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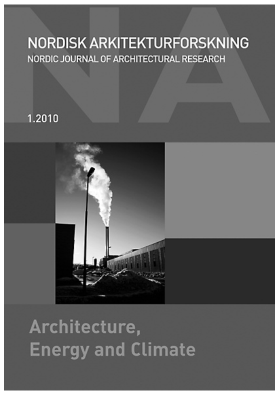

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NORDISK ARKITEKTURFORSKNING – NORDIC JOURNAL OF ARCHITECTURAL RESEARCH

Integrating Urban Design, Land Use and Transport Policies to Contribute Towards Sustainable Development.

The Bus Rapid Transit System (BRT) in Three Developing-Country Metropolises: Curitiba, Beijing and Johannesburg

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TOPIC: ARCHITECTURE, ENERGY AND CLIMATE

Abstract:

GHG (greenhouse gas) emissions can be reduced by shifting travel to a more efficient mode, which can be achieved by offering high quality public transport integrated to urban design strategies and land use policies. However, there is a scarcity of efficient and low-cost alternatives to improve urban transport and tackle GHG emissions. In this context, the development of a Bus Rapid Transit (BRT) system integrated with land use policies and urban design strategies is gaining attention as a cost-effective alternative to help addressing poor accessibility and rising GHG emissions. Firstly, this paper presents the Bus Rapid Transit (BRT) as an effective and low cost alternative to help addressing increasing traffic demands and rising GHG emissions. In the second part, a review presents the experience of three developing-country metropolises that have implemented a BRT system – Curitiba (Brazil), Beijing (China) and Johannesburg (South Africa). The review highlights empirical evidence of the development of creative solutions, which integrate transport infrastructure, land use policies and urban design strategies for fostering sustainable mobility and GHG emission reduction.

Keywords:
Urban Design, Sustainable Mobility, Bus Rapid Transit System, Curitiba, Beijing, Johannesburg.

Introduction

In 2008, for the first time in history, the majority of the world population (3.3 billion people) was living in cities. Following this trend, it is estimated that the global urban population will reach 5 billion by 2030, which will represent 60% of the world population and the majority of the new urban dwellers will be poor and living in developing cities (UNFPA, 2007). Therefore, the next few decades will see an unprecedented scale of urban growth in the developing-country cities[1], which will be depended on decisions and strategies made now in preparation for this rapid growth.

Metropolises are developing rapidly in many emerging economies, leading to huge traffic problems. In order to enhance a more sustainable development, public transport will need to demonstrate its ability to tackle the challenge of rapid growth and scarce financial resources. It is important to integrated urban design strategies to land use and transport policies to enhance a more efficient and sustainable urban environment. However, empirical evidence shows that such integration is difficult to achieve in daily practice, due to many institutional barriers and substantive differences.

The question that this paper is dealing with is: How to provide public transportation in developing-country metropolises with accelerated demographic growth and traditional absence of good governance that could enhance a more sustainable urban development while remaining affordable to local authorities?

In order to contribute in the current debate about sustainable development, this paper focuses on how the BRT system of three developing-country metropolises – Curitiba, Beijing and Johannesburg – are integrated to urban design strategies and land use policies, aiming a more sustainable urban development.

The conjunction of fast urbanization, population growth and sprawling is creating a growing demand for travel and rapidly increasing transport related GHG emissions (IPCC, 2007). Emissions from the transport sector represent the fastest growing source of GHG emissions. Of all human activities, motor vehicles produce the most intensive CO2 emissions and other toxic gases per capita, and over 25% of transportation-related GHG emissions originate from urban passenger travel. The predicted road transport growth to 2030 is driven largely by increased demand for mobility in developing countries, where growth rates are predicted to increase by 2.8% a year (IEA, 2005).

Several studies provide clear evidence that traveling by public transport – per person and per kilometer – uses less energy and causes less pollution than a similar travel by private vehicle (UNEP, 2009; Shapiro et al. 2002; Southworth, 2001). GHG emissions can be reduced by shifting travel to a more efficient mode, which can be achieved by promoting non-motorized modes and, at the same time, offering high quality public transport integrated with land use and density policies (European Environmental Agency, 2008).

