$90-100 million**
Light railway system	**$20 million**
Curitiba's direct route busway system (using boarding tubes)	**$0.2 million**

transport for a Third World medium sized city (see Box 2). Along the main axes of the city, a central lane was set aside for buses only. New bus lines were created and expanded as the city grew. Map 1 shows how a series of circular inter-district bus routes developed, to complement the express busways. For the first time, a new mass transportation idea was created to meet the needs of a Brazilian city where the bus routes and land use were more important than the vehicle itself. Buses are colour coded: the express buses are red, inter-district buses are green and the conventional (feeder) buses are yellow.

One of the key concepts in the transportation system is the ease with which people can transfer from local buses to the express buses and back to other local buses. There is full integration between express buses, inter-district buses and conventional (feeder) buses. There are large bus terminals at the end of each of the five express busways where people can transfer to inter-district or feeder buses. One single fare is valid for all buses. Along each express route, smaller bus terminals are located approximately every 1,400 metres and are equipped with newspaper stands, public telephones, post offices and small commercial facilities. Here passengers arrive on feeder buses and transfer to the express buses or inter-district buses.

The latest innovation is the introduction of the "direct" express bus system, where there are fewer stops and where passengers pay before boarding the buses in special raised tubular stations. These run along the one-way routes which run each side of the structural axes' central road. These new stations with platforms at the same height as the bus floors cut boarding and deboarding times; a rapid bus system with these "boarding tubes" can take twice as many passengers per hour. They also take three times as many passengers per hour when compared to a conventional bus operating in a normal street. The boarding tubes also eliminate the need for a crew on the bus to collect fares, which frees up space for more passengers. In this way, one of Curitiba's express buses does the work of many traditional ones (see Box 2).

Curitiba's public transportation system is used by more than 1.3 million passengers each day, and attracts nearly two-thirds of the population. Twenty eight per cent of direct route bus users previously travelled in their cars. This has helped secure savings of up to 25 per cent of fuel consumption city-wide. Curitiba's public transportation system is directly responsible for the city having one of the lowest rates of ambient air pollution in Brazil. Another effect of Curitiba's transport policy is the savings for inhabitants in expenditure on transport; on average, residents spend only about 10 per cent of their income on transport which is a relatively low proportion for Brazil.

The mass transportation system implemented in 1974 is managed by URBS (Urbanization of Curitiba, a mixed capital company) and is

continuously being developed by the Curitiba Research and Urban Planning Institute and by URBS. Since 1979, the introduction of inter-district lines, a standard fare for the whole network and new integrated terminals have allowed for the operation of a 514 kilometre network. Automatic fare collection, articulated buses and traffic lights which give priority to buses (operated by the vehicles themselves) allow the optimization of the system's operation and the low operating costs. New initiatives are constantly being sought to improve the system. For instance, a "bi-articulated" bus is being developed which will have a capacity of 270 passengers. These will have five lateral doors for passenger entry or exit and will significantly decrease boarding and deboarding times, when linked to the new boarding tubes. The vehicles are being developed in Curitiba and some 33 of these should be operational from October 1992.

The buses operating within this integrated transport system are privately owned by companies which receive a concession from the municipal government to operate specific routes. These companies have to abide by the city government guidelines and monitoring policies. The bus fares go to the municipal bus fund (managed by URBS) with the bus companies paid according to the number of kilometres their buses cover. Each bus company purchased a concession to operate particular routes with operational details and timetables defined by the municipal authorities. The whole public transport system operates with no direct financial subsidy.

IV. THE INDUSTRIAL CITY

THE REGION'S ECONOMIC structure began to change with the operation of an industrial city in 1973. Located seven miles from the city centre, it is well integrated within the urban structure and is equipped with services, infrastructure, schools, housing, green spaces and transportation axes connecting it to the rest of the city. One reason why the city authorities have been able to develop this industrial city without a high cost is that they own the entire site. Part of the site was already in public ownership when they began to develop it in 1973 while the rest was expropriated before the infrastructure was installed (and thus before the value of the land increased). Part of the land has been allocated to low-income public housing. With over 400 non-polluting industries, this industrial area now accounts for one-fifth of all jobs in the metropolitan area. Any industry wishing to locate in this industrial city must conform to local environmental legislation. Industries located within the metropolitan region of Curitiba account for 31 per cent of the industry in the state of Paraná and generate over US $ 100 million annually.

