Can Cities Reduce Global Warming?

Urban Development and the Carbon Cycle in Latin America

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ISBN 970-31-0466-5

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Layout by Héctor López Villafranco, Matías Collado.

Design by Héctor López Villafranco.

Cover Photos: Héctor López Villafranco; *Montañas (Andes)* and *Rio Contaminado (Cd. Cardel).* Canadian Goverment www.for.gov.bc.ca april 2005; *Factory and Fire in the woods.*

Printed by: Estirpe, concepto e imagen, Lucas Alamán núm. 30, segundo piso, col. Obrera, 55888033, estirpe@prodigy.net.mx

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Cite this document as:
Romero Lankao et al. 2005. Can Cities Reduce Global Warming? Urban Development and Carbon Cycle in Latin America. México, IAI, UAM-X, IHDP, GCP. 92 pp.

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Primera Edición Abril 2004
ISBN 970-31-0466-5

Universidad Autónoma Metropolitana Xochimilco Universidad Autónoma
Metropolitana Xochimilco
Calzada del Hueso 1100
Col. Villa Quietud
C.P. 04960
México, D.F.

Impreso y hecho en México/Printed and made in Mexico

Preface

"Can Cities Reduce Global Warming? Urban development and the carbon cycle in Latin America"is a first phase of a longer-term networking and research effort, it has taken one year and involved the participation of investigators and students from the Metropolitan Autonomous University (UAM-Xochimilco) in Mexico, the University of Chile, and the Universities of Mendoza and *del CEMA* in Argentina.

This research report is a first step of a long-time effort aimed at establishing a well-coordinated set of case studies on urban development and the carbon cycle in the Americas. A two-fold purpose lies behind this endeavor. We intend firstly to further develop two research priorities identified by the Global Carbon Project (GCP): understanding the consequences of different pathways of urban development on the carbon cycle, and identifying points of management and intervention aimed at designing less-carbon intensive development pathways. We seek secondly to integrate those studies with the ones underway within other programs and institutional umbrellas, namely: "Urbanization, emissions and the global carbon cycle" sponsored by System for Analysis Research (START) and Training, National Center for Atmospheric Research (NCAR), GCP, and the Packard Foundation, and "Integrating Carbon into Developing Strategies of Cities - Establishing a Network of Case Studies of Urbanization in Asia-Pacific", financed by the Asia-Pacific Network for Global Change Research (APN).

This report has been possible thanks to the generous sponsorship and endorsement of diverse institutions: Inter American Institute for Global Environmental Change (CGP II-030), Human Dimensions Program on Global Environmental Change (IHDP), Global Carbon Project (GCP), and the Metropolitan Autonomous University-Xochimilco (UAM-X).

We hope that this document helps promote and encourage research on the relationships between cities and carbon, not only in the Americas, but also all around the world.

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I. Introduction

Patricia Romero Lankao

Analysts studying large cities have developed two sets of optics relevant for the purposes of this study. First, there are those who have examined the relationships between both local and global socioeconomic and institutional processes. For example scholars focusing on the role of large urban areas within the global economy (i.e. their weight as production, financing or control centers, see Sassen 2000), and stating that patterns of regional economic integration, and industrial and financial decision making are increasingly determined by transnational corporations and international organizations (Aguilar and Ward 2003).

To this group belong researchers analyzing the current urban transition sweeping around the world and defined by diverse features. The unprecedented and rapid pace of urbanization is happening more quickly in countries having relatively lower levels of per capita income, in some of which urban growth seems to have become partially decoupled from economic growth. Nature and direction of urbanization are increasingly driven by the global economy. Urban and rural lifestyles are converging in new settlement systems that are not easily captured by a simple urban/rural dichotomy. And urbanization is happening under a qualitatively different set of demographic regimes (Cohen 2004).

Those specialists concur to state that notwithstanding urbanization shares commonalities all around the world, and it is driven by forces like globalization, democratization, and decentralization, there are differences in the pathways of urbanization between countries, regions and cities. Concentration of national population in urban centers is for instance impressive in Latin America, where urban population has grown around 3.5 % per annum during 1950-2000, and urban areas have risen from 42% in 1950 to 75% in 2000. Patterns of urban development in the region have generated a high degree of urban primacy with a remarkably large percentage of the population living in large cities: "32% compared with 15% for Asia or 13% for Africa" (Cohen 2004: 40).