Urban designers, architects, planners, traffic engineers and policy makers have been trying to address fast population growth, poor public transport infrastructure and increasing GHG emissions. There is a scarcity of efficient and low-cost alternatives to improve urban transport and tackle GHG emissions. In this context, the development of a Bus Rapid Transit (BRT) system integrated with land use and density policies, and street design that enhances accessibility, are gaining attention as a cost-effective alternative to address poor accessibility and rising GHG emissions (see Figure 01).

Firstly, this paper presents the integration between Bus Rapid Transit (BRT) and land use and density policies as an effective and low cost alternative to help addressing rising GHG emissions. In the second part, a review introduces the experience of three developing-country metropolises with different social and political contexts – Curitiba (Brazil), Beijing (China) and Johannesburg (South Africa). The review focuses on how the description of their

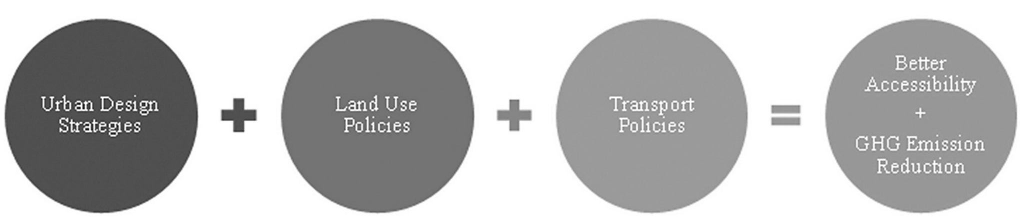

Figure 01: The integration between transport, land use, density and street design to address poor accessibility and transport energy-related GHG emissions

BRT systems and how they are integrated to urban design strategies and land use policies for fostering sustainable mobility and GHG emission reduction. Moreover, it highlights the current high complexity of transport and urban development and the kind of creative solutions implemented in these different developing-country metropolises.

Analyses were conducted through review of official documents, scientific papers, reports and newspaper articles about the BRT system and the three reviewed cities, followed by the gathering of documents during visits to the cities studied during the period between January 2007 and March 2008. Follow-up phone interviews and email exchanges were performed for information clarifications.

Bus Rapid Transit (BRT)

The innovative concept of BRT was developed in the 1970s in Curitiba, the seventh largest Brazilian metropolis. Local urban designers, city planners and engineers developed and implemented the first BRT system as a creative and low-cost solution to one of the biggest Brazilian urban challenges: increasing transport demands and lack of public funds to improve and expand transport infrastructure, especially rail systems. Last but not least, the integration between the BRT system, land use policies and urban design strategies was critical for the experience to succeed.

According to Levinson et al. (2003) and EMBARQ (2006), BRT is a recently developed mode of public transport with the potential to reduce travel time, attract new commuters and to encourage transit-oriented development (addressing private vehicle dependency). In addition, the Transit Cooperative Research Program report (2003) defines BRT as:

"a flexible, rubber-tired, rapid-transit mode that combines stations, vehicles, services, running ways and intelligent transportation system (ITS) elements into an integrated system with a strong positive identity that evokes a unique image. BRT applications are designed to be appropriate to the market they serve and their physical surroundings, and they can be incrementally implemented in a variety of environments".

The main feature of a BRT system is its dedicated bus lanes which operate separately from all other traffic modes. Therefore, BRT is operationally faster, safer, more reliable and more energy efficient than the normal bus operation. While maintaining the lower cost of a bus transit system, BRT imitates closely the punctuality, the comfort, and the safety of rail systems.

Although electrified public transport system is in fact more environmentally sustainable and rail systems have higher speed and more passenger capacity, the BRT system has some advantages: (i) lower cost related to investment and maintenance, (ii) faster planning and shorter implementation time, (iii) more flexible and adaptable design for different urban structures, (iiii) better accessibility, and (iv) usually profitable while maintaining reasonable fares for passengers.

GHG emissions and air pollution should be addressed by a comprehensive strategy and a BRT system can be part of that strategy, especially when there is integration between transport system, land use policies and urban design. Based on the Bogotá experience implementing a BRT system, Wright and Futon (2005) developed a GHG emission cost reduction scenario. In this kind of scenario the BRT system, walking and bicycling would have their shares in the transport modes used by commuters increased by 20%, 20% and 10%, respectively. It would cost US$ 370 million, and a reduction of 12,398 tons of C02 emitted in the atmosphere over 20 years would be expected. Having said that, it is important to notice that full effect on reductions of GHG emissions is quite dependant on the choice of bus engine and fuels.

