The Report Committee for Jorge Mata Otero
Certifies that this is the approved version of the following report:

DEVELOPMENT OF SUSTAINABLE TRANSPORTATION SYSTEMS: Lessons from Curitiba, Brazil

Approved by
Supervising Committee:

Supervisor:

Ming Zhang

Kent Butler

DEVELOPMENT OF SUSTAINABLE TRANSPORTATION SYSTEMS: Lessons from Curitiba, Brazil

by

Jorge Mata Otero, BArch

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Abstract

DEVELOPMENT OF SUSTAINABLE TRANSPORTATION SYSTEMS: Lessons from Curitiba, Brazil

Jorge Mata Otero, M.S.C.R.P.

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Supervisor: Ming Zhang

Curitiba's Integrated Transportation Network (ITN), in Brazil, has been highly regarded as a model of sustainable transportation for several years. Since its inception, the system has not only been molded to address the three core dimensions of sustainability –environmental, social and economic- but has also successfully brought together the government, the private sector and the general public. The purpose of this study is to describe the case of Curitiba's planning process and transportation system. More specifically, this report first examines the conditions that led to a system to be well-regarded as sustainable and then determines some lessons learned that can guide the implementation of similar systems in other cities.

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Chapter 1: Introduction

There is no universal consensus about what sustainability means. However, by reading and analyzing a portion of the myriad of definitions by several authors and organizations they all share parallel basic concepts. Thus, sustainability can be broadly viewed as an ideal state where a healthy environment, economic prosperity and social justice are coupled together with the overarching goal of ensuring the well-being and quality of life of both present and future generations.

Not as prominent in sustainability is the consideration of transportation. However, the transportation sector has enormous repercussions on sustainability. It consumes natural resources, including land and oil, at a rapid pace. Therefore, any sustainability development strategy should consider transportation. On the other hand, there are different perspectives regarding the concept of sustainable transportation. In any case, the core dimensions of sustainable transportation are the same as those of sustainability: economic, environmental and social. On top of that, for a transportation system to be deemed as sustainable it is necessary a partnership between the government, the private sector and the public at large.

The city administrators of Curitiba, a city in southern Brazil, knew all of the above. In 1964, the elaboration of a master plan marked the beginning of a transformation that still today is unfolding. To a significant degree, the plan had well-defined goals for achieving a sustainable transportation system. With a strong vision, leadership and uninterrupted implementation the city has achieved many of its objectives. Even though there are some urban problems still prevalent, the city is now a model of sustainability for

other countries. This report attempts to provide a thorough analysis of the different steps and decisions that Curitiba took in order to see the applicability of those in other cities. Overall, the main research objectives of this report are encapsulated in one goal: presenting the case study of Curitiba's successful sustainable transportation system in order to gather insights into what other cities considering sustainable transportation might take into account.

Chapter 2: Defining Sustainable Transportation and its main features

The debate over the definition of sustainability perseveres when trying to define and characterize sustainable transportation. The purpose of this section is to review what scholars have noted and identified as the main features, factors and challenges that typify sustainable transportation. To begin with, it is necessary to have some facts that characterize current transportation trends and practices. Next, the dilemma over accessibility or mobility as regarded by scholars is analyzed. Then, given that there is no general consensus on what exactly sustainable transportation is, views by different scholars on the topic are examined. Similarly, the factors, challenges, goals, indicators and tools related to sustainable transportation are discussed in this section.

a. Transportation facts

Transportation has a number of unfavorable effects. First, the construction of transportation infrastructure takes approximately 30% of the developed land area and destroys valuable natural habitats. Additionally, road transportation causes pollution problems such as air and noise pollution (Wing-tat, 2000). Present transportation infrastructure and travel behavior trends are the cause for the exploitation of oil reserves at a rate that risks the availability of fuel for transportation (Vincent, 2002). At the global level, transportation consumes more than 60% of the world's total oil products (Szyliowicz, 2003). As urban transportation has improved, labor market mobility and

accessibility to employment opportunities have augmented and changed the scale and form of urban agglomerations (Fahimuddin, 2002). Moreover, the transportation sector consists of a combined infrastructure that receives huge amounts of funding from the government and with the potential to affect the quality of life, depending on its level of integration with land use and development (Silva-Portugal & Flórez, 2006).

On the other hand, a transportation system integrates the individual activities that contribute to urban change (Rabinovitch & Hoehn, 1995). However, transportation systems are complex since they are conformed by a mix of technologies, public and private investors, managers and users (Sperling & Clausen, 2002).

b. A dilemma: mobility or accessibility

Litman (2002) considers that the most important goal of transportation is accessibility, the ability to obtain desired goods, services and activities. However, access is difficult to measure so transportation planning usually focus on traffic (vehicle movement) and mobility (the ability to move people and goods).

Several authors have pointed out the differences between the concepts of accessibility and mobility. For Dimitrou (2006) accessibility is an indicator of transportation improvement. For him, the concept of accessibility has many dimensions and it refers to physical accessibility. This physical accessibility is the physical proximity to infrastructure and services and is conditioned by the cost of transportation in relation to disposable income. In the same vein, Horner (2004) informs that the detailed information on the physical separation between home and workplace is usually used when measuring accessibility.

Wing-tat (2000) sees mobility and accessibility as indicators of the efficiency of a transportation system. On the one hand, mobility refers to the easiness to move about to engage in social activities. On the other hand, accessibility is the easiness to be reached and can be used to evaluate the quality of service provided by alternate transportation modes. He also acknowledges that good mobility is conditioned to the availability of transportation facilities and the affordability of using these facilities.

Today, high levels of mobility in free time are seen by many as an important component of their welfare. In a democratic setting, political means cannot change basic values easily (Tengstrom, 1999). However, those same high levels of mobility can be seen from a different perspective. Fahimuddin (2002) acknowledges that there are not only congestion and fuel consumption problems associated with mobility but also there are social impacts such as dispersed, polarized, less child-friendly, more culturally homogeneous, less healthy, and less democratic societies.

Similarly, different transportation modes give different accessibility levels. Sperling and Clausen (2002) acknowledge that private vehicles give accessibility to goods, services, and activities and to an "expanded" array of jobs and educational opportunities.

c. Sustainable Transportation

Many authors and organizations have tried to explicate the concept of sustainable transportation and have come up with a varied range of descriptions that even though they all share a common conceptual base they all have subtle differences from each other.

Because of that it is necessary to review what the current views on sustainability and sustainable transportation are.

For Rabinovitch and Hoehn (1995) "a sustainable city is one that wastes the least and conserves the maximum." As simple as it might seem, this definition gives the basic idea of the concept of sustainability. Sustainability *per se*, has been vaguely defined. More predominant is the definition of concepts like sustainable development. Yevdokimov and Mao (2004) recognize that a sustainable system comprises three different components, namely, the economy, the environment and the society. Therefore, considering that transportation is a system it should have those components interconnected in order to be considered as sustainable. He also criticizes that, traditionally, transportation has followed a more piecemeal approach for reaching sustainability.

Now then, the lack of sustainability in transportation has been acknowledged by world institutions such as the Organization for Economic Cooperation and Development (OECD, 2001):

> Our current transportation system is not on a sustainable path. Our admirable achievements in terms of mobility have come at some considerable environmental as well as social and economic costs. The challenge now is to find ways of meeting our transportation needs that are environmentally sound, socially equitable and economically viable.

Similarly, the Canadian Centre for Sustainable Transportation characterizes a sustainable transportation as a system that:

1. Allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations;

2. Is affordable, operates efficiently, offers choice of transportation mode, and supports vibrant economy;
3. Limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise.

In the same vein, for the World Business Council for Sustainable Development sustainable mobility is "the ability to meet the needs of society to move freely, gain access, communicate, trade, and establish relationships without sacrificing other essential human or ecological values today or in the future" (Shay & Khattak, 2002).

Furthermore, Yevdokimov and Mao (2004) see a transportation network as a system with complementary components such as durable goods, associated goods and services. Vester (1995), on the other hand, considers that systems created by man cannot be sustainable since they expand exponentially.

For Wing-tat (2000) sustainable transportation is "a transport system without un-recoverable destruction to the natural environment, i.e., minimal land destruction, noise, air and water pollution." However, there are views contrary to this.

Silva-Portugal and Flórez (2006), for instance, consider a transportation system as "the most powerful tool to address sustainable urban development, which fosters greater equity and a better quality of life."

For Black (1997) there are five aspects that result in a transportation system not being sustainable: 1) the heavy reliance on non-renewable oil resources 2) oil-based

emissions from vehicles 3) motorized vehicles fatalities and injuries 4) traffic congestion and 5) urban sprawl.

Other authors such as Szyliowicz (2003) think that a sustainable transportation system must have economic efficiency as well as be environmentally benign, safe and secure and be instrumental in achieving social development. Evidently, the three basic dimensions of sustainability are always considered in any attempt to define sustainable transportation.

Shiftan et al. (2002) acknowledge the importance of having sustainable developed transportation systems in urban environments as indispensable for keeping the quality of life.

Other scholars go further as to suggest that there are factors other than those pertaining to the core dimensions of sustainability. For Rabinovitch and Hoehn (1995), for instance, a sustainable transportation system consists of a partnership between three parties: the government, the private sector and the residents. In this partnership, the city must formulate and convey the resident's interest in effective transportation. For this, the city carries out planning processes, defines routes and service standards and monitors and enforces. The private sector provides the transportation services including the hiring of people, investment in capital, and competition with other firms and with themselves to lower costs and increase profits and at the same time maintaining convenience, timeliness and safety. Finally, the residents need to pay the fares to cover the costs of the service.

So far we have analyzed different views that resemble each other. However, one of the most important set of principles that encapsulates and synthesizes all of the above comes from the Organisation for Economic Co-operation and Development (OECD). In

the OECD Conference held in Vancouver, Canada in 1996 a number of principles for sustainable transportation were established. Those principles were: 1) access 2) equity 3) individual and community responsibility 4) health and safety 5) education and public participation 6) integrated planning 7) land and resource use 8) pollution prevention and 9) economic well-being.

Those principles can be useful in gauging the sustainability of a transportation system.

d. Factors

In the literature reviewed by Shiftan et al. (2002) the authors found five principal factors that impact the development of transportation. Since those factors have an effect on mobile technology, infrastructure design, travel behavior, motorization levels and policy measures, they serve to evaluate the progress of transportation towards sustainability.

The five factors are:

1) Spatial and land use patterns. The size of an urban area, building density, level of specialization and the spread of activities within the urban area influence the travel demand and consequently the transportation system.

2) Economic forces. Economic changes due to the enormous financial investment involved, the primary capital required, the long time span of the project and the slow rate of returns easily affect large-scale transportation projects.

3) Technology. Technological options such as the improvement of waste treatments and substitutes to physical travel through communication can help a transportation system become sustainable. However, the scale and cost of the projects, the long periods of research and development and the long life expectancy of infrastructure and mobile equipment are the causes for technological developments to be slow.

4) Government policy. The need for long term planning and the reservation of right-of-ways for future development, the enormous financial investment and the evaluation of negative external effects are all in the hands of authorities and hence transportation development is influenced by political priorities.

5) Social and behavioral trends. Habits, practical and emotional considerations shape individual behavior. Therefore, social values and norms influence people's transportation choices.

e. Challenges

Fahimuddin (2002) identifies two main obstacles to sustainable transportation:

- The decision-making in transportation is locked into modes that favor current unsustainable trends
- The need for finding new renewable alternatives to low-cost oil which accounts for 99 per cent of the energy utilized by motorized transportation.

Shiftan et al. (2002) point out that:

> Planning for a sustainable transportation system is a complicated task that involves a high degree of uncertainty due to several reasons: a) the large number of alternative potential policy packages, b) the way of implementation and c) the traveler's response to each of these policy packages (p. 327).

Regarding urban transportation one of the most challenging aspects of strategy formulation is the inclusion of the goals of the sustainable development vision in the urban transportation sector at the local level (Dimitriou, 2006).

f. Tools for developing sustainable transportation

Shay and Khattak (2002) suggest a number of tools for the development of sustainable transportation systems from different areas:

- Intelligent transportation systems (ITS) and new fuels and vehicle designs in the case of technological tools.
- New models for business creation and attraction, small-scale and local entrepreneurship and public-private partnerships as financial tools.
- Human services delivery and educational/social initiatives as governmental tools.
- Grassroots movements to change land use and community behavior as community tools.

All these tools focus on the different dimensions of sustainability, namely, environmental, economic and social.

g. Goals

While there could be a considerable number of goals that any transportation system should consider in order to be sustainable some authors have identified the most general ones.

Shiftan et al. (2002) defined nine sustainable transportation development goals that fall into three categories:

Environmental goals: a) reductions in air and noise pollution, b) preservation of land, and c) wildlife and natural habitats preservation.

Economic goals: a) energy savings, b) reduction/minimization of transportation infrastructure costs and c) saving travel time.

Social goals: a) improving accessibility to employment, cultural activities and open land areas, b) maximizing public transportation availability and c) increasing road safety.

Tengstrom (1999) determined four goals for achieving a sustainable transportation:

- Reducing speed on the entire road network
- Increasing the use of carbon-neutral or carbon-free fuels
- Stabilizing present motor vehicle transportation volumes for individual mobility
- Reducing the use of private cars.

h. Indicators

For evaluating sustainability it is necessary to look at measurable indicators in order to analyze trends, compare areas and activities, weigh up policies and planning options and establish performance targets. It is fundamental to consider methods that can

help determine to what extent a planning decision succeeds in attaining sustainability goals and objectives (Litman, 2002).

On the other hand, Shay and Khattak (2002) acknowledge that the concept of sustainability has not been defined precisely and is still under constant refinement. However, they agree that traditional transportation metrics can help in measuring sustainability of a transportation strategy. Among those metrics are vehicle miles traveled, commute times, transportation costs as percentage of households budget, land use statistics such as acres used for development or residential density and fuel consumption or emissions, health and safety data on transportation related death, disease and injury.

The scenarios that Shiftan et al. (2003) analyzed revealed that the spatial and land use measures obtained the highest scores for the achievement of sustainable goals. The best spatial measure was the development of highly-dense populated areas and job activities in proximity to "main" public transportation stations.

For Wing-tat (2000) the per capita private car ownership and road length can be used as indicators of both mobility and accessibility. However, he also recognizes that these indicators might not reflect situations different from the more developed nations. He suggests per capita vehicle kms of public transportation modes and per capita walkway length as mobility and accessibility indicators. The number of buses and train stations that are adapted to serve handicapped people also indicate accessibility.

Other indicators presented by Wing-tat (2000) are the percentage of income used for transportation and the number of road accidents. The former measures affordability whereas the latter measures safety in a transportation system.

On a more qualitative approach, Litman (2002) also thinks that sustainability planning can be evaluated by looking at the process, considering the different possible impacts and the extent at which engagement of diverse stakeholders and points of view happens.

i. Findings

In this chapter we found out some important facts regarding current transportation practices:

- Transportation infrastructure takes about 30% of developed land
- Globally, transportation consumes over 60% of the world's oil resources
- An improved urban transportation has blown up and transformed the scale and form or urban settlements

Also, we identified a series of principles that can be applied when analyzing the sustainability of a transportation system. Those principles are:

1) access 2) equity 3) individual and community responsibility 4) health and safety 5) education and public participation 6) integrated planning 7) land and resource use 8) pollution prevention and 9) economic well-being.

This set of principles will be later used and further discussed when analyzing Curitiba's BRT system.

Chapter 3: Urban Planning process in Latin America

Evidently, understanding the success of Curitiba and its sustainability goals requires an overview of how urban planning is carried out in developing countries, and more specifically in Latin-America. It would be erroneous to think that the problems, resources, shortcomings, processes are all the same everywhere. This will reveal the constraints, shortcomings, focus of the business-as-usual planning practices in that part of the world. In the same way, it is important to pinpoint the characteristic features of Latin-American cities in order to understand the context in which the planning efforts for Curitiba took place. Also, it will help us define what where the circumstances that favored the city's departure from traditional planning practices.

a. Traditional Planning

Rabinovitch (1996) describes the traditional way of doing urban planning as one that does not consider the needs and participation of low-income groups and one that focuses on creating colored maps completely separating residential, commercial, recreational and other uses. He also explains that traditional planning does not allow for a balance in mixed uses, social integration aspects and the vision of a city as a structure for life and work.

b. Planning in Developing Countries

Developing nations have problems in terms of funding and planning expertise as well as institutions that lack experience that in turn inhibit effective transportation

planning, infrastructure development, and policy implementation. Cities in developing countries such as Santiago, Mexico City, Kathmandu and Delhi, for instance, are now addressing the air pollution problem by imposing new rules and laws.

In a study done by the National Research Council, it was found that in almost all cases rapid growth in demand for motorized transportation has overwhelmed the transportation infrastructure capacity in the cities of the developing countries (Sperling & Clausen, 2002).

c. Planning in Latin America

After WWII, Latin American cities experienced rapid urbanization caused by flows of rural immigration. The urban population of this region went from 41.6% to 71.4% in the period from 1950 to 1990. Brazil had an even more intense urbanization process with a population growth from a little more than 32 million people in 1960 to almost 138 million people in 2000. However, today the annual demographic growth rates of Latin America have decreased (Silva-Portugal & Florez, 2006).