V. WATER, SANITATION AND GARBAGE: MANAGING AND RECYCLING SOLID AND LIQUID WASTES

CURITIBA METROPOLITAN AREA produces around 1,000 tonnes of garbage each day, of which three-quarters is generated within the city with the rest coming from 13 neighbouring municipalities. In 1990, Curitiba received an award from the United Nations Environment Programme for two successful waste management programmes. The first, launched by Jaime Lerner in 1989 is the "Garbage that is

not Garbage" recycling programme. This encourages city residents to separate organic and inorganic garbage for recycling and collection. Once a week, a "garbage that is not garbage" lorry collects the materials which households have sorted. Over 70 per cent of the community now participates in the programme and its success is largely due to a city-wide environmental education programme which highlights the benefits of recycling. In all, two-thirds of the city's recyclable garbage is recycled, more than 100 tonnes daily. Since the beginning of the programme, Curitiba has recycled some 13,000 tonnes of garbage. Just its paper recycling saves the equivalent of 1,200 trees a day. Apart from the environmental benefits, this recycling programme has generated other positive side effects. One is support for social programmes since the income earned through the sale of the recyclable garbage is reinvested in local social programmes. The city authorities have also provided jobs in the main garbage separation plant to the homeless and to those recovering from alcoholism.

The second solid waste management programme, also launched by mayor Lerner, is the "Purchase of Garbage" programme. This is run in the squatter settlements (*favelas*) of Curitiba; around 10 per cent of Curitiba's population lives in *favelas*, most of them on the outskirts of the urbanized area. In most *favelas*, there was no service to collect household garbage, usually because the settlements lack the access roads which permits the garbage trucks to enter them (for instance many are located on the bottom of the valley, close to the river). The residents would simply dump their garbage in open air pits or vacant plots where flies and rats could breed and thus increase the risk of certain diseases. There was no basic knowledge of hygiene and the inhabitants were often undernourished. To help deal with these potential health problems, the city introduced a programme where *favela* residents could "sell" their bags of garbage in return for bus tickets and for agricultural and dairy products. This programme has led to a considerable decrease in city litter and has helped to improve the quality of life of the urban poor. The cost to the city authorities arising from the provision of bus fares and food for garbage are the same as they would pay a private company to collect the garbage. This programme has proved very successful and at present there are 52 communities involved, with more than 22,000 families. Preventing garbage from being dumped in rivers, forests and valley bottoms is also an important step towards environmental preservation in these areas. Infant mortality rates have also decreased substantially in these poor areas. In addition, the reduction in diseases has also meant a saving for many families in expenditure on medicines.

With regard to water and sanitation, a relatively high proportion of the city's population is served - especially in comparison to cities of comparable size in Latin America, Asia and Africa. Some 90 per cent of the population have piped water supplies which are treated and 60 per cent live in housing units connected to a sewage system. Curitiba is also developing an innovative sewage treatment system which makes greatest possible use of a system of lagoons located close to the rivers into which the water will be discharged. The initial lagoons will be anaerobic (where micro-organisms break down the sewage in the absence of oxygen) followed by aerobic lagoons and finally the treated water will be discharged into the river. This treatment system has substantial cost advantages over conventional treatment systems, although more conventional sewage treatment plants will be needed in certain areas where residential densities (and thus sewage volumes

per hectare) are highest. Various other measures are being used to reduce the pollution of the Iguazu river and its tributaries - including an open air canal running parallel to the river which will be a protection against flooding and also serve as a stabilization pond in which pollutants can break down before entering the river. A pedestrian walkway and cycleway is being developed on one of the banks of this canal.

VI. PRESERVING ARCHITECTURAL HERITAGE, THE EXPANSION OF PARKS AND THE PROTECTION OF GREEN AREAS

THE INTEGRATED LAND use planning and transportation system has also permitted an enormous expansion in parks and green areas and the preservation of the architectural and cultural heritage in the city centre. The city centre underwent a major refurbishment process in the 1970s. Many streets became pedestrian areas while old buildings and the historic centre were protected, public squares upgraded and shopping and commercial facilities developed.