Despite the fact that BRT has a shorter history than other mass rapid transit systems, it has rapidly gained popularity. In 2004, forty cities around the world had a BRT system operating and more than eighty cities were planning to implement a BRT system (WBCSD, 2004).

Finally, BRT should neither be a singular solution nor the universal answer for urban transportation problems, but it can be part of the solution. In a metropolitan area, integration of various transport modes is required at different levels and a BRT system could be part of an integrated transport system – bus based systems and track bound systems can work more efficiently when complementing each other. Integration is the key to a more sustainable mobility and responsive public transport.

Towards Sustainable Development in the Contemporary Metropolis: Strategies to Integrate Urban Design, Land Use and Transport Policies

The second part of this paper introduces three developing-country metropolises that implemented a BRT system – Curitiba (Brazil), Beijing (China) and Johannesburg (South Africa). The review presents how these metropolises have been searching for solutions to integrate transport strategies, land use policies and urban design strategies for fostering sustainable mobility while reducing GHG emission. In scenarios of high complexity, the review highlights creative solutions to address increasing transport demands, lack of funding, rising GHG emission and escalating air pollution.

Curitiba, Beijing and Johannesburg are located in developing countries which are the most economic power of their continents. Currently, the three metropolises share also the experience of fast urbanization and intense pressure for infrastructure. At the same time, Curitiba, Beijing and Johannesburg have very diverse urban structure and socio-economic, political and cultural characteristics.

It is rewarding and fruitful to compare how these three developing-country metropolises – with their similarities and differences – have integrated urban design and land use policies to their BRT systems as part of their strategies to achieve a more sustainable urban development.

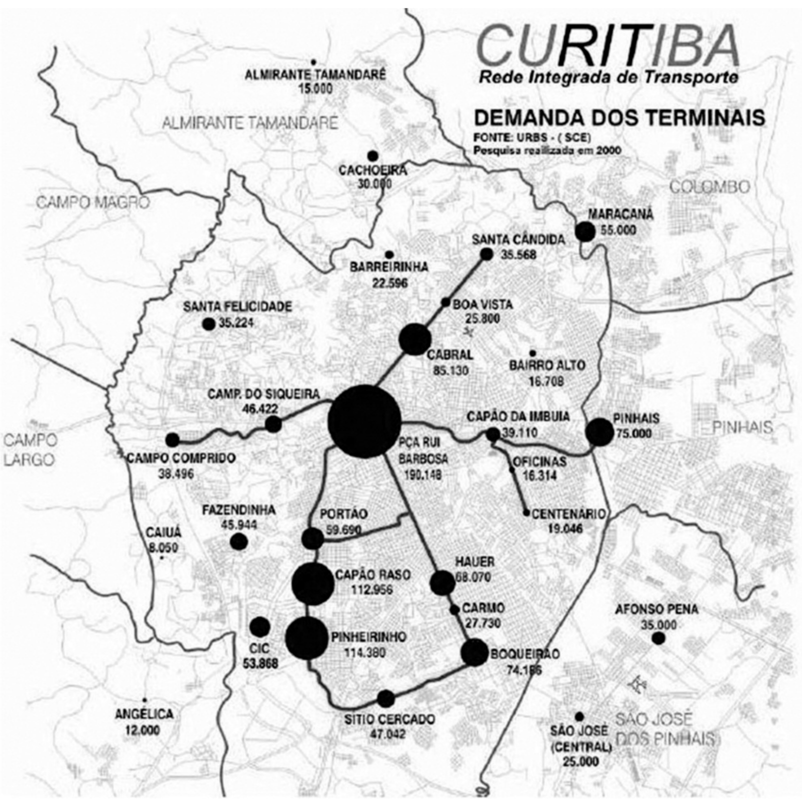

Figure 02: Curitiba BRT corridors and main stations with their volume of passengers per day (Source: Prefeitura de Curitiba)

Finally, Curitiba, Beijing and Johannesburg – in different ways and different extends – have implemented BRT systems and have been searching for creative solutions to enhance sustainable urban development through the integration of urban design strategies and land use and transport policies.