Notably, Latin American cities lack urban plans with adequate technical, political and social basis responding to community interests. Another problem is the lack of enforcement to guarantee compliance with plans, when they exist. The lack of infrastructure and transportation plans integrated to land uses, in a broad and long-term context, preventing the proper use of available resources and to use them as tools for development and income redistribution are widely considered as characteristics of planning in Latin America nations. Plus, institutional flaws and poor democratic

representativity also contribute to the breaching of urban regulations and this in turn results in increases in density and incompatible land uses.

According to Sperling and Clausen (2002), it is in Latin America and Asia where the fastest growth in the number of motor vehicles is happening. Cities usually have conflicting needs for infrastructure and services, including transportation. To a significant degree, collective resources are usually insufficient to meet all these demands. As cities grow, those demands become more intense.

Also, the urbanization in Latin American countries has mostly concentrated in big cities. In terms of income distribution, the World Bank estimates that only 10% of the population, the richest, have 48% of the total income, and the poorest 10% receive only 1.6% (Silva-Portugal & Flórez, 2006).

d. Characteristics of Latin American Metropolises

Metropolitan areas in Latin America have many characteristics:

1. Accessibility is poor and unequally distributed on most of the territory with radial transportation networks for guaranteeing that central areas, with higher values, have good access.
2. Activities and jobs are concentrated in downtown, and hence many of the residents living far from the city center must travel considerable distances in order to reach their workplaces. It is estimated that about 30% of the jobs are found in the CBDs.
3. Despite the long commutes and corridors that have huge numbers of trips and with the conditions necessary for the introduction of high-capacity transportation

modes such as railroads or subways, the transportation systems are mostly based on automobiles and buses. In the big cities in Latin America more than 90% of the motorized commuting is done by cars or buses.

4. The public transportation system does not have a hierarchy and is not integrated. There are also informal transit systems based on van pools that pick up and drop passengers off at any location along the route (e.g. Mexico City).
5. Vehicular traffic usually uses a low-grade road infrastructure, with little capacity and not hierarchized.
6. Even though there is a high proportion of walking trips this does not reflect sustainable mobility but rather a type of exclusion. Plus, the pedestrian infrastructure is oftentimes not in good conditions.
7. The importance of public transportation for commutes and the predominance of buses in this sector have not been strong factors to classify transit as a top priority due, to a great extent, to pressures and lobbying by car users.
8. There are higher population densities and smaller proportions of space utilized for roads and parking areas, the urban fabric is more restricted in terms of motorized trips.

   Also characteristic of Latin American cities are:

9. Transportation systems with a large range of modes and a significant proportion of non-motorized and public transportation trips
10. Informal transportation systems that are less predictable

Silva-Portugal and Flórez (2006) affirm that the cities of Latin America are complex and that they offer challenges that can be addressed "only through more competent and elaborate control and planning processes, based on solid technical, political and social grounds." They also mention the three main bases for change: "a) reforms should be implemented in the social and economic fields and their institutions; b) better access for the poor to vital goods and services, especially education and health; and c) the implementation of social inclusion and income transfer policies."

e. Findings

- Latin-America experienced significant population growth in the period following the WWII up until 1990.
- There is a lack of public participation in urban planning decision-making
- Lack of Enforcement
- Lack of Integrated Planning
- Institutional flaws

Moreover, Latin American cities are characterized for:

- Poor accessibility, with radial transportation networks
- Concentration of activities in the central area
- Main transportation modes are automobiles and buses
- Non-hierarchical public transportation system
- Low-grade road infrastructure
- Informal transportation systems less predictable

Chapter 4: Curitiba and its Urban Planning system

So far a description of what characterizes a transportation system as sustainable and what are the aspects and issues in Latin-American cities on the one hand has been laid out and on the other hand we have reviewed how urban planning is carried out and what the challenges in developing countries are. Now then, it is important to have an understanding of the context in which Curitiba developed itself as a world's model case of a successful sustainable city.

a. History

The city of Curitiba was founded in 1693 by the Portuguese. Originally, it was a crossroads of trade routes and a place for gauchos to stop with their cattle. Later would be a stopover for coffee traders (Parliamentary, 2002). During the next two centuries the city grew slowly. By 1853, there were 5,819 people and the city comprised 27 blocks. In that year, Curitiba was designated the capital of the state of Paraná -a nomination that still prevails to the present time-. Two years later, in 1855, Pierre Taulois, a French engineer, was commissioned with the design of a new layout for the city. With the new layout the circulation would be improved.

In the 19th century, the city experienced considerable immigration. By 1895, the tremendous demographic growth made necessary the elaboration of the Curitiba building code. Later on, in 1903, land use classifications were established. With this, areas for special urban activities were delimited. In the 1920s the city adopted the modern Brazil

nationalistic model. The downtown area received special attention and new avenues were built that now serve as major arteries.

The 1930s was marked by the downfall of the matte industry. Additionally, the city was divided into three zones: Zone I, corresponding to the downtown area, for businesses and high-quality housing; Zone II, for industries and residences for skilled workers; and Zone III, for regular employees and small property owners.

As it happens in other cities, Curitiba experienced a significant flow of migration coming from rural areas after the end of WWII. One of the causes of this was the mechanization of agriculture. Later on, in 1973, the creation of the Curitiba Industrial City helped in the transformation of Curitiba with its predominantly agricultural character into a more industrial city. As of today, the main economic activities in Curitiba are services, manufacturing and commerce.

b. Planning

In Brazil, the elaboration of master plans, as effective planning tools, is mandatory for those municipalities with more than 20,000 people (Silva-Portugal & Flórez, 2006). The city of Curitiba, one of the most populated cities in the country, could not be the exception to this rule.

Rabinovitch (1996) describes the planning process in Curitiba as interactive and pragmatic since there was interaction between a concept and a reality. He also views the planning efforts that started in the 1970s, in conjunction with the social objectives formulated in the 1980s, as a positive detachment from the traditional planning approaches. Similarly, Moura (2003) describes Curitiba's planning approach as one that

has a strong relation with the market economy, with a productive flexibility and infrastructural optimization.

Smith and Raemaekers (1998) describe the planning in Curitiba as proactive, given that a well defined model was selected to guide city growth and transportation infrastructure and was built to induce development; and interactive, considering that there was a continuous process of feedback between implementation and planning.

Flexibility is another characteristic of Curitiba's planning. The planning process is characterized by being in continuous adaptation and with refinement projects and logical improvements. Also, the planning is unorthodox in essence. As Parliamentary (2002) states it "[p]lanning for Curitiba is based on spatial thinking, and a focus on outcomes and systems, rather than an emphasis on process, legislative framework and outputs as it happens with narrowly focused reports or projects" (p. 10)

Also, Friberg (2000) singles out the case of Curitiba from those of other Latin American cities in that the city did not see in reconstructions of its downtown area or large scale highway constructions a solution to its problems.

Taniguchi (2001) recognizes that the planning issues in Curitiba are comprehensive. They include social equity, job generation, participatory processes, neighborhood improvements and regional landscape programs. Parliamentary (2002) acknowledges that a considerable portion of city planning in Curitiba is earmarked to integrate the provision of health and education services, funded by the state of Paraná, with access to transportation and in harmony with density and housing.

i. Plans

1934 Agache Plan

The formal history of Curitiba's urban planning starts in 1934 with the plan implemented by the French architect Alfred Agache. This plan comprised sanitation measures, housing, services and industrial zoning. Also, the street network would be restructured. The plan included urban growth and zoning guidelines. As a result of the Agache plan, the Civic Center, housing local, state and federal government agencies were built and the city got its first Mass Transit System Plan in 1955. After the implementation of this Mass Transit Plan, the city was divided into eight areas, and there were eight different companies in charge, one for each area (IPPUC).

Additionally, considering that this plan was centered on the car dominance experienced in the city it included massive infrastructure investments such as boulevards and radial arteries (Matsumoto, 2003).

1964 Curitiba Master Plan

In 1964, the city organized a contest for a preliminary urban plan for Curitiba. The city had approximately 470,000 residents at that time. Overall, the plan proposed the shift from a radial development pattern, as conceived in the Agache Plan, into a linear expansion pattern. Other objectives were the elimination of heavy traffic from the downtown area in order to preserve its valuable characteristics; containment of the city

within its territory; economic support to urban development; and urban equipment for the entire city (IPPUC).

In summary, this plan was based on the following principles:

a) decongestion of the city center and preservation of the historic center
b) demographic control and management
c) economic support to urban development
d) infrastructure improvement
e) changing from a radial urban growth pattern into a linear one. (Rabinovitch, 1996; Friberg, 2000)

Initially this master plan considered four structural sectors (north, south, east and west) but with the unpredicted demographic growth in the southeast that occurred in the 1970s characterized by low and middle income groups it was necessary to add a new sector (Rabinovitch, 1996).

The Urban Research and Planning Institute of Curitiba (IPPUC) mentions that "among the basic Master Plan guidelines are the prioritization of the street system, land use, zoning, regulation of lots, urban renovation, preservation and revitalization of traditional historic districts, public services, and community equipment." From 1966 to 1970, the IPPUC expanded and refined the plan's basic proposal. This plan was the instrument necessary for the start of the physical, economic and cultural transformation.

Rabinovitch (1996) points out that it is not enough to have a city plan as guidance but it is also important to have an implementation strategy for having positive results. In

this regard, Curitiba has been notorious for its ability to implement the plans it has created.

ii.1970-1980 Period

Resulting from modernization of farming practices, the population started growing more than 5% a year in the 1970s. Importantly, the IPPUC implemented the master plan without interfering with the city's structure, or major urban interventions, and respecting the city's scale, history and culture (IPPUC).

Physical Structure

Land use in Curitiba was organized and functioned as an urban planning mechanism. Specific purposes were zoned in order to guide investments and organize both; public and private activities. Land use regulations in Curitiba defined residential areas, according to population density rates; zoning for services, manufacturing and other activities. Land use also defined structural sectors, pedestrian areas, natural preservation areas, parks and the historical district. The existing street network served as the base for the transportation axes without the necessity of expropriating land.

Admittedly, planning was the result of the willingness to procure a public transit system to the city. With the help of legislation, special land use and occupation sectors were created in order to solve environmental problems due to land occupation, such as

sewage and garbage disposal issues. Laws helped preserve green areas and protect flood-prone areas along the rivers, converting them into recreation sites (IPPUC).

Economic Structure

Curitiba did things differently from the rest of the country. Instead of promoting the establishment of manufacturing plans, as other Brazilian cities did, Curitiba delimited an Industrial District with appropriate urban infrastructure, including basic services, housing and preservation areas. Legislation restricted the establishment of polluting industries in the district.

In the early 1970s, the city created a Heritage Sites Preservation policy. Also, the Historic District was formally created by decree in order to preserve residences built in the 19th century. Around this time, the Rua XV was closed to vehicular traffic and transformed into the Rua das Flores, Brazil's first pedestrian mall. Another important characteristic of Curitiba's cultural structure is the recycling and restoration of historic buildings. Old deposits or factories have been transformed into theatres, military facilities, cultural centers, etc (IPPUC).

Social Structure

The 1970s witnessed the construction of several community centers for the implementation of programs with education, health and public services components in poor communities near the city. A Slum Relocation Plan was designed for the assistance of families living in slums established in risk areas. There were also new housing policies implemented by the Housing authorities (COHAB-CT).

iii. The 1980s

This decade was characterized by the decentralization process that took place in the country. The city reorganized itself into more than a hundred neighborhood associations by 1984. Curitiba used the Municipal Urban Development Plan as a planning tool to propose guidelines for a development model that created secondary administrative centers. A municipal housing plan was devised in 1984 to improve the housing policy guidelines included in the Municipal Government Action Plan. One important housing project, called the Barrio Novo Project consisting of houses for 20,000 households in vacant lands, took place during this time. Additionally, a greater demand for cultural facilities resulted from the better conditions for artistic and cultural activities that the democratization process in Curitiba provided (IPPUC).

iv. The 1990s

In the 1990s the demographic growth rate in the city was lower than the previous decades at 2.29%. This period is characterized by the promotion of transformations in environmental, transportation, housing, education, health and employment and income generation issues. It is also in this time when the city receives the denomination of Ecological Capital of Brazil as a result of the several parks and wooded areas.

In terms of transportation, there was an expansion of the Integrated Transportation Network (ITN) with the creation of cycleways. The direct line, or “ligeirinho”, and the articulated buses, both using the tube stations for boarding and disembarking, started operating in the early 1990s.

On the other hand, the Citizenship Streets, meeting points for the public with buildings concentrating basic public services, sports and cultural facilities, were inaugurated in 1995. Fully equipped mobile units for emergency assistance were also established under the Integrated Emergency System program, previously conceived by the IPPUC. There is also a Municipal Education Network formed by 129 schools for pre-school and elementary education of more than 90,000 students.

Other important projects occurring during this decade are:

Lighthouses of knowledge, neighborhood libraries found near schools, open for everyone and providing access to knowledge.

The ***Municipal Housing Fund***, for the provision of financial support for low-income housing. Popular development, land regulation and home construction resulted from this funding program.

The ***Vila dos Oficios*** -or Village of Trades- program combines housing and work at the same location, an idea conceived by the IPPUC.

The ***Linhas e Liceus do Oficio***, translated as Jobs Lines and Schools, is a program intended to address the need for creation of jobs and income generation as part of the city's strategy.

The ***Linhão do Emprego***, or Jobs Route, is a project with the objective of giving a framework for the creation of jobs for neighborhoods in the periphery with a population of about 400,000 residents -28,000 of which were unemployed in 1996- (IPPUC).

c. Urbanization process

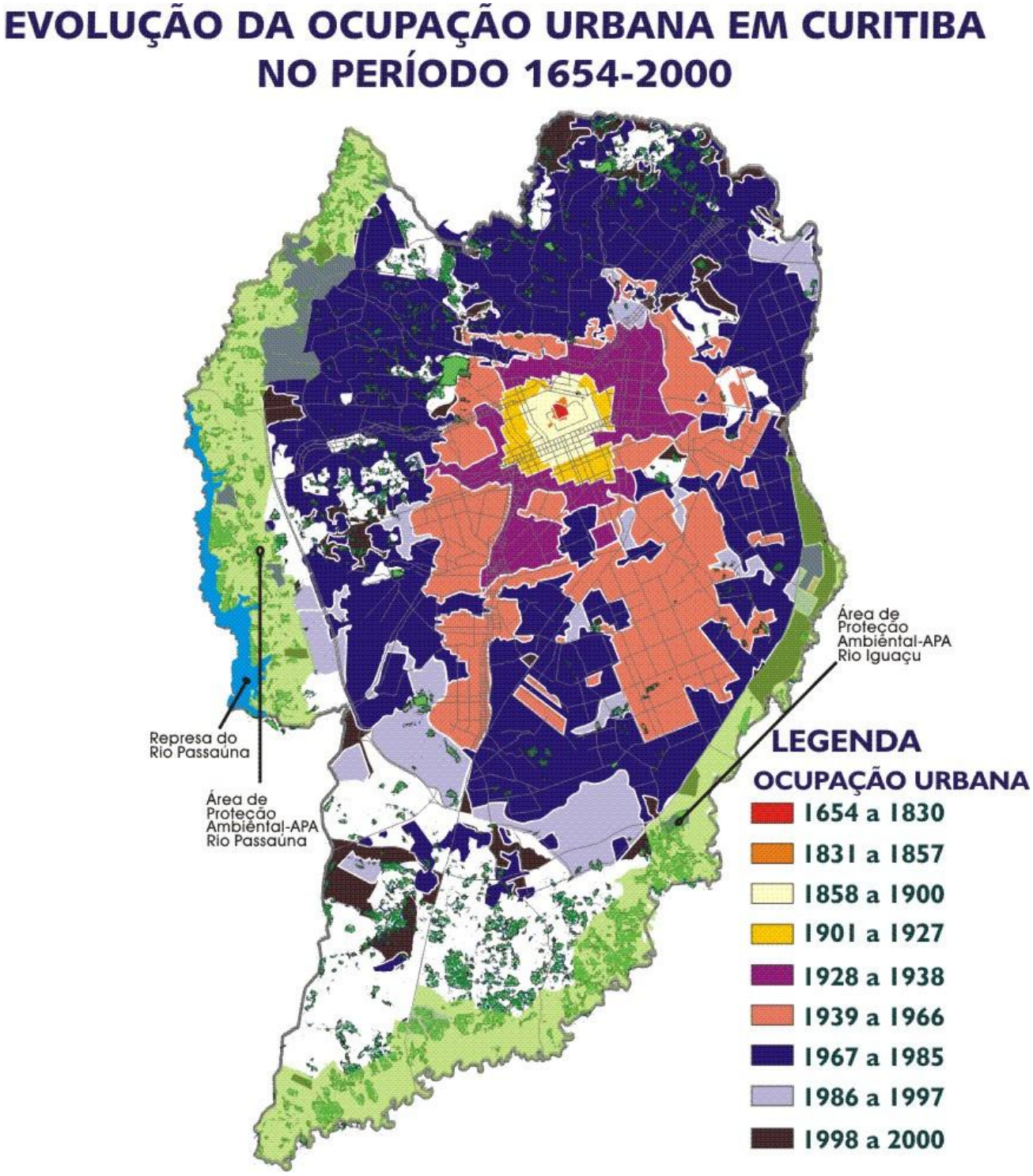
According to Rabinovitch (1996) Curitiba was the fastest-growing Brazilian city in the 1970s.