The municipal authorities encouraged the conversion of old buildings into new uses. Owners of buildings designated as of historic value are permitted to develop new uses in their buildings, but not to fundamentally change the facade and layout. In addition, to compensate for this restriction, the municipal authorities allow the owners to sell the development potential foregone to a builder for use on another site. One of the city's most popular shopping malls developed in what was previously a foundry. A former gunpowder arsenal has been converted into a theatre and an old glue factory into a creativity centre. What had previously been the army headquarters has been converted into a cultural foundation and the city's oldest remaining house has become a documentation and publication centre. The old railway station has become a railway museum whilst a stone quarry has been converted into an open air theatre. In 1991, a "twenty-four hour street" was created downtown with the city authorities working in partnership with local merchants. Businesses here stay open 24 hours a day, seven days a week and this street has helped to sustain commercial activities in the city centre.

The city has a well defined policy and strong commitment towards preserving its woods and parks. In the past 20 years, more than 1.5 million trees have been planted in the city. The ratio of open space to inhabitant has increased from 0.5 square metres to 52 square metres which means that Curitiba has one of the highest averages of green space per inhabitant among urban areas worldwide. The *Guarda Verde* (the "green guard" - a municipal corporation) protects and maintains the green areas; the guards also keep the public informed about environmental issues and are trained for first aid.

There are also programmes to encourage community responsibility for care and maintenance of the parks - for instance the Association of Friends of the Park formed by volunteers, the Boy Scout Bicycle Watch to promote and protect the parks, and the use by local schools of parks to promote knowledge about them and about ecological principles.

Another innovative feature of Curitiba's green spaces is their integration with flood control. The parks not only provide recreational and aesthetic value but many have artificial lakes which provide flood

control for the entire city. Each park is equipped with information centres on the local environment and ecology. A 90-mile (145 kilometre) bike path mostly through the urban parks is nearly complete.

A recent addition is the new botanic gardens. This covers an area of 17.7 hectares and has been developed over an abandoned garbage dump. It includes some of the last remaining natural fauna and flora of the region. A museum is to be included along with a research facility to study local flora and the cultivation of native and exotic species, including species from lower coastal areas and other regions of the country.

The city also provides a free bus service during the weekends on its "pro-park" line. These are "retired" city buses painted green which carry people from downtown to the city's numerous parks (Brazilian legislation demands that all buses in use on the roads be less than ten years old).

VII. SOCIAL SERVICES AND ENVIRONMENTAL EDUCATION

LIKE MOST CITIES, Curitiba strives to provide the social services needed by the inhabitants in the form of health care, child day care, adult education, rehabilitation programmes and others. To help provide more day care centres, the city is offering incentives to the private sector to supply more facilities. As part of the education system, the city has developed "mobile classrooms", which are remodelled old city buses. They run short courses for adults in the low-income sectors of the community to teach new skills such as hair-styling, mechanics, sewing, carpentry and word-processing. These buses go to different low-income neighbourhoods each day of the week.

The city's recycling programme not only benefits the environment but helps those in most need. Money earned by the city from selling recyclable garbage is reinvested in the city's social programmes.

A lack of education is one key reason for environmental destruction. By providing environmental education, the city hopes to improve the quality of life of low-income households, especially the children, and also to teach them to be responsible for their actions. In the case of the *favela* communities, a "self-subsistence education" is required which will teach them to respect and care for the environment they live in and from which they may benefit. One of the programmes addressing this need is the Infant and Adolescent Environmental Education Programme (see Box 3).

In addition to launching environmental education programmes in low-income districts, the city has incorporated environmental education into its education system, especially in the elementary schools. When Curitiba launched its recycling programme, city planners believed that the most effective way to teach people about the benefits of recycling was through the children. Much of the environmental education was taught by the "leaf" family, actors dressed up as trees or leaves who visited schools, distributing brochures and who also appeared on television. The children responded positively to the idea of recycling (for instance collecting spent batteries and empty tooth-paste tubes from their homes) and went home to teach their parents.

Another important educational tool was the recent launching of the

Box 3: Integrating Environmental Education and Social Provision - the Infant and Adolescent Environmental Education Programme (PIA).

This programme was created to educate children from the *favelas* and other low-income areas. Units set up for the programme are generally simply built rooms with wood-burning stoves for cooking and heating. These units offer a place for children to go to during the day. They are given a meal with the food usually prepared by volunteer mothers. For every 300 children there are two employees, making this programme very inexpensive and viable to run. Prior to PIA, no infrastructure existed to support any kind of day care. Most children wandered around their settlement unsupervized while their parents were away at work.