Curitiba, Brazil

Curitiba has the largest economy in Southern Brazil, and it is the seventh largest Brazilian metropolis. Curitiba municipality has approximately 1.8 million inhabitants and its metropolitan area over 3.5 million. Currently, it is the fastest growing metropolis in Brazil, and it has been facing an explosive urban growth since 1950 (IBGE, 2008). Regarding sustainable development, Curitiba has attracted worldwide attention for remarkable accomplishments with limited resources. Curitiba won the 1996 World Habitat Award for its accomplishment of how a fast growing developing-country metropolis could successfully integrate land use and transport planning for fostering sustainable development.

In 1965, Curitiba developed a new Master Plan that included effective measures to control sprawling through the integration of public transportation into all the other elements of the urban structure. Curitiba was a traditional monocentric spatial structure, but the new Master Plan concentrated growth in five main corridors (structural axes), where zoning and land use policies promoted high density mix-use development. At the same time, subway lines were planned to be implemented through these five corridors. But the lack of funding for a subway system meant that a more creative and low-cost solution was required. Nine years later, the first BRT system in the world was created: the median lanes from the main axes became dedicated lanes for buses, which were physically separated from the lateral service roads (Goodman et al., 2006).

Figure 02 shows the current Curitiba BRT system, which has 25 bus transfer terminals and 65 km of dedicated bus median lanes, divided into five main corridors – South Axis, North

Axis, East Axis, West Axis and Boqueirão Axis (Meirelles, 2000; ITDP, 2007). Curitiba's BRT consists of a hierarchical system of services. Minibuses routed through residential neighborhoods feed passengers to conventional buses that feed passengers to the BRT stations located at the five main corridors – the backbone of the system – where the Bus Rapid Transit operates through dedicated lanes.

Moreover, an innovative design was created for the bus stations in order to boost the image of the system. Considered a unique design in the 1970s, the cylindrical, clear-walled tube stations (made of glass and steel) are well known among local residents and other Brazilians, and they became one of the most representative images of Curitiba (see Figure 03). The tube station design allows loading and unloading at bus floor level, providing a simple and creative means of speeding up operations.

The main purpose of an BRT station is to bolster connectivity among the BRT system itself, its customers, and other forms of public transportation. BRT stations and their components represent the public face of BRT and their design need special attention. The design of a BRT station can influence how individuals perceive the BRT service and public transportation systems in general. Moreover, a BRT station is also an opportunity to design waiting areas such that their identity is distinguished from other modes of transportation.

In addition, while it is advised to establish a well-defined, consistent identity for BRT, it is important that BRT stations correspond to the larger urban fabric. The integration of BRT into the urban realm can initiate the opportunity to enhance the streetscape and public life.

Curitiba's Master Plan defines a land-use control that encourages development of the highest population densities along the five main corridors; high-rise buildings were limited to a four-block strip on either side of them. The high density and pedestrian-oriented development along the main corridors generate a large number of commuters, contributing to the BRT success (see Figure 04). Moreover, the land use policy discourages auto-oriented centers and channel new retail growth in these corridors (Goodman et al., 2006).

According to Goodman et al (2006), the efficiency of Curitiba BRT has become the incentive for a modal shift from private automobile travel to bus travel. It is estimated that the introduction of the BRT had caused a reduction of about 27 million private motorized trips per year, saving about 27 million liters of fuel annually. Over 70 percent of Curitiba`s commuters use public transportation in their daily journeys, and Curitiba uses 30 percent less fuel per capita than other Brazilian metropolises.

The Curitiba BRT system has also democratized the Brazilian transport system through the provision of a high quality public transport at relatively low-cost, working with a one-fare system regardless of the distance traveled. As a result, the average commuter only spends about 10% of his/her personal income on transport (Birk and Zegras, 1993). According to Wright (2001), an integrated, one-fare system

Figure 03: Campo Comprido Station, Curitiba BRT

Figure 04:
Curitiba BRT corridor with dedicated bus median lanes and high density along the corridor.

does not only simplify customer understanding of the system, but it also addresses social inequalities. In the Brazilian cities, most of the low-income population lives in the periphery and thus is often disadvantaged by relatively high travel costs to reach central areas.