Rabinovitch and Hoehn (1995) also recognize three different features that characterize the settlement pattern in Curitiba:

1. Integration of the settlement pattern with the transportation system in order to reduce uncertainty for developers and avoid speculation in undeveloped lands.
2. The city determines land use and makes transportation plans in advance of settlement.
3. There are density controls that establish minimum and maximum densities along the structural corridors and reduce congestion in the city center.

The city also established structural sectors with the purpose of redistributing density more evenly and, by doing so, reducing the congestion in order to ease travel but at the same time securing the number of passengers necessary to have a financially self-sustained public transportation system.

Fig 4.1 Map showing Curitiba's urban expansion from years 1654-2000



Source: IPPUC

Urban transportation is the inducing force of Curitiba's growth. Today, Greater Curitiba is growing southwards because of topographic and occupational viability conditions, and as a consequence the north has lower densities (Taniguchi, 2001).

d. Urban Form

Parliamentary (2002) summarizes the main characteristics of Curitiba's urban form:

> At the macro level, transport needs are integrated with the location of housing, hospitals, schools, childcare and work centres. At the micro level, the city is filled with places and spaces that enrich encounters between people and offer opportunities for recreation, reflection and leisure (p. 11).

Other important features that the city of Curitiba has are:

1) Central shopping centers, 2) Parks and trees everywhere, 3) Recreation spaces in high-density areas, 4) Innovative architecture, 5) Heritage buildings and 6) Ethnic parks

Fig. 4.2 One of the many historic monuments in Curitiba: Catedral Basílica na Praça Tiradentes (Curitiba's Cathedral at Tiradentes Square)

Source: Photo by Jorge Mata Otero

The importance of urban form for a sustainable transportation system has been broadly studied. For instance, researchers on urban form have identified three main variables that can help reduce the fuel consumption and emissions: settlement shape, density and location of activities (Smith & Raemaekers, 1998).

Fig. 4.3 Plaza in Curitiba's Civic Center

Source: Photo by Jorge Mata Otero

i. Settlement shape

According to Owens (1986), there are three shapes considered as energy-efficient: "a) the compact city, a centralized high-density city; b) the 'archipelago' pattern, a cellular-like tissue of nucleated urban subunits, and; c) the linear-grid structure, based on lines of high density development." On the other hand, Gilbert et al. (2003) consider that low-density settlements in urban areas stimulate transport activity.

The shape of the city of Curitiba resembles a five-spoke star. The longest spokes in terms of development correspond to the North and South lines while the West and East lines are the shorter spokes of planned high-density development but not in terms of bus

service coverage. The shape of the bus network is also that of a star. In Curitiba, those structural lines were to be the city's new center that would provide services and access to citizens via public transportation (Smith & Raemaekers, 1998). However, Smith and Raemaekers (1998) found in their study that implementing the structural axes does not appear to have sparked an increased demand for public transport considering that there was a 120% increase in trips per capita in the decade before the structural axes were implemented.

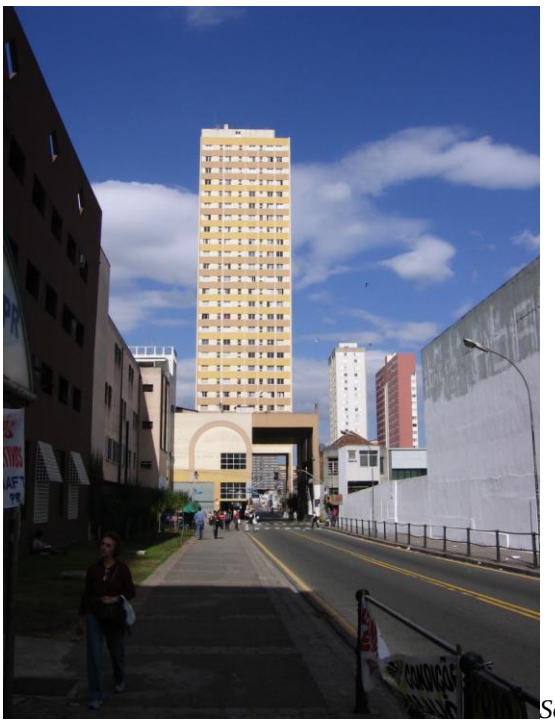
ii. Density

The most important factor in the relationship between urban form and transportation energy requirements is the physical separation of activities determined by density and location of different land uses. Theoretically, high densities reduce trip lengths and the need to travel. In linear cities, high densities do not reduce the need to travel but they contribute to the maximization of public transportation (Smith & Raemaekers, 1998).

Rabinovitch and Hoehn (1995) agree that "[t]ransportation is more effective if the most densely populated areas are near high-volume transportation routes."

Curitiba's residential uses vary according to density. Three types of densities can be differentiated: High, medium and lower. One fifth of the total households in the city are considered high density households. On average, density in Curitiba was 49 people per hectare a decade ago (Rabinovitch, 1996).

Fig. 4.4 High-rise building in proximity to main roads



Source: Photo by Jorge Mata Otero

iii. Location of Activities

Among researchers there is significant agreement that proximity between different uses reduces the need to travel and encourages the use of non-motorized modes such as walking and cycling (Smith & Raemaekers, 1998). In the case of Curitiba, it is necessary to analyze the degree of land use mix along any of its structural sectors and to look into the trip generation to see if this is the case.

Fig. 4.5 Tiradentes Plaza: a node of cultural, economic, social and recreational activities

Source: Photo by Jorge Mata Otero

Services and industry are the main activities in the city. Industry is concentrated in a special area far from the city center. Services are provided near the main roads in the city.

e. Problems

Despite all the success that Curitiba has touted, there are some persistent problems that a few authors have written about. Alberti and Dos Santos (1996), for instance, acknowledge the sporadic emergence of squatter settlements in the periphery and the negative impacts on the city. Those settlements are usually organized hubs of unskilled workers, more commonly known as *favelas*.

In a different vein, the city also struggles with some environmental problems. Parliamentary (2002), for example, recognizes that in the case of water and wastewater management the city does not have adequate standards though that is changing.

More importantly, not all areas are privileged with the good things Curitiba claims to have. Sanchez and Moura (2005) assert that the Curitiba Metropolitan area is clearly segregated considering that the central areas have a remarkable quality of life and innovative urban elements while the periphery lacks all this.

Additionally, false expectations of employment in Curitiba have contributed to the high number of immigrants coming from neighboring municipalities (Moura, 2003). Yet, employment is but one of the reasons for Curitiba's high in-migration levels. Holston (2004) considers the promise of public services not available in other cities as another important cause for immigration.

f. Findings

In colonial times Curitiba shared trends similar to those of other Brazilian and Latin American cities. Initially, the city grew slowly and it was not until the 19th century when, because of high migration, it was necessary the implementation of building codes and land use classifications. A second migration flow came at the end of WWII.

Important highlights in Planning for Curitiba

- 1934 Agache Plan. The plan included urban growth in a radial pattern and zoning guidelines had a strong focus on infrastructure investments to serve the automobile.

- 1964 Curitiba Master Plan. This plan proposed a linear development pattern, decongestion in the central area, provision of urban equipment and economic support to urban development.
- 1970-1980. The population grew at a 5% per year rate; a Heritage Sites Preservation Policy was introduced; and a strong detachment from traditional planning emerged.
- 1990s. The population growth rate declined to 2.29% per year. In 1995 the Citizenship Streets program was launched with the purpose of defining gathering points for the public. There was also:
  - Financial support for affordable housing
  - Creation of neighborhood libraries
  - Housing and work programs
  - Programs for the creation of jobs and income
  - Integration of the settlement pattern with the transportation system
  - Density controls established along structural corridors

  Identified as current problems are:
  - Emergence of squatter settlements in the periphery
  - Inadequate waste and wastewater management
  - High immigration flows due to false employment expectations and the promise of public services

Chapter 5: Curitiba's Bus Rapid Transit System

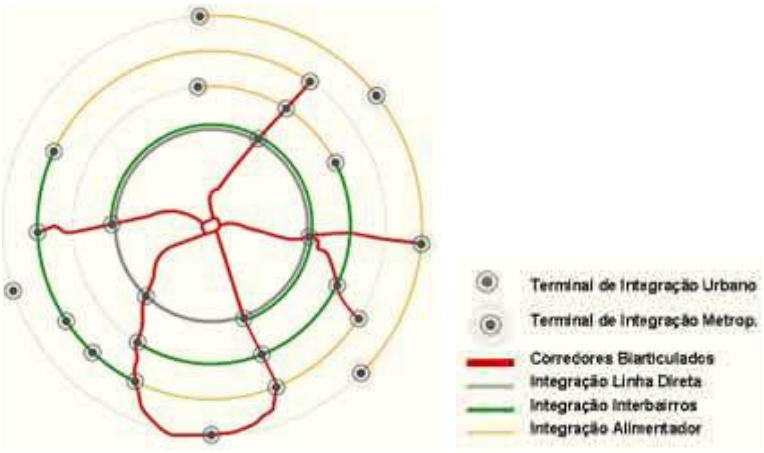
With the realization of exacerbated urban problems in the 1950s and early 1960s the planners of Curitiba had to think of solutions to resolve them. Some of the main objectives of the 1964 Curitiba Master Plan, as discussed in chapter 4, were the decongestion of the downtown -already overloaded with traffic- and a change of the way the city was growing from a radial to a linear development pattern. One of the solutions the city administrators came up with was a plan to improve the transportation system. In this chapter, the rationale of why they came up with the type of transportation system running up until now is examined. Also, a description of the different tools the government has used in order to enforce different urban and transportation policies, how is the road hierarchically defined and what pedestrian, cycling and green spaces were created as a complement to the transportation system are analyzed here.

a. Surface versus underground transit systems

Many are the reasons why subway systems are so prevalent around the world. First, municipalities see subways as the opportunity to maximize disbursements to the local economy. Secondly, a high level bus rapid transit system (HBRT) demands reorganization of existing bus routes and operations which is politically difficult and can result in loss of popularity for local administrators. Conversely, subways are usually implemented without any, or minimum, resistance from existing operators. Thirdly,

subways are viewed as a symbol of modernity which is not the case for buses. (Hidalgo, 2006)

Fig. 5.1 Curitiba's Integrated Transportation Network



Source: URBS

According to Rabinovitch (1996), "the city could not afford a subway system and invested all its creativity and resources in developing a surface system." The city's transportation planning process reveals that there were financial and social constraints. The result was a system that is comparable in quality to a subway system but at a lower cost. The advantages that a surface system has against an underground system are that they provide a solution for moving people though they do little to avoid cars filling streets to capacity. Nevertheless, a public transportation system running on the surface helps keeping human activity on streets.

Even though, as it is, Curitiba's BRT system is supposedly meeting all the city's transportation demands, there are plans for putting in place a monorail system in the near future.

Fig. 5.2 Curitiba's BRT Fleet Makeup

	Line type	Capacity	Operating Units	# of Lines
	Central/Minibus	30	09	01
	Conventional/Mini-Special Mini	40/70	280	89
	Conventional-Troncal/Regular bus	80	115	19
	Troncal / Articulated	160	24	19
	Feeder/ Special Mini	80/70	670	212
	Feeder / Articulated	160	75	212
	Interneighborhoods / Standard	110	35	06
	Interneighborhoods / Articulated	160	90	06
	Direct Line / Standard	110	385	18
	Express / Biarticulated	270	165	06

Source: URBS

Fig. 5.3 Typical layout of an ITN station

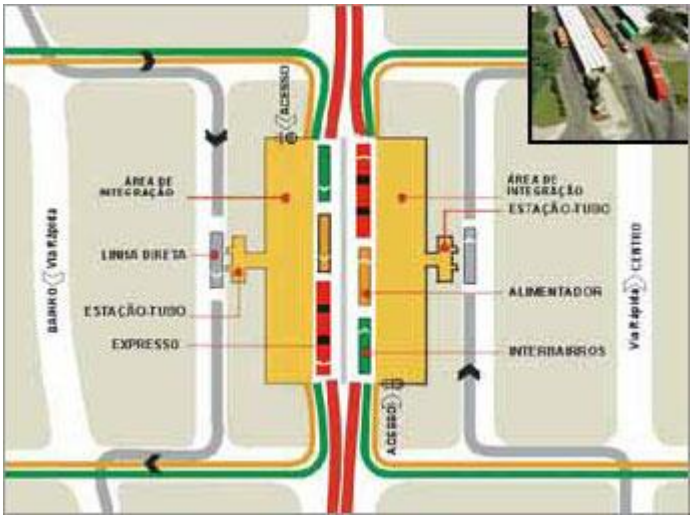
Main Features

- The ITN stations allow the integration between the different lines that form the ITN including Express, Interneighborhoods, Feeders and Direct Lines.

- They also make possible the implementation of shorter Feeder routes, with better services to the neighborhoods because it increases the number of trips while reducing travel time.

- A demand concentration facilitates mode substitution in the corridors.

- They structure the neighborhoods with a concentration of multiple activities.

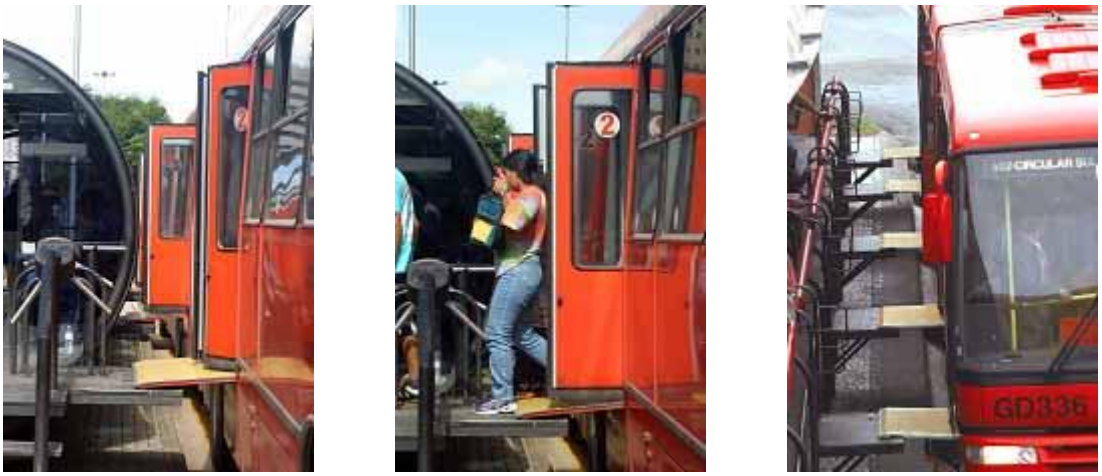


Source: Prefeitura Municipal de Curitiba

b. Effective Transportation System

An effective transportation system is one that gives residents access to services, jobs and relationships (Rabinovitch & Hoehn, 1995). Szyliowicz (2003) considers that a "healthy and robust" transportation system should be composed of diverse modes. A transportation system that depends in one or two modes is more prone to inefficiency and failures. However, he also recognizes that intermodalism does not guarantee sustainability.

Fig. 5.4 Boarding System at Station level



Source: Prefeitura Municipal de Curitiba

On the other hand, in terms of sustainability Gilbert et al. (2003) agree that a well-occupied small car can be more sustainable than an almost empty bus. Therefore, sustainability is not totally dependent on one mode or another but rather on the occupancy and use intensity.

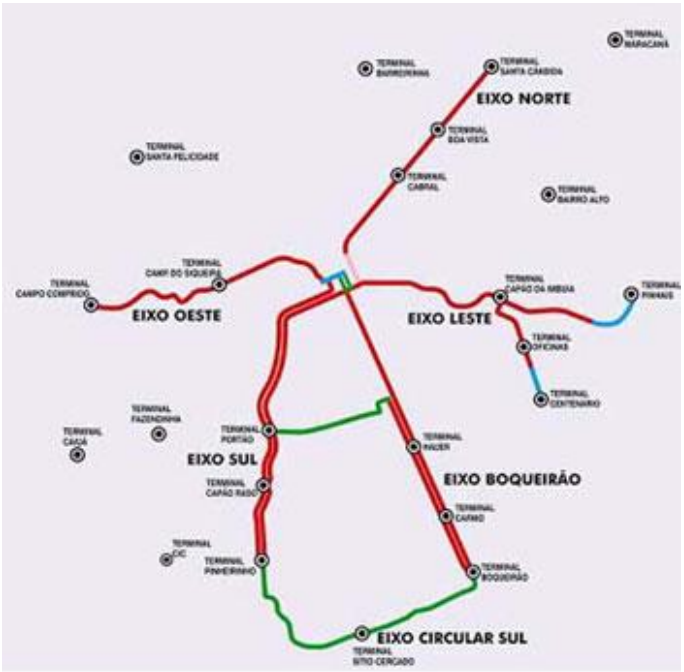
In social terms, Litman (2002) considers that "...the condition of the least advantaged in society is an important indicator of society's overall social and economic progress. Applied to transport this suggests that basic access for people who are mobility disadvantaged is an important indicator of transport system performance."