With the implementation of PIA, the children have a place which provides them with meals and a practical education. Initially, there was some vandalism from local gangs, but with patience from staff and educators, and without police intervention, the gangs started to become involved in the programme. Among other things, PIA children are taught how to take care of younger children and how to clean and grow vegetables plus other skills which they can use elsewhere.

With ever increasing numbers, the programme has been growing to keep up with demand. Many teenagers are learning gardening skills and money earned as gardeners is passed on to their *favela* neighbourhood association. Before PIA, *favela* children were often isolated socially. Now they feel more part of a community and participate in cleaning, washing-up and cooking. The community is very satisfied with the results of the programme and gives its full support. Family life has improved and the surrounding environment is being protected and improved instead of being destroyed. This programme has been nominated as an United Nations Local Government Honours Programme by the International Council for Local Environmental Initiatives for "environmental regeneration of low-income communities". There are 15 operating PIA units and a total of 28 should be operating by the end of 1992. Each PIA unit looks after an average of 250 children.

Free Open University for the Environment. This provides courses for people from all backgrounds (for instance taxi drivers, journalists, child carers) to encourage awareness of the environment and the importance of its preservation. It is also involved in research and in developing local environmental projects and is creating a data library.

VIII. CONCLUSIONS

THE EXPERIENCE OF Curitiba demonstrates some principles which might be considered applicable elsewhere:
- An urban growth pattern should be established in conjunction with a conscious decision to promote an integration of different elements

of urban development. A city must know where it is growing, how and why. Conscious technical, political and economic decisions should be made in response to existing trends. Many urban related problems linked to the uncontrolled physical expansion of cities (for instance increasing infrastructure and service costs, loss of agricultural land, minimum provision for open space) can be avoided if correct decisions are made at the right time.

- One of the key lessons from Curitiba's experience is the importance of establishing a close relationship between the public transport system, the land use legislation and the hierarchy of the urban road network. This can provide an integrated framework that can be used as a guidance and development tool.
- Successful decisions are also related to conscious technological choices and in many instances, the most appropriate choice may represent a challenge to certain technological dogmas. Curitiba has shown that a city with more than 1 million inhabitants does not necessarily need a "metro" style underground transport system or a light rail system and that surface solutions based on buses could be developed incrementally at a much lower cost. The city's solid waste programme has also shown that the recovery from household wastes of recyclable elements does not need an expensive mechanical separation plant, if a city transforms every household into a pre-separation plant with curbside collection schemes.
- Cities should pay attention to their visible structure (transport, housing, land use, etc.) as well as to their "hidden structure". City governments should understand the main economic opportunities and work towards developing them. The network of formal and informal economic relations should be supported and not hindered by urban planning actions.
- Total priority should be given to public transport rather than to private cars, and to pedestrians rather than to motorized vehicles. In Curitiba, less planning attention to meeting the needs of private motorized traffic has generated less use of private motorized traffic. Bicycle paths and pedestrian areas should be an integrated part of the road network and public transport system.
- A sustainable city is one that spends the minimum and spares the maximum. This choice relates to the pragmatic application of the principles of recycling. In the case of Curitiba this relates to solid waste, buses (mobile schools), houses (refurbishment) and people (low-income people being employed in the garbage separation plant and environmental education).
- The example of Curitiba seems to demonstrate that there is an "action script" for each set of problems. Solutions within any city are not specific and isolated but inter-connected. The "action script" should involve partnerships between responsible actors such as private sector entrepreneurs, non-governmental organizations, public organizations, mixed capital institutions, neighbourhood associations, community groups and individuals. This approach implies that the whole debate in favour or against privatization loses its importance when we accept the simple fact that there is a role for each actor within a given community and city and that these roles can be complementary.
- The role of every actor is a function of scale, means and knowledge. For instance, the city administration should be in a position to determine structural guidelines for the city and its wider region whereas citizens can better determine what is better for their own street or neighbourhood. A good balance between representation and

participation is essential.

- Creativity can substitute for financial resources. Ideally, cities should turn what are traditional sources of problems into resources. For instance, public transport, urban solid waste and unemployment are traditionally listed as problems but they have the potential to become generators of new resources and employment. Creative and labour intensive ideas could, to some extent, be substitutes for capital intensive technologies.
- A good information system is essential. The better the inhabitants know their city, the better they treat it. A team of officials should be developed locally who know the city well and who are committed to developing it.