Beijing, China

During the last three decades, economic growth and massive rural migration has led to a sharp increase in travel demands and car ownership in Beijing. The vehicle population in Beijing has increased at an annual rate of 14.4% since 1990 and it exceeded 2.8 million in 2006 (Liu 2006). Therefore, Beijing is facing heavy traffic jams, while the average speed of traffic is lower than 12 km per hour. Many Chinese metropolises are facing similar scenarios (U.S. Department of Transportation, 2006).

Prior to the 2008 Olympic Games, Beijing municipality and the National government were forced to address air pollution, GHG emissions and precarious public transport infrastructure. In 2004, Beijing developed a new Master Plan (2004-2020) that prioritizes a more sustainable development, which integrates land use, density and transport policies.

In accordance with the new Master Plan, the subway system was expanded and a BRT corridor implemented. These investments aimed at addressing critical urban problems facing Beijing: (i) lack of integration between land use and transportation infrastructure, (ii) growing traffic demands, (iii) increasing GHG emissions, and (iv) air pollution worsening (U.S. Department of Transportation, 2006).

In 2004, the first Beijing BRT line was inaugurated in Beijing. The BRT line 1 runs along the southern axis from Qianmen, where the subway line 8 was originally planned. Budget constraints were a critical factor that directly influenced the decision of local authorities to develop a BRT line instead of a subway line. The government was pushed to choose a creative, low-cost alternative to its subway line 8, and the BRT system was chosen. Currently, the BRT system has three lines: Line 2 and 3 were inaugurated in 2008 (see Figure 05).

Beijing BRT is 34,5km long, services 60 stations and transports up to 160.000 passengers per day (BFChina, 2009). Although local authorities announced the implementation of two other corridors in 2008, these corridors never had the BRT features. Beijing BRT is considered a supplement and feeder to the rail system, expanding the rail network system coverage (Zhenjiang 2004). In order to improve the integration between subway and BRT systems, the major BRT stations are located near subway stations.

In 2001, Beijing also established the Urban Design Department as part of the Beijing Municipal Institute of City Planning and Design. The office work is focused on the planning and research of the city's key areas and it aims at developing solutions to improve connectivity around BRT stations (BMICPD, 2009). However, the design to improve the connection between BRT stations and subway stations is non-existing. Figure 07 illustrates the precarious conditions of one of the accesses to a BRT station.

The 17- km-long Chinese BRT system built in Beijing for the 2008 Olympics took 16 months to complete from conceptualization to implementation (BFChina, 2009). As opposed to Curitiba, the development of Beijing BRT was led by a top- down process. The lack of involvement of stakeholders as well as the rapid planning - and implementation process have caused several problems.

Despite the existence of a comprehensive Master Plan and several urban infrastructure investments, modern Beijing is still far from the idealized urban environment, visualized by its Master Plan. Among several variables, Beijing`s future will also depend on how the Master Plan will be respected.

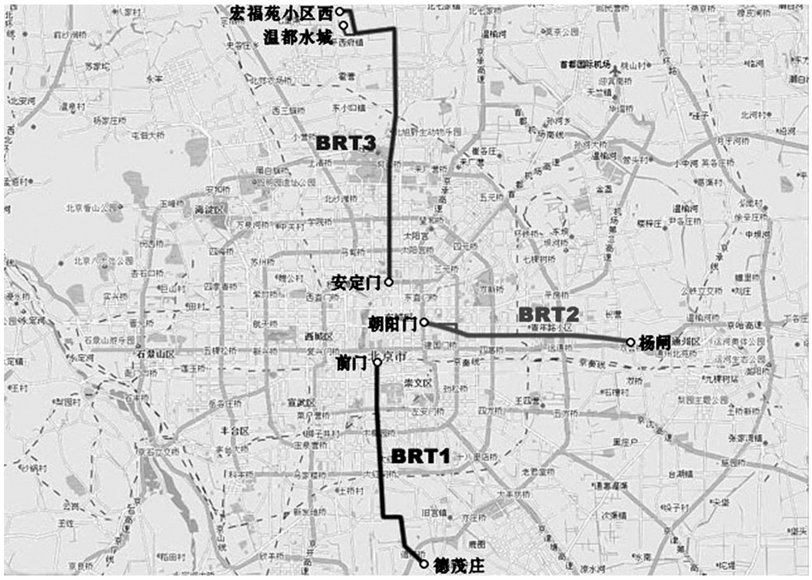

Figure 05:
Beijing BRT lines
(Source: BMICPD)

Johannesburg, South Africa

In 2010, South Africa will become the first African nation to host the FIFA World Cup; this has worked as a catalyst to accelerate strategic infrastructure investments, including public transport improvements. Focusing on the World Cup host cities, the National Department of Transport developed the 2010 Transport Action Plan, which defines several infrastructure investments, where the BRT system is a key component. Through a partnership between the National Department of Transport and local authorities, BRT systems are currently being implemented in the five largest South African metropolises – Johannesburg, Cape Town, Pretoria, Port Elizabeth and Mangaung.