There are secondly those scholars more interested in issues such as urban sustainable-development, clean energy and CO2 emissions control. Most of this carbon-related literature considers national or sector-level analysis, for example estimating net carbon balances from fossil fuel use or land-use changes. It also examines the impacts of climate change on specific sectors, such as agriculture and forest, energy or industry. It studies the relationships between GHG emissions and aggregate measures of economic growth, technology and population (Richards 1990, Greening et al 1999, Lukkanen and Kaivo-oja 2002, Kaneko and Matsouka 2003. There are finally studies analyzing the magnitudes and trajectories of urban changes in greenhouse emissions, their sources, the forces driving those emissions trajectories and the local capabilities to manage them (AAGGCLPG 2003).

This research report will draw from the approaches and tools from both sets of expertise to develop a new line of inquiry and look at the interactions between both local and global socioeconomic and institutional processes and the carbon cycle in three Latin American cities. For example, how do specific pathways of urban development interact to influence land and energy use? How do different mixes of forces or underlying factors (e.g. economic and socio-demographic dynamics, liberalization, deregulation, and urban policies) operate at different scales to produce cities' greenhouse gases (GHG) emissions trajectories? If fuel consumption and land-use changes are the most important sources of cities' impacts in the carbon cycle, what is then the pattern of causation, and what are the feedbacks with underlying factors?

Why did we select Buenos Aires, Mendoza, Mexico and Santiago? The query regarding how do specific pathways of urban development interact to influence land and energy use in cities would benefit from both the characterization of global tendencies underlying urban pathways of development everywhere and the differences of each case study. Such cases could work as a basis for developing a research protocol for use in other case studies, which should be based at universities whose faculty possessed detailed and if possible long-term knowledge of their cities.

We assume that, notwithstanding selected cities share some features with other urban areas in Latin America, Asia and the world, their diverse trajectories of GHG emissions could illustrate the ways emissions vary over time in response to the different combination of processes, e.g. Population change and technological innovations.

1. Analytic tools and methodology

To explore the linkages between activities emitting GHG and their drivers we apply a system approach (namely underlying driving forces/direct causes model[1]) and use the notion of urban development, which allows for an analysis of the context-specific articulation of those drivers.

Scale is crucial to the purposes of this research. Human induced changes in the carbon cycle arise from interactions between different domains of carbon and society, each composed of many systems operating at different scales in space and through time resulting in mismatches in scale between causes and consequences. E.g. much of city's production and consumption enabled by affluence takes place in households and factories, whereas the technologies most related to carbon and climate change operate over larger areas. Contrary to current research focusing on top down approaches, case studies such as the ones we present here “should constitute natural experiments carefully chosen for comparability and investigated by using a common study protocol” (Kates and Wilbanks 2003: 4).

Methodologically the team intended to design and test a common protocol for comparative research at local city scale that incorporates the dynamics of human activities emitting GHG, their drivers and the management potentials to alter GHG emissions. The protocol included following activities.

☞ For each city existing estimations of GHG emissions were gathered. We kept in mind that the major emitters relate to fossil fuel consumption and production (manufacturing, electricity generation, transportation, and household heating); to forestry and agriculture (livestock, wetlands, fertilization, land clearing, and timber production); to waste disposal (landfills and incineration); and to the manufacturing and use of ozone-depleting substances. Trace GHG resulting from these activities are carbon dioxide, methane, nitrous oxide, and ozone depleting chemicals. Nevertheless it was not always possible to gather data for all sectors, and in cases such as Santiago to get city-scale information at all.

We were aware of the fact that estimations are confronted to conceptual difficulties. Some releases take place at the points of final consumption (e.g. burning of fossil fuels). Other emissions are separated in space or time from the point of final consumption that causes the emissions (e.g. electric power plant emissions or fossil fuels production and transformation). Emissions from electric power production are apportioned among the diverse activity groups (e.g. manufacturing, transportation, and residential sectors). Similarly transportation emissions should be disaggregated in three vehicle types: household passenger vehicles, commercial-industrial cars and trucks and public transport.