For getting an effective modal shift, it is necessary the implementation of incentives and disincentives for the existing motorists (Koorey, 2004).

In the late 1960s, Curitiba's public transportation was unreliable and erratic and areas of the city with low potential revenue were not served. Since the majority of bus routes began in the city center and went outward, congestion was a big problem. Plus, in

terms of bus design, the doors were too small and the stairs steep and both caused a slow access and exit of passengers (Rabinovitch & Hoehn, 1995).

Fig. 5.5 Curitiba's Transportation System Structure



Legends:

Exclusive Tracks

Exclusive Lanes

Shared Streets

Exclusive Streets

Source: Prefeitura Municipal de Curitiba

Today, the popularity of the system is based on practical reasons. Buses are fast, the network of bus routes covers the city very well and the fares are very affordable. There is almost no traffic congestion -even at peak times- since the starting times of schools, businesses and retail do not coincide (Friberg, 2000).

The transportation network covers most of the city. Terminals are often located in proximity to large shopping centers or civic landmarks. The city does not have any park

and ride sites though the goals are to have one bus stop within 500 m from all households and guarantee a bus frequency of five minutes maximum (Parliamentary, 2002).

But how did this successful system start? Friberg (2000) notes that a formula of long term planning with a number of innovative solutions created this effective system that prioritizes the needs of public instead or private transportation.

c. Land Use and Zoning

The 1964 master plan endeavored to spur a mix of employment and residential uses along the medium and high density corridors. However, b y 1985 this did not seem to be achieved. Planning regulations were not succeeding in attracting employment-generating activities to the structural sectors and some areas reached too high residential densities. Smith and Raemaekers (1998) found that the objectives of the master plan were not reached. For instance, the high-density housing concentrated along the busways is not affordable for low income households.

While success of the 1964 master plan's goals is debatable, Rabinovitch (1996) gives a comprehensive description of Curitiba's current land use aspects. First, in terms of land use policy, the city has special areas that are designated by legislation in order to guarantee integration with the transportation system or secure their protection. Those areas have different characteristics depending on their function:

Structural sectors, for instance, are the five main growth vectors in the city and they "accommodate" the segregated express bus lanes in conjunction with highly-dense residential, ground-floor commercial and services uses. They are seen as linear extensions of the central business district.

The *traditional center* that does not allow commercial buildings and instead, housing development is encouraged by offering incentives. The construction of parking facilities is also discouraged.

Priority areas for pedestrians where the maximum height for buildings is five floors.

The *historic center* with three different categories of buildings: monuments, structures of general historic interest and buildings with no particular historic value.

The *connecting road zones* that serve as links between the structural sectors and the industrial city.

The *collecting road sectors* are streets that "collect" and distribute traffic and have bus routes running along.

The *river basins* that follow rivers and streams and where it is prohibited to build roads, industries or warehouses. These are normally converted into cycleways and interconnecting parks.

The *Santa Felicidade district* that has ethnic and natural value and the maximum building height is two floors.

In Curitiba there are residential, commercial, industrial and mixed land use categories whereas the availability of transportation restricts the densities allowable in an area (Rabinovitch, 1996).

Finally, it is not valid to negate that land use regulations do not address some of the city's problems. In 2000, for instance, the new Zoning and Land Use Law of Curitiba passed. Some of the main elements of this new law were the emphasis on preserving the

bottom of valleys with the institutionalizing of instruments such as transference of building rights between towns (Taniguchi, 2001).

d. Policy enforcement

Rabinovitch (1996) distinguishes four different ways in which Curitiba enforces land use polices:

1) Regulatory and planning tools

- For encouraging urban growth and density along the structural vectors legislation sets a floor-to-area ratio of six and overall densities depend on the availability of transportation.
- Those seeking a permit for commercial activities need to present traffic generation, infrastructure needs, parking requirements and similar impact analyses.

2) Economic incentives

- It is possible for those who own historic buildings in the city's historic area to have the right to transfer the building potential of their lots to a different location in the city. This works as a compensation mechanism.
- Builders can pay up to two extra floors beyond the maximum allowable height established in certain areas. All the payments are earmarked for building affordable housing. However, before this is permitted, the city analyzes the infrastructure capabilities for handling the extra construction.

3) Physical instruments

- Cycleways are physically separated as are bus lanes.

4) Informational tools

- Information regarding the building potential of any lot is available to the public so that land speculation is usually prevented.

e. Road Hierarchy

Friberg (2000) views the city's road hierarchy, including the structural axes, as the backbone of combined land use, road and transport system.

In Curitiba each road has a function (depending on the location and importance) determined by land use legislation. There are four basic categories:

1) *arterial structural roads,* located on the five growth corridors,
2) *priority linkages,* that connect the structural roads,
3) *collector streets,* regular streets with commercial activity and with all types of traffic,
4) and *connector streets,* linking structural roads with the industrial city (Rabinovitch, 1996).

Fig. 5.6 Collector street in Curitiba.

Source: Photo by Jorge Mata Otero

f. Pedestrian systems

There are approximately 49 blocks in the downtown area that have pedestrian streets linking squares and bus stations. This pedestrian system helps maintaining the vitality of the central area. In this regard, housing in this area supports a number of commercial activities and services (Rabinovitch, 1996). The pedestrian malls also connect with parks and green areas in the downtown area.

Fig. 5.7 Rua Quinze de Novembro, one of the main pedestrian streets in central Curitiba

Source: Photos by Jorge M Otero

However, the creation of this system was not easy. Initially, the creation of the pedestrian network faced opposition from the retailers though soon they realized the zone turned into a profitable place to trade.

g. Parks and green areas

In 1970 the city had 0.5 sq m of green space per capita. By 1992, the same rate increased to 50 sq m (Rabinovitch, 1996). A way to increase the green areas has been to offer incentives to the developers and convince them to keep a part of their plots for

green areas in exchange of a permit to build higher than established in legislation (Friberg, 2000).

Fig. 5.8 Passeio Público, a popular park in the city center

Source: Photo by Jorge Mata Otero

Today there are twelve municipal parks, ten public preservation woodlands and six hundred small squares and public gardens. All this has given the city the title of Ecological Capital in Brazil. Now, parks and city squares account for 18% of the city area (Parliamentary, 2002).

h. Cycleways

Another component of the transportation system is the cycleways with a length of almost 170 kms. These cycleways help encourage the use of parks and green areas and they connect parks, residential and commercial areas -including the industrial city- and the downtown area. They are located away from roads and near streams (Rabinovitch, 1996).

Fig. 5.9 Cycleways and pedestrian ways are usually placed adjacent to each other

Source: Photo by Jorge Mata Otero

However, it is not very clear whether the cycleways are used as a transportation choice to travel from home to work or school or vice versa. In the opinion of Prof. Cleon dos Santos (personal communication, August 30, 2006), the system is utilized more for recreation thus it does not contribute in a significant way in the reduction of motorized trips.

i. Bus System

The bus system is undoubtedly the most important component of the Curitiba's transportation system. However, it is not just any kind of bus system but a bus rapid transit. Sperling and Clausen (2002) regard bus rapid transit as the most important initiative in Asia and Latin America. Such a system is based on a set of measures that enhance bus performance and it is mainly characterized by the "combination of segregated bus lanes, techniques to hasten boarding and disembarking, priority given to buses at intersections, and effective coordination at stations and terminals" (p. 64). It is

the high capacity and the high speed that attracts more riders and guarantees an efficient service.

The Integrated Transportation Network (ITN) comprises transfer terminals, express routes, direct routes, feeder routes and inter-district routes. This system is supplemented by center city routes, neighborhood routes, night routes, special education routes for handicapped people and pro-park routes. Both, the ITN and the supplements form what is called the Curitiba Mass Transit System (Rabinovitch & Hoehn, 1995).

The city utilizes different types of buses to cater the needs of riders within the metropolitan area and surrounding municipalities (Friberg, 2000). In the metropolitan area the routes are different in terms of frequency, speed and the areas they serve.

The direct route bus system is characterized by a reduction in travel times and an increased convenience, comfort, and rider capacity thanks to the combination of vehicles, routes and high-service boarding tubes (Rabinovitch & Hoehn, 1995).

The feeder routes serve the low-density neighborhoods

The interdistrict routes run from corridor to corridor and allow riders to go between outlying points within Curitiba without going through the city center.

Average operating speed of the buses varies according to the type of bus:

1) biarticulated: 20 km/hr 2) direct: 30 km/hr and 3) conventional: 18 km/hr (Friberg, 2000)

The stations are very peculiar and designed with the needs of disadvantaged people in mind. Tube stations are structures made of steel and glass 10 m long and 3 m in

diameter provided with side lifts to allow access for handicapped and old people (Friberg, 2000).

An important characteristic of the bus system is adaptability. The bus fleet can be adapted to match the demand volumes along the different routes. This reduces the number of empty buses in circulation. The benefits from this are clear: reductions in capital costs, less fuel and labor wastes and less traffic congestion. With the same end, the system has smaller buses in low-density areas and articulated buses -with higher capacity- on the high-density structural axes (Rabinovitch & Hoehn, 1995).

Affordability is yet another important aspect. Innovative transportation options normally have high initial capital costs (Sperling & Clausen, 2002). Curitiba's officials were aware of this and so decided to use a system they could afford: a bus system. The bi-articulated bus system, for instance, is considered to be very cost-effective at US$3 million per km when compared to a tram system at US$ 8-12 million per km or to a subway system at US$ 50-100 million (Matsumoto, 2003). In terms of operation and maintenance, the bus system in Curitiba does not get any subsidies from the city for operational costs and purchases (Rabinovitch, 1996). Surprisingly, during peak travel times, these buses are mobilizing around 28,000 people per hour (Parliamentary, 2002).

The ITN has expanded in the past few decades to such an extent that today covers about 900 kms routes in eight neighboring cities (Friberg, 2000). The bus system now averages 2.1 million trips, which corresponds to 75% of all passenger trips (Parliamentary, 2002). In the near future, the city will improve the integration of the

metropolitan region by establishing a bus rapid train system as a supplement for the existing transportation network (Taniguchi, 2001).

j. Management and Financing

The Urbanizao de Curitiba (URBS), a government-owned institution created in 1963, manages Curitiba's ITN. The URBS is in charge of the monitoring and coordination of the system; the private companies operating the bus lines; and the maintenance of the system's infrastructure (Friberg, 2000). There are 16 different private companies that are licensed for specific lines. In terms of faring system, in 1990 a law passed that determined that the system's revenues were to be used only to pay the system itself. Also, it is important to highlight that the buses cannot be older than 10 years.

The URBS also determines routes, schedules, flat fares, and contracts operators.

k. Equity

Automobiles provide people with mobility and freedom, but they do so only for those who can use them. The poor, the elderly, the disabled are often isolated from community life if the city lacks alternative transportation modes (Szyliowicz, 2003).

Sperling and Clausen (2002) explain that the subsidies that public transportation receives in almost all cities is because of the positive externalities such as the reduced need for roadways and reduced congestion but more importantly to secure access for poor people. In terms of mobility, people without a car will be limited to places accessible by public transportation. Also, those locations might be the most polluted –from transportation- since they are likely to be in proximity to major roads (Feitelson, 2002).

In a different vein, political and market processes can cause environmental inequity near transportation facilities. Areas with the least opposition are more likely to house transportation infrastructure. Such areas are usually politically weak areas where low-income or minorities reside. Transportation facilities and routes can attract development and affect land use patterns around them. Considering that transportation facilities can lower housing prices in the surrounding areas those areas can become more affordable for low-income groups. Plus, when facilities serve as terminals or routes for public transportation this can be attractive to people that do not have cars and therefore who are dependent on public transportation (Feitelson, 2002).

In Curitiba, the inexpensive and extensive transportation network provides access to employment and service opportunities to low-income groups from any part of the city (Rabinovitch & Hoehn, 1995). Importantly, Curitiba is also known as the Social Capital given that a number of projects emphasize the city's fundamental philosophy, which is serving the needs of the citizens through programs that are beneficial at different levels (Holston, 2004).

Curitiba has also promoted social programs for addressing the housing problem. The city purchased land near the planned structural corridors before these were developed and then subsidized low-income housing near the transportation routes and to the Curitiba industrial park (Rabinovitch, 1996). In the early 1990s Curitiba developed one of the largest housing programs with funding coming directly from the city budget (Matsumoto, 2003). Parliamentary (2002) mentions that there is also a low-income housing program that offers minimum sized lots and finance for a minimum sized house of 40 sq m.

In 1979 a flat fare was established so that people with longer commuting distances, that were mostly low-income people, were "subsidized" by those people with shorter commuting distances. By doing this, a more socially equitable transportation cost would be available for the citizens. Additionally, this single fare solved some problems in revenues sharing among the different bus companies (Matsumoto, 2003).

However, not everything works perfectly in the city. Taniguchi (2001) recognizes the need to address the social inequality issues in Curitiba when he notes that "[t]here is no way of living in a world that wishes to be equalitarian with opportunities for all with these enormous income differences" (p. 15).

On the other hand, there are authors who think there has been gentrification. Moura (2003) thinks that the urban planning processes in Curitiba have in fact worsened the social disparities considering the prices of land that are prohibitive for some groups.

l. Environment

An essential component of any sustainable transportation strategy is environmental equity (Feitelson, 2002).

Sperling and Clausen (2002) assert that almost one-fourth of the carbon dioxide emissions in the world comes from the transportation sector. Transportation greatly contributes to the climate change which is caused by active compounds better known as greenhouse gases (Yevdokimov & Mao, 2004). Even though there is consensus about the need to develop environmentally sustainable transportation systems, there is divergence in approaches about the ways and the timeframes (Tengstrom, 1999).

Fig. 5.10 Universidade Livre do Meio Ambiente (Open University for the Environment)

Source: Photo by Jorge Mata Otero

Feitelson (2002) identifies three different externalities resulting from transportation: a) those resulting from the energy used to move over space (i.e., traffic), b) those from the infrastructure necessary for that movement and, c) indirect externalities that transportation effects have on land use and development patterns.

Matsumoto (2003) underscores that despite having the second-highest automobile ownership rates, Curitiba has one of the lowest levels of air pollution in Brazil. In fact, the United Nations gave a prize to Curitiba for its environmental planning (Kroll, 1999).

The city has also been denominated the Ecological Capital of Brazil due to the combination of a series of steps. The most important of those steps are an aggressive park acquisition program; the protection of historic monuments; the prioritization of

pedestrians; the provision of cycleways linking the parks; and a massive expansion of the public transportation system.

Lastly, Parliamentary (2002) points out that "Curitiba's environmental protection and enhancement programmes are working because they have clear goals and programmes have worked together to enhance environmental quality" (p. 13).

m. Economy

Economic constraints are the main obstacles to strengthen local governments in most Brazilian cities. In the case of Curitiba, progress was made thanks to the creative and original solutions the city administrators came up with (Alberti & Dos Santos, 1996).

To a significant degree, the combination of quality infrastructure (transportation in particular), skilled workforce, quality of life (parks, pedestrian precincts, etc) as well as the presence of other industries have all contributed to the attraction of industry to the area (Parliamentary, 2002).

Now, more than four hundred low polluting industries are located in the industrial city and they provide a total of 200,000 jobs for Curitiba. This has been the result, at least in part, of the city officials' awareness of the importance of having a holistic view of Curitiba's growth and development. They know that any decision made will impact the city in its social, economic and environmental dimensions.

However, there are some contradictory decisions that seem to depart from sustainability. In the 1990s, the city focused on attracting automobile manufacturing industry, a trend that did not benefit environment (Sánchez & Moura, 2005).

n. Technology

The acceptance of technology fixes by policymakers is usually motivated by the less coordination and less behavioral and institutional change that are required (Sperling & Clausen, 2002).

Shay and Khattak (2002) think that technology can change the prevailing patterns of employment, education, and other common life activities, reducing transportation needs and substitution of travel. With those changes, accessibility can be improved and therefore people can connect better with goods, services and activities. Nevertheless, the implementation of new technologies is challenging in that it demands a high degree of coordination and integration of resources (Szyliowicz, 2003).

Sperling et.al (1995) also agrees that "[t]echnical fixes preserve the fundamental attraction of vehicle travel, mobility, convenience, and privacy while requiring few behavioural changes" (p. 10).