Johannesburg is the largest city in South Africa with a population of 3,888,180 inhabitants, while 7,151,447 people live in the Johannesburg Metropolitan Area. Johannesburg is also the economic and financial hub of South Africa, producing 16% of South Africa's GDP (City of Johannesburg, 2009a). The Johannesburg BRT system is known as Rea Vaya BRT, which means "we are moving" in the native language Sotho. The Rea Vaya BRT is the single biggest component in Johannesburg's transport strategy, and it is the core component of the strategy of the National Department of Transport. As venue for the opening ceremony and for the finals, Johannesburg plays a key role in the FIFA World Cup event. The National government considers the Rea Vaya as one of the flagship projects for the World Cup (South African Minister of Transport, 2008).

On August the 30th, 2009, Rea Vaya BRT opened its phase 1a, which links downtown Johannesburg to its largest suburb, Soweto. It comprises 25 kilometers of segregated bus corridors with 27 stations, and 69,000 passengers are expected to ride the system daily by December 2009. Totaling 63 kilometers, the phase 1b will open in time for the 2010 FIFA Soccer World Cup. Finally, the full phase 1 is expected to be inaugurated in 2013, and it will expand the system to 122 kilometers of dedicated bus lanes and 150 stations; local authorities expect 434,000 passengers using the system per day (Rea Vaya, 2009).

Rea Vaya BRT system has dedicated bus mobility in specially designed routes, with designated stops at key mobility points across the trunk routes. The largest buses, with a capacity of up

Figure 06:
Beijing BRT bus and station, near Puhuangyu.

Figure 07:
BRT station access

to 112 passengers, only travel on the designated median lane trunk routes, while complementary buses feed commuters into the trunk routes.

An innovative design has been developed for the system, including the Rea Vaya logo, stations and buses. The station design was put together through a comprehensive public participation process, to which many different stakeholders and interest groups contributed. Moreover, every Rea Vaya BRT station will have a unique artwork sandblasted on both sides of their entrances (see Figure 10). In a context of social polarization and urban violence, public art promotes urban regeneration, and it can assist in creating more attractive public spaces for all groups.

Figure 08:
Rea Vaya BRT station in Johannesburg CBD (Source: Rea Vaya)

Regarding sustainable development, the Rea Vaya BRT is the single largest climate-changing initiative ever undertaken by Johannesburg; therefore, it represents a major turning point in how Johannesburg addresses traffic demands, air pollution and transport energy-related GHG emissions. Promoting the Rea Vaya BRT as an alternative form of public transport, local authorities expect to persuade private car drivers to change their mode of transport and ultimately alleviate congestion in and around Johannesburg.

In this context, Johannesburg conducted an extensive study to determine the impacts which the Rea Vaya BRT will have on GHG emissions. It is expected that 15% of car users living near downtown will switch to the Rea Vaya BRT by December 2009, saving 382 940 tons of CO2 by 2010 and 1.6 million tons by 2020.

Johannesburg has also been integrating its transport and land use policy. The Regional Spatial Development Framework (RSDF) is an official plan compiled by the City of Johannesburg, having the force of law, which sets out guidelines that must be followed by the Municipality in relation to zoning and land-use applications. The RSDF aims to arrange land use and infrastructure associated with the needs of specific communities within Johannesburg. The RSDF was amended in order to integrate the land use policy with the Rea Vaya BRT infrastructure, ensuring higher densities and mixed use along Rea Vaya BRT routes (City of Johannesburg, 2009b).