Vehicle technologies, such as electric, fuel cell and even hybrid vehicles could be considered good sustainable transportation options. Nevertheless, the sustainability of these options depends on the sustainable production of the energy, electricity or hydrogen they consume (Muntwyler & Koch, 2002).

However, technology alone is not sufficient to attain sustainability. The benefits that come from lower fuel consumption, for instance, are to some degree diminished by increases in distances travelled. Also, a better vehicle engine cannot prevent or reduce two main transportation problems: congestion and safety (Koorey, 2004).

Additionally, the introduction of advanced technology, more complex systems or higher costs is not essential to achieve innovation for sustainability in transportation.

There are some simpler innovations in transportation that are less costly (Shay & Khattak, 2002). The latter seems to be the case of Curitiba as we will see later in chapter 7.

o. Findings

The advantages of a BRT system are that they have a lower cost compared to a subway/underground system and it helps keeping human activity on streets. The cost per km of BRT is estimated, on average, at US$3 millions while a km of tram and underground greatly surpass that average cost at US$8-12 millions and US$50-100 millions respectively. Also, an effective transportation is one that provides access to services, jobs and relationships. In this regard, basic access for people with mobility disadvantages becomes an important indicator of transport system performance. Similarly, sustainability in a transportation system is not totally dependent on one mode or another but rather on the occupancy and use intensity. To guarantee the maximum occupancy and use intensity, the ITN is supplemented by other routes to cover the whole city. URBS, a private company, is in charge of managing Curitiba's ITN and licensing the private companies that operate the buses. The bus system combines vehicles, routes and high-service boarding stations resulting in a reduction in travel times, heightened convenience, comfort and passenger capacity. It is claimed that the system provides 2.1 million trips per day, or 75% of all passenger trips. It also has an adaptable bus fleet according to the needs in both space and time.

Other characteristics are that is affordable and extensive which gives low-income groups access to jobs and services anywhere in the city.

On the other hand, by mid-1980s the plans were failing in attracting employment-generating activities to the structural sectors and there were too high residential densities in some areas. For securing enforcement a series of instruments were required:

- Regulatory and planning tools: developers need to present impact analyses
- Economic incentives: there are compensation mechanisms so that building rights are transferable to other parts of the city. Builders can also "buy" the right to build higher than permitted under certain conditions.
- Physical instruments: There is a distinction and physical separation between cycleways and buses.
- Informational tools: All information about incoming development projects is available to the public.

Other important facts are:

- A road hierarchy has been instrumental for the integration of land use and transportation
- Green space per capita grew from 0.5 sq. meters to 50 sq. m from 1970 to 1992.
- There is a cycleways network of 170 km and a pedestrian area conformed by 49 blocks in downtown.
- Low polluting industries provide 200,000 jobs
- There is a strong focus on the environment. In fact, the city is considered as the Ecological Capital of Brazil thanks to having: the lowest air pollution levels among Brazilian cities; a remarkable park acquisition program; a proved interest in the preservation of historical buildings, etc.

- Technologically, the city opted for simpler and less expensive innovations for its transportation system.

Now that an overall description of the main features of Curitiba's BRT system it is important to go through the different strategies followed by the city of Curitiba in order to pursue sustainability.

Chapter 6: Sustainability Strategies for Curitiba

As mentioned at the beginning of this report, sustainability is a difficult concept to define. Even more difficult, however, is to determine what the steps necessary to achieve it are. Curitiba, long considered a role model for other world cities seeking sustainability, established a group of strategies that have guided every planning process ever since in its goal of becoming sustainable. Next, a brief description of each of the components of Curitiba's sustainability strategy is presented.

a. Leadership

Jaime Lerner, Curitiba's mayor for three times, is deemed as the key figure behind the shifting from the traditional model of sprawling development to a well managed, comprehensive, socially inclusive and integrated approach in Curitiba. The influence of this mayor is perceived in many strategic plans and operational matters. To date, he stills keeps an interest in the key projects in Curitiba.

But not only the mayor plays an important leadership role. Councillors, city agencies and departments, business leaders, they all contribute leadership qualities and strong values (Parliamentary, 2002). Since implementation of solutions was always a political process the staff that had worked with Lerner was promoted to key political positions and gain control over the implementation. That is, governance consistency was secured by promoting the technicians.

Among those values the most important were: civic pride, solidarity, passion and focus on the quality of life.

b. Vision

In the last three decades, Curitiba's mayors have defined a vision based on the quality of life. They have also established a clear direction and framework set that allows for innovation and flexibility. The philosophy has been to take risks, find simple, pragmatic solutions and implement them quickly (Parliamentary, 2002).

In the same vein, political will and skill have been very important in implementing the plan in the long term.

Taniguchi (2001), a recent Curitiba's mayor, describes the importance of having a vision for the city. He notes that "[a] clear vision of the future ensured that piecemeal decisions made over a period of three decades added up to an extraordinary fit between transit and land use/cityscape" (p. 14).

However, it is important to note that the vision has to be a positive one. According to Dimitriou (2006) in Asia there is a development vision that is fulfilled by accepting motorization which is normally viewed as a reflection of economic vitality. This has resulted in an increased activity of the motor vehicle industry. Clearly, an encouragement of such motorization goes against the efforts of developing sustainable transportation strategies in urban areas.

c. Institutions

Institutional frameworks support actions resulting from planning, based on knowledge, in order to provoke changes that the citizens want. Also, they intervene at the policy level to avoid duplicated duties and responsibilities and to guarantee that resources are according to their missions (Silva-Portugal & Flórez, 2006).

The planning agency that is responsible for maintaining coherence and integration is the IPPUC (Curitiba's Planning Institute). A central planning institute separated from the local authority, the IPPUC has been successful in keeping consistency and commitment through different administrations and mayors. This important institutional element also helps support both; leadership and vision (Parliamentary, 2002).

d. Integration of Land use and transportation

Vincent (2002) sees the coordination of land use development with transit and the integration of different modes and facilities of the transportation system as essential for building a comprehensive and sustainable public transit system.

Rabinovitch (1996), on the other hand, considers the integration of land use legislation with transportation as instrumental for implementing an organic zoning system.

In the early 1970s Curitiba started directing growth in favor of quality of life. The integration of land use and transportation planning was deemed as an important strategy for guiding and coordinating growth (Rabinovitch, 1996).

Rabinovitch and Hoehn (1995) considers transportation development and land use controls as powerful tools for guiding the quality and quantity of growth along the desired axes.

Taniguchi (2001) explains that one of the fundamental concepts in Curitiba is "never to think about transport in an isolated manner; never to isolate the shantytown issue; never to use land in an isolated manner" (p. 16).

Nevertheless, such integration should be controlled to avoid unwanted results. Smith and Raemaekers (1998) point out that high densities permitted along the structural sectors cause excessive pressure on the transportation system. Furthermore, there are areas where high densities have produced changes in the microclimate and increases in air and noise pollution. Obviously, this goes against sustainability. The maximum density permitted along the sectors had to be lowered in 1990 in order to deter the deterioration of the urban environment in those sectors.

e. Policies

According to Shiftan et al. (2003) it is a major challenge for policy makers to determine the policies that can achieve a sustainable transportation system considering that it is uncertain how a set of policies will have an effect on a transportation system and the urban environment.

Szyliowicz (2003) claims that in order to meet human needs instead of favoring only the privileged groups the priorities for transportation policy in the developing world need major changes.

Similarly, for Shiftan et al. (2003), the combination of policy measures is fundamental for the achievement of sustainable development because of the complexity of the concept of sustainable development and the interdependency of some policy objectives.

Daly (1990) is more specific and suggests three principles that a policy for sustainable transportation most be based on:

1. Non-renewable resources should not be used faster than their regeneration rates
2. Non-renewable resources should be used at a slower pace than substitutes become available
3. Pollution emissions should remain within the capacity of the environment to assimilate them

A measure must have complementary measures in order to be accepted. As an example, when parking restrictions or congestion pricings are proposed as sustainable policies, there must be an efficient public transportation system so that people will be willing to shift mode. When such a transportation system is not in place the policy could turn as non-sustainable since people would change their activities to the suburbs and as a consequence a higher dependence on private cars (Shiftan et al., 2003).

On the other hand, Rabinovitch (1996) suggests "...the ultimate objective of any urban land use policy: to affect social, environmental and economic aspects so as to benefit as many people as possible, especially the most vulnerable groups, - which, in the context of most developing countries, constitute the majority of the population anyway" (p. 51)

Sperling and Clausen (2002) recognize that "Curitiba is a superb example of policy coordination, in this case between land use planning and public transit investments. This is one of the few cities in the world that has implemented a linear pattern of development together with an efficient transportation system" (p. 63).

Parliamentary (2002) summarizes the different policy tools that the city used including:

- A single master plan for the city's development
- Various types of incentives
- Transferable development rights
- Public-private partnerships
- Community education/information
- Solid waste and green exchange programs

f. Public Participation

Tengstrom (1999) agrees that changes in transportation policies, technologies and practices often need strong public support.

Along the same lines, Szyliowicz (2003) stresses the importance of public support in order to achieve sustainable transportation systems: "...it is the public that influences decisions concerning transportation projects and policies, and it is the public that will make a new transportation system an effective one" (p. 188). He also thinks public involvement helps to improve legitimacy and the acceptability of policies and projects and can help discourage potential conflicts. Plus, the community has local knowledge and information that planners can utilize for the formulation of policies and projects.

In an interview that the then mayor of Curitiba, Rafael Greca de Macedo, gave to Alberti and Dos Santos (1996), he explained that the identification of people with their city is a real co-responsibility network that was created.

In the 1960s and 1970s, there was no public participation in the planning process in Curitiba since at that time there was a military regime in Brazil and a technocratic approach was preferred. However, in recent years this is starting to change and more public involvement is present as the system grows (Friberg, 2000).

According to Parliamentary (2002):

> The city appears to invest a lot of effort in listening to its citizens. The mayor holds regular public hearings in the regional offices and there are an array of web-based resources and hot lines. These have very high user rates because they are means for citizens to convey how they would like their taxes spent in their area or where they would like a new bus stop or route (p. 6).

On the other hand, there are scholars that question the above claims. Oliveira (1995), for instance, criticizes the public participation process in Curitiba for including only the influential and dominant groups that have particular interests.

Shay and Khattak (2002) explain that when there is little citizen participation and sense of community, transportation planning can be very traditional, with the usual methods and guidelines used by transportation departments and planners for many years. Therefore, public participation must be broad and all-inclusive in order to propose innovative sustainable transportation solutions.

g. Information

Tengstrom (1999) emphasizes that it is important that the information encourages dialogue with the public and business sectors. He also points out that information is a

one-way communication not adequate to create political acceptance of innovative policies.

In a similar way, Parliamentary (2002) considers that "good information is the lifeblood of good decisions, and in Curitiba they put significant resources into urban research and making the information available" (p. 9)

Notably, people can have access to the information regarding the direction of development in Curitiba. This has eliminated land speculation in a significant way which in turn has helped local authorities to reduce political pressures to develop transportation with the purpose of serving land investments (Rabinovitch, 1996).

Information can be useful not only for the public at large but also for the institutions. URBS takes advantage of the availability of turnstile and trip data and adjusts bus route frequency on a daily basis (Parliamentary, 2002).

h. Findings

- **Leadership** is important for the implementation of a plan
- A **vision** provides a clear direction that glues together any piecemeal decisions to reach a greater goal
- **Institutions** maintain coherence and integration to keep consistency and commitment through different administrations
- A controled **integration of land use and transportation** is crucial for guiding and coordinating urban growth

- It is fundamental to have an excellent **policy coordination between land use and transportation** that positively affects social, environmental and economic aspects bringing benefits to the most disadvantaged groups.
- **Public participation** helps to improve legitimacy and acceptability of policies and projects and it must be broad and all-inclusive. Besides that, the public has local knowledge and information that can influence those policies and projects.
- Finally, **information** is fundamental for good decision-making

Chapter 7: Assessment of Curitiba through different indicators

Sustainability indicators are usually organized into a framework of three dimensions, namely natural environment, economy and social well-being. This chapter attempts to provide a general overview of how the city is doing in terms of sustainability by choosing different data relevant to each of the three dimensions mentioned above. It is important to note that the analysis could be more thorough were there more numerical data readily available.

a. Natural Environment Indicators

There is data to analyze three different indicators related to this dimension: green space, water availability and waste management. Even though this might seem a little limited in scope, it allows us, nevertheless, to gauge the overall environmental situation of Curitiba.

Table 7.1 Green and leisure Spaces by type in Curitiba, 2002

Kind of Leisure Space	Number	Area in Sq. Meters
Forests	15	660,807.00
Parks	15	18,419,051.00
Squares	398	2,471,963.00
Gardens	330	281,757.00
Lakes	54	62,878.00
Environmental Pockets	11	14,891.00
Environmental Gardens	5	48,725.00
Sport Centers	2	64,100.00
Animation Axles	15	535,623.00
Total	840	22,559,795.00

Source: Municipal Secretariat for the Environment

As already noted in past chapters, there is approximately 52 sq meters of green area per inhabitant as estimated by several sources. However, by taking the total area from the table and dividing it by the estimate of population in year 2009 of 1,851,215 it only amounts to 12.18 sq. meters per capita (Table 7.1). Unless there is another type of green/open spaces area not being considered in the table above, the claims made by several sources might be somehow misleading (Fig. 7.2).

Table 7.2 Hydrological Basins in Curitiba

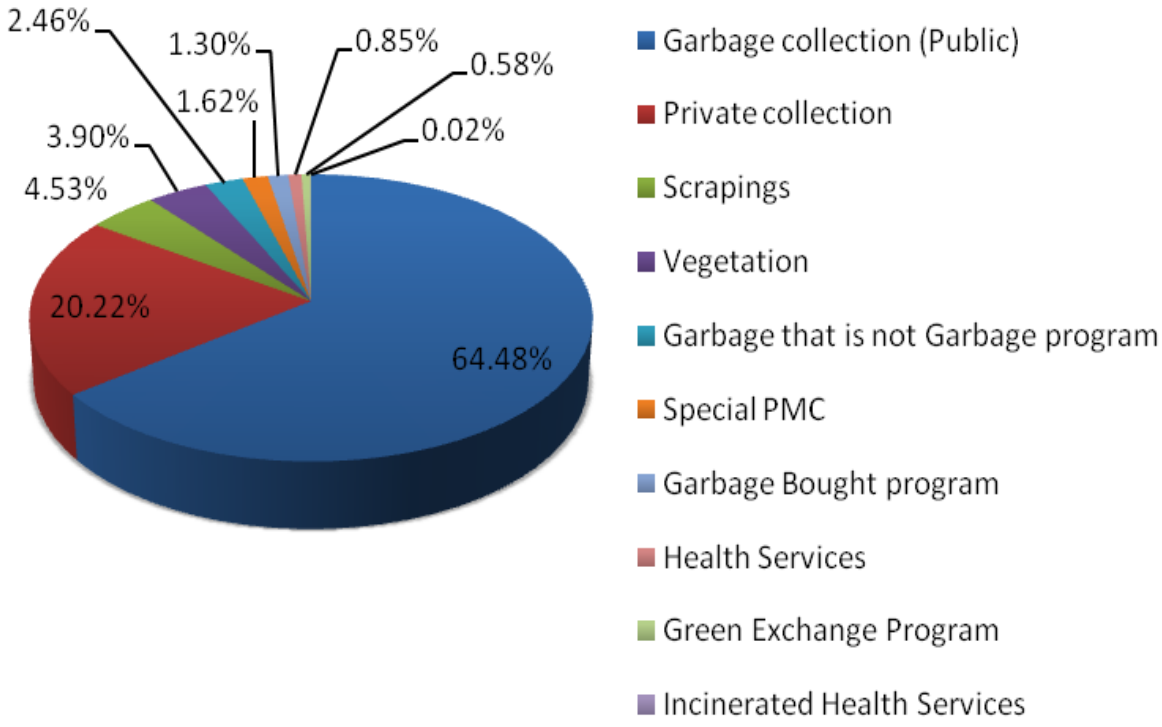
Hydrological Basins	Area (Km2)
Ribeirão dos Padilhas	33.6
Rio Atuba	63.3
Rio Barigui	139.9
Rio Belém	87.2
Rio Iguacu	67.7
Rio Passaúna	37.7
Total	429.4

Source: Municipal Secretariat for the Environment

In terms of water supply, the Curitiba Metropolitan Region has several hydrological basins that together total 429.4 sq. Km (Table 7.2). Also, there are about a thousand artesian wells throughout the city still used by hospitals, companies and condos. Despite this apparently richness in water resources there are some problems. During the rainy season, there are floods that worry not only the residents but also the city officials which has made necessary the promotion of projects to channelize the rivers and streams proner to be flooded. On the other hand, the city consumes approximately 7,500 litres of water per second supplied by SANEPAR (the Water Supply company of Parana) which puts pressure on an overloaded system. Some of the locals note that for the last few years

in wintertime the water supply is not optimal or lacking which is another concern for the city administration. There are projects underway such as the construction of dams (Piraquara II) and a catchment and water treatment plant in the Miringuava river.