Through a Bonus system, the RSDF also encourages more public transit-suited urban design, improving public realms which are inclusive spaces. Furthering better life quality and higher numbers of commuters public spaces are important, because they accommodate pedestrians, who are the commuters using public transit. Pedestrian-friendly neighborhoods and high connectivity are critical elements in supporting a BRT system and creating a more vibrant environment around stations. Especially in the South African cities, where there is still strong racial segregation and a gap between socio-economic groups of the population, public spaces can play a key role in building up social relations through repeated contact among inhabitants in multiple overlapping roles and relationships. In bringing inhabitants together, the public realm contributes to a more democratic way of life and encourages everybody to share observations and perspectives.

Rea Vaya BRT has recently been inaugurated, and several policies supporting a more sustainable development in Johannesburg exist. However, governability and public participation should be carefully addressed in order to ensure continuity to this process and assure a more sustainable future for Johannesburg.

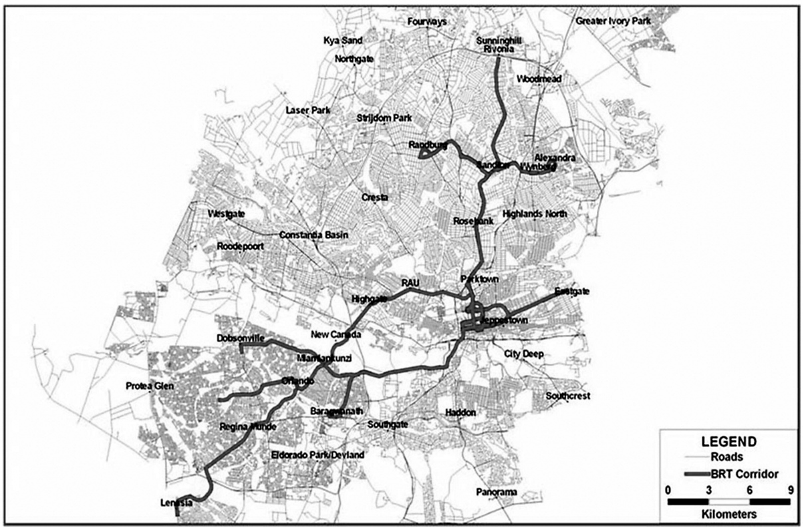

Figure 09:
Rea Vaya, full phase 1, indicating trunk, complementary and feeder services (Source: Rea Vaya)

Conclusion

The paper highlights innovative and low-cost alternatives to address transport energy-related GHG emissions and, at the same time, improve accessibility and quality of urban space. Representing developing-country metropolises, Curitiba, Beijing and Johannesburg have been searching for strategies to provide a more sustainable development.

Currently, developing countries do not have obligations to mitigate GHG emission. However, they have several opportunities to contribute to the reduction of GHG emission. Investments in a transport sector more integrated to land use policies and street design strategies have the potential to improve accessibility, reduce GHG emissions and introduce mechanisms that provide paths to social and economic development as well as to environmental protection.

The experiences of Curitiba, Beijing and Johannesburg highlight the need to rethink urban design strategies and land use policies in relation to transport policies and the need for strong political leadership to spearhead changes. The three metropolises visited provided examples of BRT systems that are, in different extensions, integrated into urban design strategies, land use patterns and the transport network. The particulars of each case – related to socio-economics, culture and urban structure – are reflected in the design solutions.

BRT is a low-cost alternative to help addressing increased traffic demands, and it has been implemented in several cities around the world. However, the quality and performance of these new systems will ultimately depend upon how they are integrated with land use policies and the rest of the transport systems, and how they address local demands and particulars. And reductions in GHG emissions are also dependent on the choice of bus engines and fuels.

Moreover, every mass transit technology has its own strengths and weaknesses. Urban designers, architects, traffic engineers and policy makers have to carefully select a proper alternative, or a combination of them that best fit local conditions.

Finally, BRT should neither be a singular solution nor the universal answer for urban transport problems, but it can be part of the solution. In a metropolitan area, integration of various transport modes is required at different levels and a BRT system could be part of a

Figure 10:
Art work at Rea Vaya Station (Source: Rea Vaya)

transport network system. For instance, bus based systems and track bound systems could work more efficiently when complementing each other. Integration is the key to a more sustainable mobility and responsive public transport.

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NOTES

[1] Although both developed and developing countries have been experiencing an increase in urban population, the rates of change between them vary greatly. According to WUP (2005), the urban population in developing countries is estimated to increase annually at 2.20% between 2005 and 2030, while in developed countries is estimated to increase at only 0.47% per year (UNFPA, 2007).

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