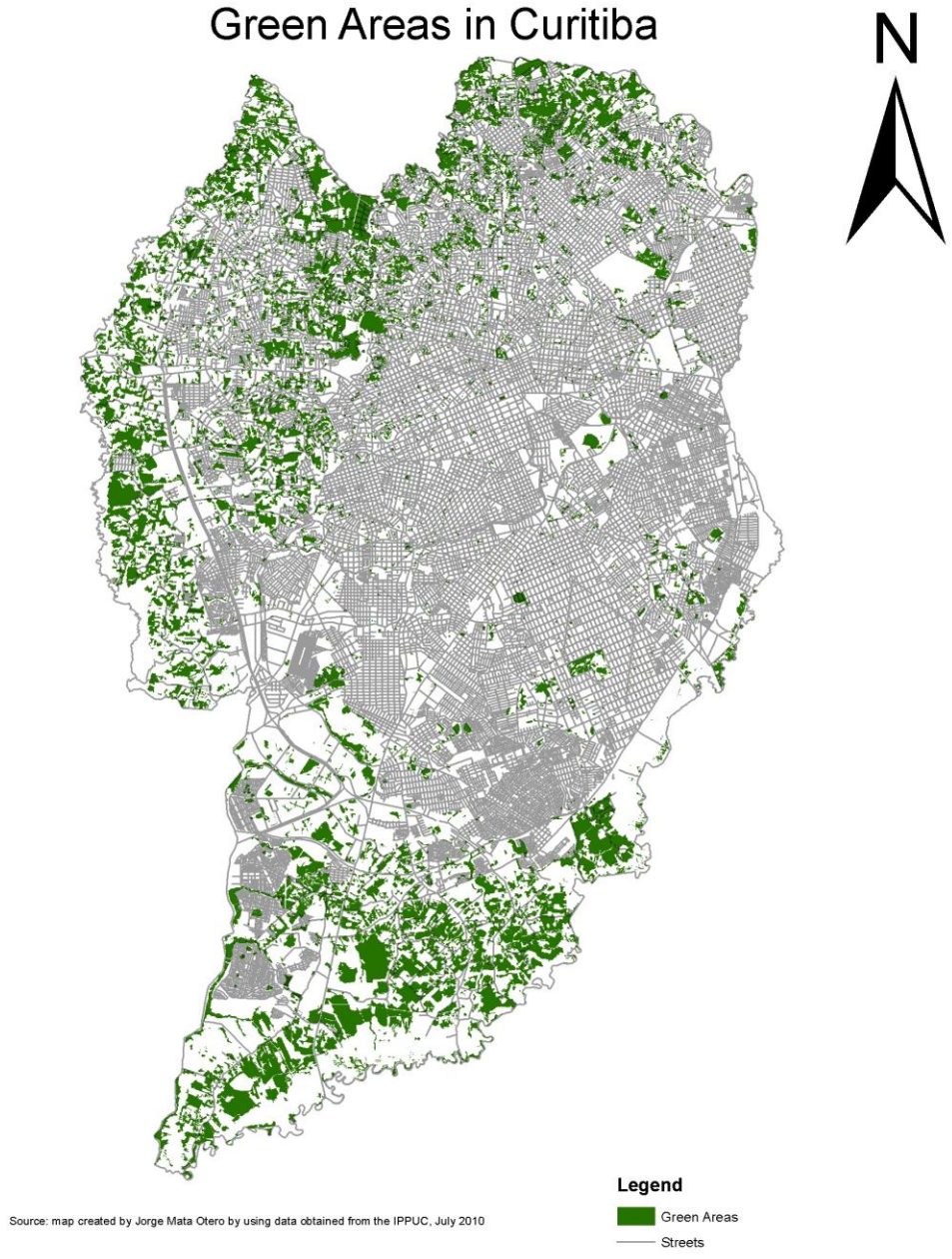
Fig. 7.1 Solid residues collected by type in Curitiba, 1990-2001



Source: Municipal Secretariat for the Environment

Fig. 7.1 illustrates the proportions of garbage collected by type of service for the 1990s. Most of the garbage is collected by regular Public collection or Private collection. A little over 15 % is collected by any of the special programs established in Curitiba. Notably, less than 10% of the total garbage is collected through all the recycling programs combined which puts into doubt the success of the recycling efforts by the city.

Fig. 7.2 Map showing green areas in Curitiba



Map created by Jorge Mata Otero, Source: IPPUC

b. Economic Indicators

For the assessment of this dimension different indicators in three different categories are used: Economic performance (Proportion of GDP by sector, GDP per capita), Employment (Proportion of jobs by sector) and Education (Schooling and Illiteracy rates).

Fig. 7.3 Jobs by sector in Curitiba (%)

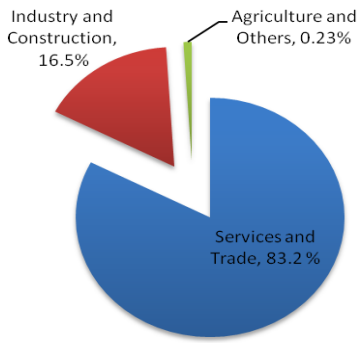
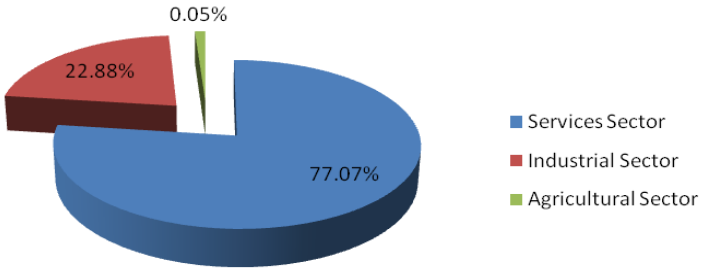


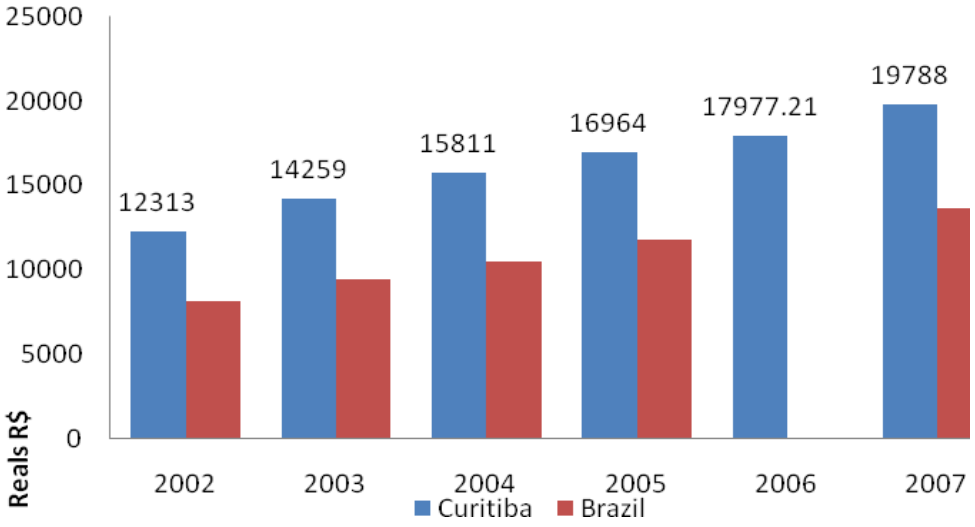
Fig. 7.4 Curitiba's GDP by sector



Source: IPARDES

Fig. 7.3 shows the percentages of jobs in each sector in Curitiba in year . As an overall trend, it is clear that most of the jobs fall in the category of Services and Trade with 83.2% followed by jobs in Industry and Construction (16.5%). Similarly, Fig. 7.4 shows that the GDP for the Services sector is much greater than that of both the industrial and the agricultural sectors. One thing that this could mean is that the local economy will not be impacted as much by continued reductions of manufacturing jobs. Since productivity growth in manufacturing is very high, it is likely that many jobs will continue to be eliminated.

Fig. 7.5 Graph comparing Average GDP per Capita in Curitiba and in Brazil, years 2002 to 2007



Source: IPARDES

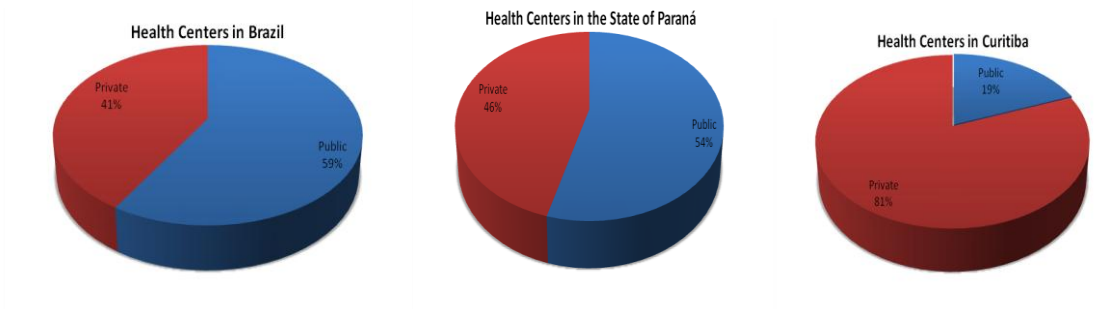
As shown in Fig. 7.5, it can be clearly seen that the GDP per capita for both Curitiba and Brazil rose steadily throughout the period 2002-2007. Also, there is an overall trend that the average GDP per capita in Curitiba has been significantly greater

than the average for Brazil during the past few years. An interpretation of this is that Curitiba's local economy it has been better than its counterparts in other regions in Brazil.

c. Social Indicators

There is data to analyze a set of indicators corresponding to this dimension. As for health indicators it is possible to analyze the proportion of public and private health units, life expectancy and infantile mortality rates. As for accessibility indicators there are only two indicators for which data is available: average household income and car ownership.

Fig. 7.6 Comparison of Public versus Private health centers in Curitiba, the State of Parana and Brazil in 2008

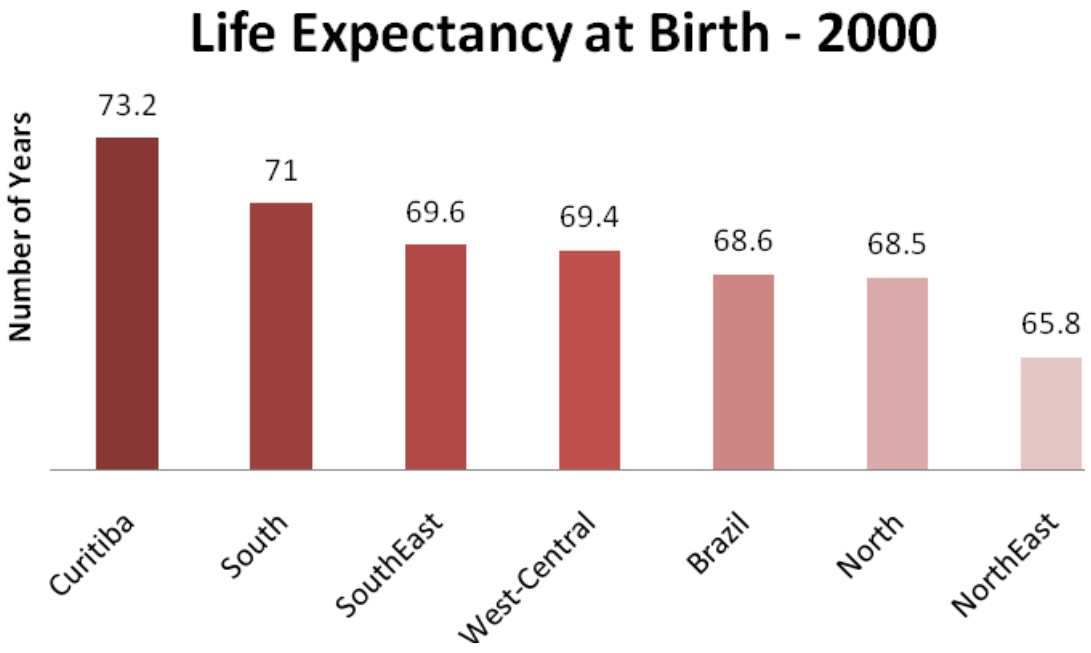


Source: IPARDES

The three charts in Fig. 7.6 compare the proportions of both Public and Private Health Centers in Brazil, the State of Parana and Curitiba. While Brazil and Parana maintain a closer balance between the number of Public Health Centers and the Private Health Centers, Curitiba surprisingly has more Health Centers classified as Private. An interpretation of these results might be that accessibility to health services is not as easy

for the general public, and in particular for the most economically disadvantaged people. If this is the case, this goes in the opposite direction to sustainability.

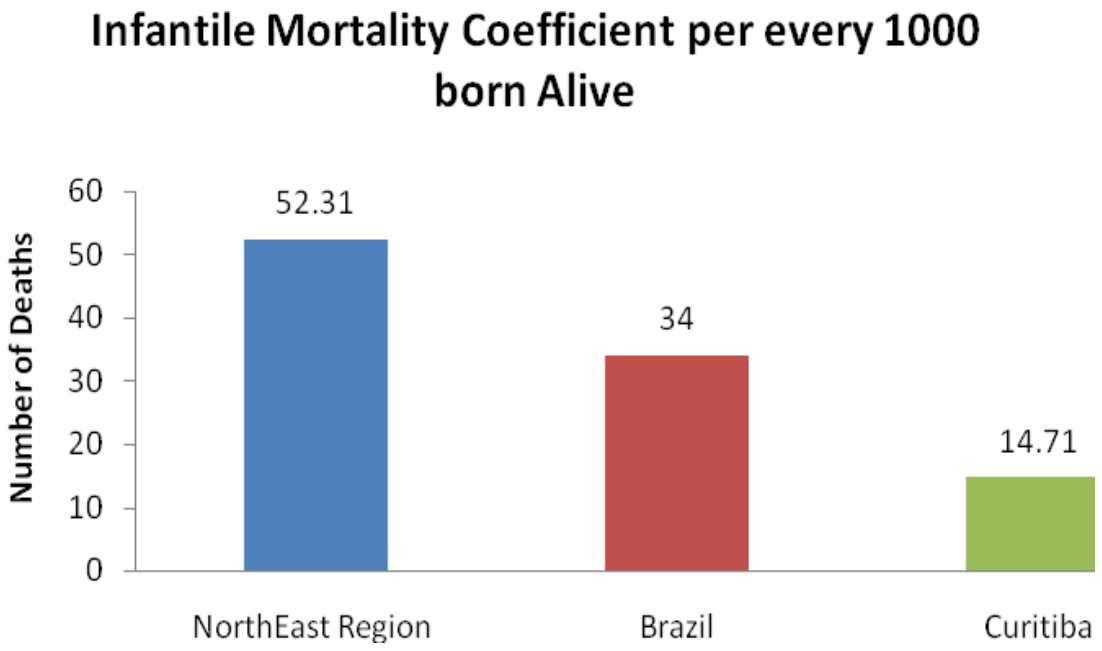
Fig. 7.7 A comparison of life expectancy at birth between Curitiba, different Brazilian regions and Brazil in 2000



Source: Curitiba's Municipal Secretariat for Health

According to the United Nations, in 2000 the average life expectancy for countries with a high Index of Human Development it was 77.4 years. By looking at Fig. 7.7 it is clear that Curitiba is in the way to attain the same levels of life expectancy as those in the most developed countries. Compared to life expectancy in Brazil and in other regions Curitiba's is the highest with 73.2, almost five years higher than the average in Brazil and just 4.2 years below the average reached in highly developed countries.

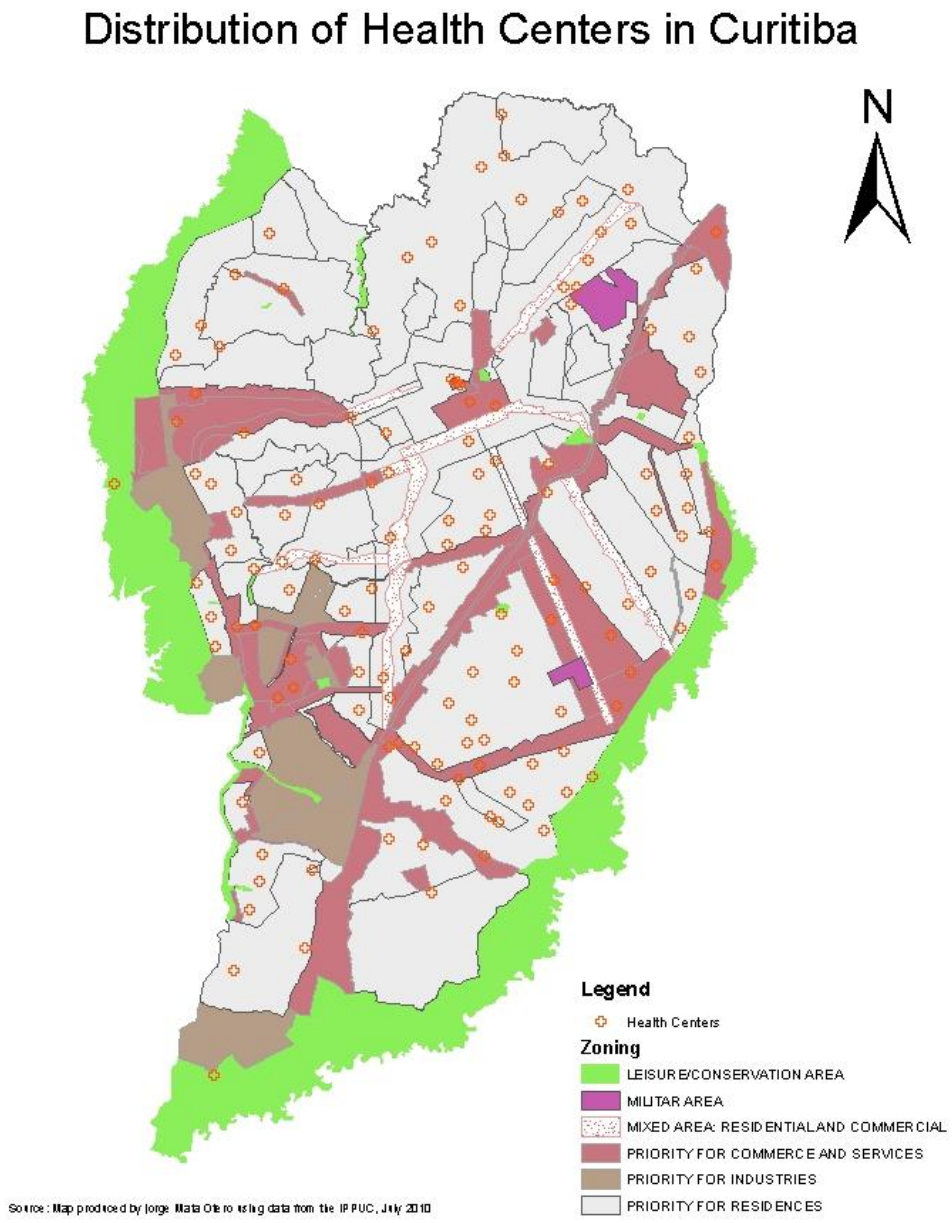
Fig. 7.8 Infantile Mortality Coefficients per every 1000 infants born alive in Brazil, the NorthEast Region and Curitiba



Source: Curitiba's Municipal Secretariat for Health

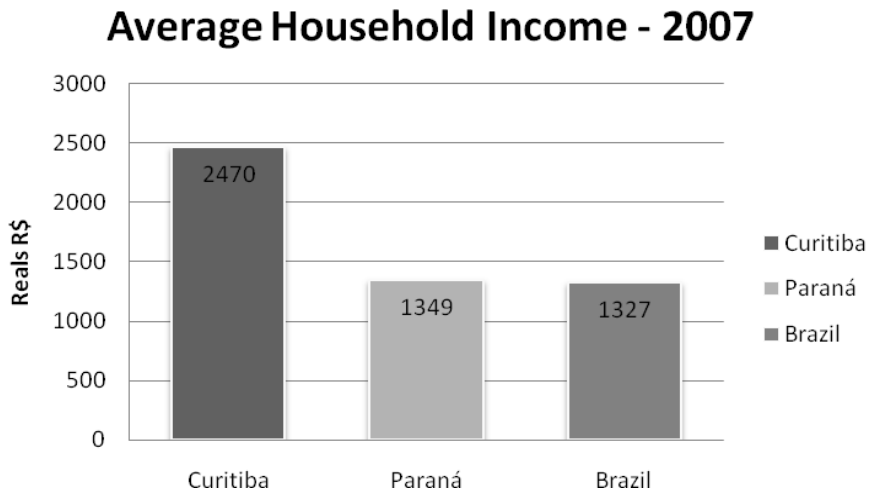
Fig. 7.8 shows that Curitiba's levels of mortality among infants are lower than those in other regions and in the nation. A potential explanation is that health units in Curitiba might either offer better services or else that they are more readily available to the public at large (see Fig. 7.9). This could also be the reflection of better hygiene, expansion of immunization campaigns and improvement in maternity and infantile health services. In any case, this is a positive indicator of quality of life and hence sustainability for the community.

Fig. 7.9 Distribution of Health Centers in Curitiba



Map created by Jorge Mata Otero, Source: IPPUC

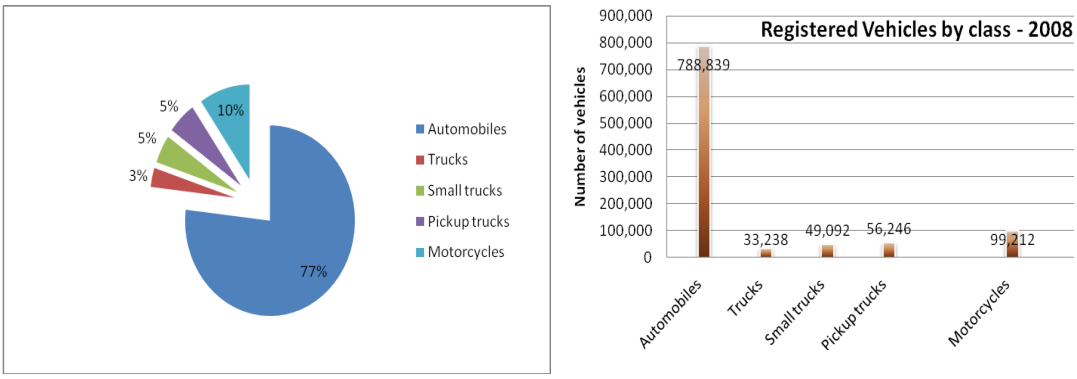
Fig. 7.10 Average Household Income comparison between Curitiba, the State of Parana and Brazil in 2007



Source: IPARDES

Fig. 7.10 shows a comparison between the average household incomes for Curitiba, the State of Parana and Brazil in year 2007. Clearly, Curitiba stands out with an average household income 86% greater than that of the national average. A higher income implies a higher accessibility to services and goods which is in parallel with sustainability goals. Also, this is a sign of the sound economy of the city reflecting higher wages than other cities in Brazil.

Figs. 7.11 Proportions and Registrations of motorized vehicles by type in 2008



Source: IPARDES

Fig. 7.11 compares the number of registered vehicles (by type) and the predominance of automobiles is obvious. Even more telling are the car ownership rates. Car ownership per capita is 0.43 while the same figure is much lower for Brazil which stands at 0.156. Even though this is an indication of the potential mobility locals have by looking at other statistics it is valuable to point out that the city's gasoline use per capita is just one third below that of eight other similar Brazilian cities, a fact which might indicate that Curitiba's residents do not rely as much on automobile for their transportation needs.

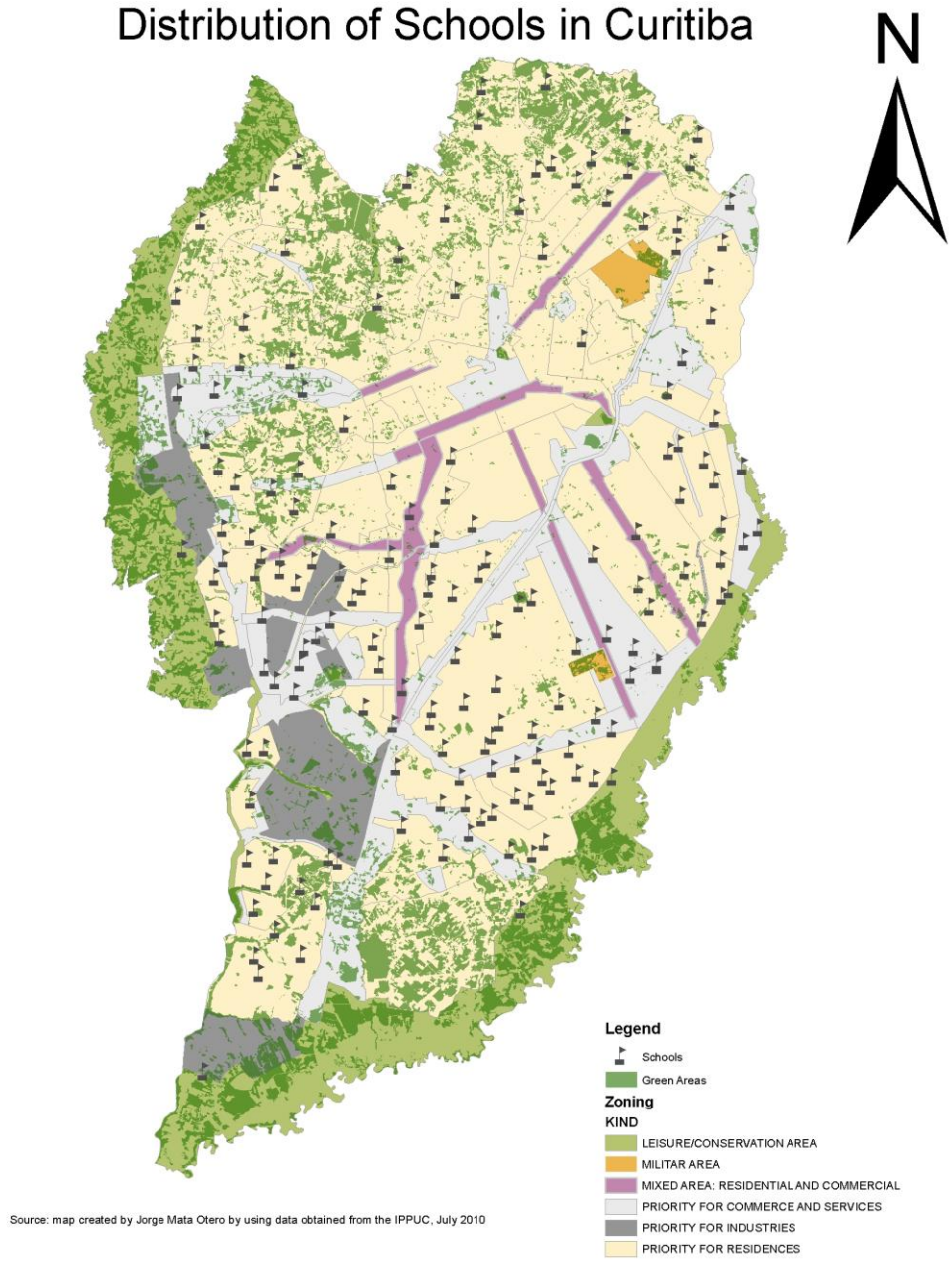
Table 7.3 Distributions of People by years of study in Curitiba, the Southern region and Brazil for years 1996 and 2000

Schooling	BRAZIL		SOUTHERN REGION		CURITIBA	
	1996 (%)	2000 (%)	1996 (%)	2000 (%)	1996 (%)	2000 (%)
Without Education or with less than 1 year	18.4	16.1	9.8	8.8	4.9	4.1
1 to 3 years	19.7	18.4	19.4	16.8	11.2	9.9
4 to 7 years	31.1	30.7	30.7	37.3	27.9	24.9
8 to 10 years	11.4	12.7	12.7	14.1	15.4	15.9
11 years or more	18.4	21.6	21.6	22.6	39.7	44.7

Source: IBGE, 2000 CENSUS

From table 7.3 it can be deduced that Curitiba has less people without schooling and a population with at least 11 years of schooling greater than the national average. Moreover, the average years of school for Curitiba's population is 8.64. Also, spatially, Curitiba seems to have plenty of schools well-spread over the city which make education accessible even to those living in the periphery (see. Fig. 7.12).

Fig. 7.12 Distribution of Schools in Curitiba



Map created by Jorge Mata Otero, Source: IPPUC

Table 7.4 Illiteracy rates in selected Brazilian cities for years 1991 and 2000

Porto Alegre		Curitiba		Sao Paulo		Recife	
1991 (%)	2000 (%)	1991 (%)	2000 (%)	1991 (%)	2000 (%)	1991 (%)	2000 (%)
4.15	3.45	5.49	3.38	14.08	4.89	25.55	10.55

Source: IBGE, 1991 AND 2000 Censuses

Illiteracy is an important indicator in that it is representative of a reduction in the capacity of people being able to have an independent life and hence limiting the individual's social, economic and political sustainability.

Regarding quality of life, dos Santos (personal communication, August 30, 2006) mentions that the city has been successful in attracting businesses and investment to the region thanks to diverse factors such as good schools, restaurants, excellent air quality, among others. He also recognizes that the transportation infrastructure and reduced congestion are factors taken into account by big companies considering moving to the area. He gives as an example Renault that made it clear that all those factors were decisive for them for installing their assembling plants in Curitiba.

Chapter 8: Sustainability Analysis of the Curitiba's BRT system

In Chapter 2 we specify several potential indicators for measuring sustainability in a transportation system. Nevertheless, only the set of principles determined during the OECD conference in 1996 seems to compile all the different sustainability aspects or measures as identified by different authors and organizations. Next, an analysis of each of the principles as they apply to the case of the Bus Rapid Transit system in Curitiba is here presented.

a. Accessibility

> Except for assessing the impact of the transportation system on special groups and for special purposes, planners and policymakers have not routinely and continuously evaluated urban [transportation] systems on the basis of accessibility. (World mobility, 2004)

In Curitiba, access to other people, goods, places and services is important to the socioeconomic well-being of the community. Paying a flat fare can take a passenger as far away as 70 kms. There is a total fleet of 1,980 buses serving 395 lines or routes. In the case of bus units, 20% of the seats are reserved or adapted for disabled people and 65% of the total fleet have special lifting systems and ramps. Similar lifting systems are available in the stations.

Regarding accessibility to services, Curitiba has the so-called citizenship streets which are located next to the transportation terminals and they provide residents with access to service providers (power and water utilities) and local, state and federal

agencies as well as leisure, education and cultural activities. Each has distinct design features and serves as urban landmarks.

b. Equity

The city's transportation system is a crucial component of the city's strong economy and contributes directly to the building of the community and advancing quality of life. The basic mobility needs of all people -including the disabled, the elderly, the poor- are met by the BRT system. Curitiba has the highest public transportation ridership of all Brazilian cities with more than 2 million passengers per day. A flat fare is used in order to benefit the poorer people –usually living in the periphery-. In this way, a short trip subsidizes a longer trip.

c. Land and Resource Use

Curitiba is making efforts to have a transportation system with the minimum physical and ecological stress, not surpassing the assimilative and regenerative capacities in the ecosystem and preserving the habitat necessities of other species. There is a high awareness of the importance of minimizing waste throughout every stage of the life-cycle of transportation vehicles and infrastructure. The size of the Curitiba's urban area is estimated at 435 sq. km which compared to the average Brazilian or Latin-American city is rather vast. This size obviously presents more challenges for land use planning and hence sustainability. Furthermore, the city has used most of the municipal territory so there is nowhere else to grow. The Metropolitan region is, for that reason, growing to

where the springs are that supply the city with water, an event that was not planned and it is not desirable (Cleon dos Santos, personal communication on August 30, 2006).

Fossil fuel consumption is the resource use of greatest concern associated with transportation considering the depletion of non-renewable resources and the resulting air emissions. The quality of fuels used in the BRT vehicles is being improved in order to reduce the impacts on health and the environment. By enhancing efficiencies and demand management, Curitiba is able to reduce non-renewable fuel consumption and similar transportation energy uses. The use of alternative fuels and renewable energy is also expanding continuously. Also, the city is registered as the Brazilian city with the lowest rates of both environmental pollution and per capita gas consumption. The ITN's environmental superiority is mainly due to the guaranteed efficient operation demonstrated by high occupancies which are reached without inducing trips that should not be otherwise made.

d. Pollution Prevention

Transportation needs must be met without the generation of emissions that have a negative effect on global climate, public health, biodiversity and interfere with ecological processes. It is important to note that, notwithstanding the good prospects that improvements in fuel efficiency and in control over emissions might represent, there should be a concern over the growth of transportation activity that can outweigh the benefits resulting from those improvements. An increase in vehicle kms traveled offset what has been achieved in terms of improved efficiency. When one visits Curitiba, one can see that the performance of public transportation vehicles, particularly buses, is close

to perfect (in terms of timing and ridership). In Brazilian and South American cities, those vehicles, mainly buses, are usually the most polluting, noisiest vehicles on the streets.

Fig. 8.1 Buses in Curitiba running on biodiesel

Source: Photo by Jorge Mata Otero

In order to improve air quality there is now a widespread use of clean fuels, such as biodiesels, on the buses. Given that Brazil is one of the main producers of soy beans and alcohol, the production and use of biodiesels is viable and at the same time generates jobs in the agricultural sector. Another measure being implemented is the regular testing of smoke in the exhaust pipes in order to improve the maintenance of diesel motors to reduce emissions of smoke and other pollutants. With the reduction of emissions of particulates, harmful ambient air levels have been reduced. In the same vein, there are frequent measurements of noises in motor, brakes and honks in order to check that

outdoor noise levels do not become health threats and serious nuisances for the locals. On top of that, the city has installed traffic radars to control speeding on the streets which potentially helps not only to reduce noise but also to reduce traffic accidents.

In a different vein, recycling has been of top interest for Curitiba. There are programs such as 'Green exchange' which has a significant social inclusion component and specifically targets the poorer living in the "favelas" or slums. In this program people bring their garbage bags to specific points where they exchange them for either bus tickets or food. By doing so, other benefits are achieved: less garbage in environmentally sensitive areas (i.e. rivers) and less diseases. Along the same lines, 'Garbage that is not garbage' is another important program that accounts for 10% of the recycled trash and more people take part. It is claimed that 1,200 trees are saved just from paper recycling under this program (though these claims are not well-documented). Notably, any funds resulting from the selling of materials are earmarked for social programs (URBS). Despite the seemingly good results that these programs have had, in chapter 7 it was concluded that there might be an overrating of the success claimed since the numbers provided by the Municipal Secretariat of Curitiba yielded much less smaller proportions of recycled garbage in the past few years.

e. Economic Well-Being

Economic policies, taxation and other market mechanisms should favor sustainable transportation by attempting a fuller cost accounting that reveals the total social, economic and environmental short and long-term costs to secure that users pay equitable costs. In the Curitiba's transportation system all external costs deriving from

transportation are internalized. Also, the restructuration of the transportation system results in the increase of employment as a major economic benefit.

On the other hand, it seems that the city is welcoming the arrival of automobile industries to the region which, on the surface, is contradictory to the city's and transportation system's goals of getting cars off the road. Cleon dos Santos's view (personal communication, August 30, 2006) is that the governor –ironically, former mayor Jaime Lerner- is the one who has brought all that industry and he considers the creation of jobs as a prime social necessity and believes that the benefits greatly outweigh any problems created by automobiles by other control means.

f. Individual and Community Responsibility

The case of Curitiba is one of a long-term sustained civic engagement shared among elected officials, business leaders and residents by which planning and policy are shaped reactively and proactively. Transportation-related decisions are made in an open and inclusive process. The locals in Curitiba are informed about any transportation alternatives and impacts and are encouraged to contribute in the decision making process in order to understand and account for the needs of different groups. Public participation there is of paramount importance and a given. Also, Curitiba and its residents have the responsibility of safeguarding the natural environment, making sustainable choices in regard to personal mobility and consumption.

Finally, Curitibanos acknowledge responsibility for sustaining the economy, the environment, human health and social well-being, with each being accountable for decisions and actions in a spirit of partnership and open cooperation.

g. Health and Safety

The design and operation of a transportation system should be in a way that the health and safety of all people are secured and quality of life in the community preserved and improved. In 1970, the city had about 1 sq. meter of green area per capita. Currently that per capita area has increased tremendously. This is an indicator that contributes directly to quality of life by helping the community alleviate respiratory and stress problems of the people using those green spaces and hence it helps to the overall health of the residents.

Fig. 8.2 Location of Forests and Parks in Curitiba in 2000

Source: Municipal Secretariat for the Environment, IPPUC, 2000

h. Integrated Planning

The achievements of the city as an international model for sustainable development are the result of strategic and integrated city planning carried out uninterrupted throughout four decades thanks to strong leadership with the imperative of turning the city into a better place to live. All of the different projects have been imbued with a strategy focused on quality of life and integrated planning. In the same vein, according to dos Santos (personal communication, August 30, 2006), transportation plans have been fundamental in securing an organized expansion of the city.

Fig. 8.3 High-density development has the critical mass of activity compatible with living without the automobile.

Source: Photos taken by Jorge Mata Otero

i. Education and Public Participation

The city is characterized for its strong interests in delivering environmental democracy by permitting the access to environmental information to the public at large. There is opportunity for consultation and meaningful public participation in transportation decision making. Such environmental awareness and education can

positively influence transportation safety and driver performance and has an impact on consumer choice of transportation mode. Curitiba's residents are completely engaged in the transportation decision making process, and encouraged to take part. They are given adequate resources and support such as equal and timely access to information on issues at hand and on the benefits and costs of the range of available alternatives.

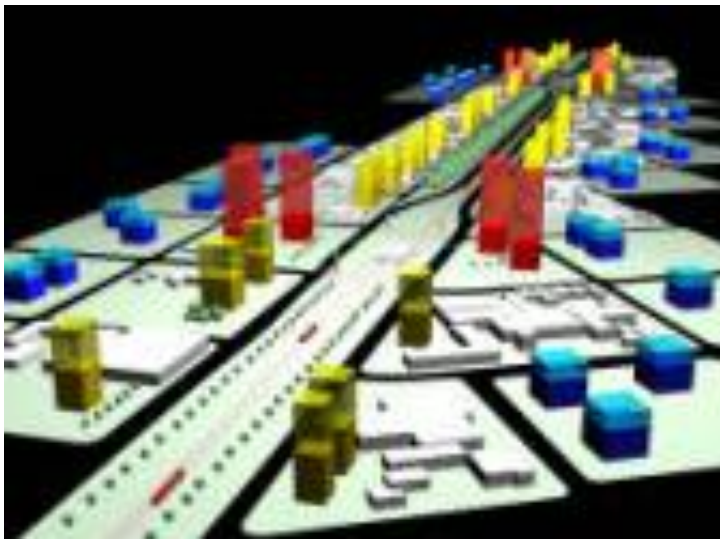
Chapter 9: What's Next for Curitiba?

Today, Curitiba is planning an investment in an urban transportation program with a total cost of US$133 millions for new projects and improvement of the existing ITN. Part of that, $80 millions to be exact, are funded by the Inter-American Development Bank.

The program consists of 4 different elements:

1) The conversion of a section of the old BR116 road into a corridor that allows the integration of the East and West zones of Curitiba. This would become the Sixth Transportation corridor for the system.
2) The expansion of the ITN capacity
3) Acquisition of buses
4) Road Safety

Fig. 9.1 Three-dimensional model of Curitiba's Sixth Corridor



Source: URBS

Generally speaking, the main objectives pursued by the program are: a) expansion of the ITN capacity b) Neighborhood integration c) improvement of access, safety and efficiency of the ITN d) Travel time reductions in the express system and in waiting time in stations/stops e) reduction in the number of road accidents and victims f) Upgrading of population's quality of life (Lindau, 2009).

At the time Cassio Taniguchi was mayor of the city, in 2002, the Green Line project was conceived and it was initially named the Metropolitan Axle. The Green Line project is the major street and public transportation transformation in Curitiba in the last 3 decades and it was started in 2007. In 2009 the Green Line BRT corridor started operating with a fleet of 18 articulated buses from which 6 buses run on pure biodiesel (B100 type) and has every component of a full BRT system. Up until now 9.4 out of the total 18 km have been completed allowing access to 20 neighborhoods. Once completed, this corridor will benefit the region in terms of mobility of people and services. An equally important benefit will be in terms of zoning given that is possible to implement mixed use development. It is important to note that around 260,000 people live within close distance of the area where the corridor will be developed. Developers such as Construtora MRV are already investing in a couple of projects that total 1,326 housing units. In the commercial sector Top Imoveis owner of Curitiba Park Office has an ongoing project that once completed will have 3 towers with 6 floors each. The Green Line has cycleways, green areas, etc. Because of this project, Curitiba recently received the Sustainable Transport Award 2010 by the Institute for Transportation and Development Policy (Prefeitura Municipal de Curitiba).

Chapter 10: Conclusions

a. Lessons Learned

The lessons from the city of Curitiba seem to be clear and applicable to other fast growing cities in developing countries. However, the success might depend on factors such as institutional strength, coordination, continuity of the political support and especially control over the allocation of land.

Traditional planning *per se* might not be sufficient to pursue sustainability goals. It is important not only to have good physical planning but also to have social objectives.

Curitiba serves as an example that it is fundamental to understand the relation between land use and transportation and how the coordination of both with a coherent urban policy is an approach towards sustainable urban development that can induce beneficial growth.

Sustainable transportation policies can not help prevent all of the problems experienced by cities in developing countries such as inadequate location of industries, squatter settlements, shantytowns, lack of infrastructure, lack of land use regulations –or lack or enforcement when they exist-, land speculations and similar urban problems that contribute to create an unsustainable milieu.

Even though it is never too late to start implementing sustainable policies, in transportation or city planning in general, the more the cities grow the more costly and

difficult the solutions become. Part of Curitiba's success is the fact that the city officials realize the need of such policies for planning and controlling growth at the right time.

Importantly, land use and transportation policies encourage connections between housing and transportation issues in planning urban and peripheral development.

Along the same lines, transportation should be seen as an integral system interconnecting housing, land use, road network, commercial development, recreational spaces and historic preservation.

Last but not least, successful urban planning requires vision, leadership and flexibility. In the case of Curitiba, a clear long-term vision, strong leadership to carry out a plan, and flexibility for making adjustments by following a step-by-step approach were key ingredients for success.

b. Replicability

When asked why the Curitiba's model has not been more intensively copied and applied to other Brazilian cities, Cleon dos Santos (personal communication, August 30, 2006) responded that Curitiba is a unique case with its own economic, geographic, social and other characteristics that prevent the model from being fully replicated. Nevertheless, he acknowledges that some of the individual projects and programs have been imitated by other cities such as the recycling programs, the creation of pedestrian ways and to some extent the BRT system.

Among the elements from the Curitiba case that can be replicated by other cities Smith and Raemaekers (1998) identify the following:

a) a central institution, particularly at the local level

b) the adoption of an integrated approach to land use and transportation planning

c) the definition of priorities

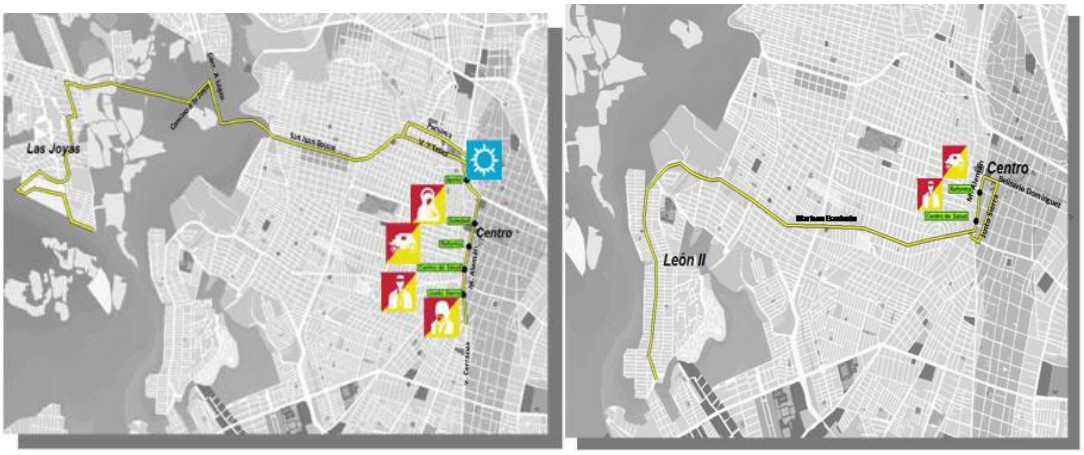
d) the recognition of the importance of design

Also, Rabinovitch (1996) thinks that following a linear urbanization pattern may not bring the same positive results as it did in Curitiba taking into account that in every city there will be different constraints and opportunities.

There are, however, attempts to copy the Curitiba's BRT system model and so currently there are bus-based rapid mass transit systems in cities in South America and other parts of the world. Leon and Mexico City in Mexico (Figs. 10.1 and 10.2) and Bogota in Colombia (Fig. 10.3) are three cities that have implemented Curitiba's BRT system. However, there is not complete agreement as to whether the systems are successful or not.

Fig. 10.1 Optibus: BRT system in Leon, Gto in Mexico

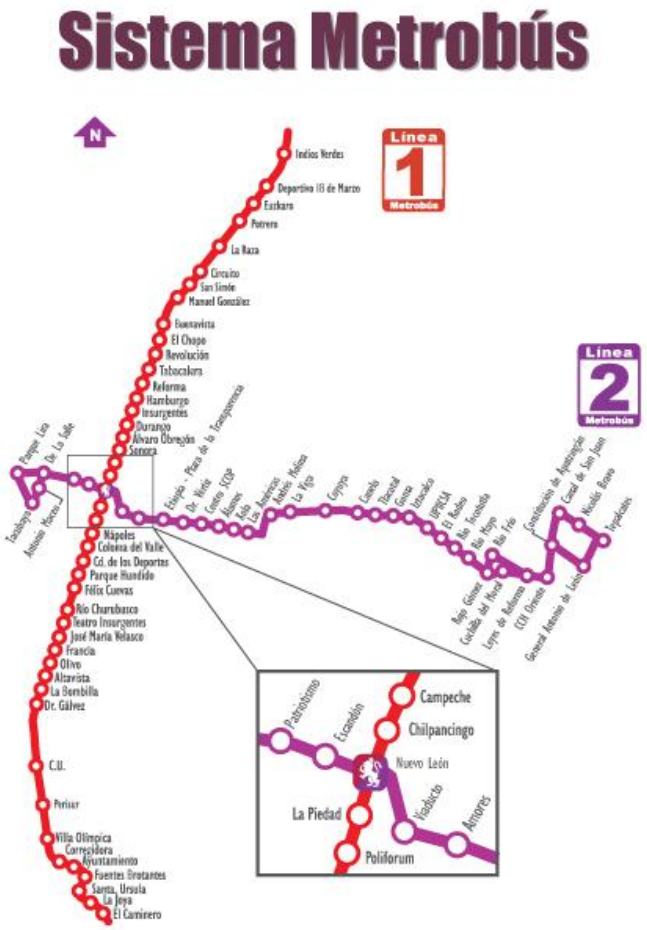
Articulated Buses Stations



Plans for 2 additional corridors currently under consideration

Source: http://www.leon.gob.mx/ciudadanos/transporte.php, Photos taken by Jorge M Otero

Fig. 10.2 Metrobus: BRT system in Mexico City, Mexico



Metrobus system map, Source: http://www.metrobus.df.gob.mx/images/mapprint.jpg

Metrobus articulated bus, Source: http://www.obrasenmiciudad.com.mx

Fig. 10.3 Transmilenio: BRT system in Bogota, Colombia

Designated right-of-ways and lanes

Source: Photo by Jorge Lascar

BRT Stations at peak times

Source: Priorizar obras de TransMilenio sobre las del Metro pide el presidente Uribe, Eltiempo.com Bogotá Accessed on July 20, 2010

Appendix A: ITN Lines Makeup

Express Lines

They operate with biarticulated vehicles in vermilion color that link the integration stations to the city center through exclusive avenues. Accessing and exiting the vehicles it is done at existing tube stations level along the route.

Feeder Lines

They use micro, regular or biarticulated vehicles, in orange color that link the integration stations with the neighborhoods.

Interneighborhoods Lines

They operate with standard and articulated vehicles, in green color, that link the different neighborhoods and stations without crossing the city center.

Direct Lines (Ligeirinhos)

They operate with standard vehicles, with stops every 3 km in average with boarding system at tube station level. These lines complement the express and interneighborhoods lines.

Troncal Lines

They operate with standard or articulated vehicles in yellow color that link the integration terminals in the city center, using shared lanes.

Conventional Lines

They operate with mini or regular buses in yellow color that link the neighborhoods with the city's center.

Central Circular

They operate with mini buses in white color -with differentiated displacements, costs and fares- that link the main attraction points in the central area.

SPECIAL LINES

Interhospitals

They link the main hospitals and laboratories in a 5 km radio from the central area.

Tourism

They depart from the central area and go through the main parks in the city. The fare is differentiated.

SITES

Integrated System of special education that serves a network of specialized schools for people with physical or mental handicaps. Currently, serves 2,100 students (from 38 special schools) per day with 43 lines.

Source: URBS

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Vita

Jorge Mata Otero was born in San Luis de la Paz, Gto, in Mexico on November 17, 1976. After completing his high school studies in 1994, he attended the Universidad de Guanajuato, and received his Bachelor of Architecture in November 2002. In the Fall of 2001, he left for Hachioji, Japan where he participated in an exchange program at Soka University supported by a scholarship from the Association of International Education, Japan (AIEJ). After returning from Japan and receiving his BArch degree, he worked as a project inspector for both the state and local governments. In the Spring of 2003 he went to Arcosanti in Mayer, Arizona where he did an internship in the Planning and Construction departments. During his seven-month stay at Arcosanti he grew increasingly interested in planning. Under the auspices of the Fulbright Scholarship program he began his graduate education in planning at the University of Texas at Austin in the Fall of 2004. He received his Master of Science in Community and Regional Planning in December 2010.

Permanent address: Jimenez 505, Col. Internado, San Luis de la Paz, Gto., Mexico, 37900

E-mail addresses: jorge_mata@mail.utexas.edu and jmataotero@yahoo.com.mx

This report was typed by Jorge Mata Otero.