For this stage of the project it was almost impossible to allocate emissions to both their points of production and consumption, or to different emission groups within a sector. We know though that such accounting yields trenchant explanatory power and has critical policy implications. For instance allocating emissions only to end-consumers obscures the role of firms in the production of GHG. Allocating emissions solely to points or areas of production downplays the impacts of consumption.

☞ We examined emissions patterns to understand the forces that drive human activities releasing GHG, assuming that GHG emissions result from the articulation of four drivers (technology, population, affluence and institutional settings), and used the notion of pathways of urban development as an articulator.

[1] According to Geist and Lambing (2001) “at least two major pathways of explanation have emerged to explain patterns of causation“ in the analysis of issues of sustainable development: „single factor causation versus irreducible complexity”. The underlying driving forces / direct causes model belongs to the second pathway.

☞ As of intermediate driving forces, most of the drivers that are commonly identified (population growth, technological dynamics) are regulated by other social processes (consumer-market demand, regulation, energy supply and price, economic organization and social organization), interweaved within an essential structure, in our cases the pathways of urban development. These drivers work as stronger links, given their influence on local economic development, associated increases in the number of households, technologies in use, and the resulting GHG releases.

☞ We assumed that case studies help identify key processes of change, but that diverse caveats should be kept in mind when working on each city. Features of particular places seem to shape the local outcomes of processes operating at larger geographical scales rather than altering those processes themselves. Effective control (agency) often resides outside cities, in national and international business strategies, facility investment options, fuel choices, technologies in use, and pollution control regulations. Relocation strategies of big corporations are for instance a key driver for the current, region-based pathway of urbanization in Mexico City and Buenos Aires. Even for cities explanations are complex. The drivers of GHG emissions can not be reduced to "a discrete, limited set of autonomous variables, such as population growth or increasing affluence" (Wilbanks and Kates 2003: 169). Those variables are themselves intermediates, with their own variables that are determined by multiple processes operating at different scales.

2. Notions of city

One of the problems facing researches when dealing with cities is the measurement of urban itself. There is not unique approach to define an urban area, notwithstanding the world is becoming more and more urban or precisely because cities are constantly changing over time and space. Mexico City for instance included the core area during the 1930s, grew into the intermediate ring and the suburban built area during the import substitution industrialization (ISI) period, and currently corresponds to the central city, the suburban area and both the whole built up area and the rural hinterland and satellite centers functionally linked to the core (Aguilar and Ward 2003: 7 and Map 1).

Some scholars and policy makers define urban people as those living within certain administrative boundaries (e.g. wards, municipalities). Others use criteria such as population size and density to define urban, though the boundaries between urban and rural become so arbitrary and culturally determined, that those criteria differ between countries. Yet others delimit urban based on a combination of population size and density as well as other socioeconomic indicators. "In Botswana, for example, an agglomeration of 5,000 and more where 75% of the economic activity is nonagricultural would be considered urban. For Cuba, places with 2,000 inhabitants would automatically be considered urban" (Cohen 2004: 25).

In our study we will assume that our cities have constantly changed in space and time. We are aware of the fact that each city has experienced diverse patterns of urban growth, but have tried at the same time to establish features common to all cities. We will try to make explicit the criteria used in each city to define urban both by the agencies producing urban data and by each national team.

3. Difficulties confronting the team

One of the main problems facing the team when studying city-carbon linkages in Latin American cities relates to data. Some cities lack information for the locality in question or for the time period we were analyzing: the last twenty years. That was the case of GHG inventories. When available they did not go very far back in time, but only a couple of years and even one year. We decided not to discard such indicators, because we know that only recently have countries or cities begun to accumulate databases on carbon related issues. We were confronted in other cases to politically potent or sensitive information, or to information a private entity only would make available if we paid a good amount of money for it. In other cases information was available, but inconsistent. Latter was the example of records on vehicle fleet size and composition in Mexico City, which lacks a

Metropolitan registration system and coordination among state authorities involved in its management.

A second problem confronting the team refers to the fact that most management strategies in those cities explicitly target air quality and not GHG emissions with the exception of Mexico City and Mendoza. Therefore much information was on air pollution. Furthermore, the management of GHG emissions is a complex process. This means that carbon related policies comprise not only environment, but also transportation, land use and even policies targeting energy. When possible the team targeted all this areas and tried to see their carbon implications.

II. Mexico City

Patricia Romero Lankao, Angélica Rosas Huerta, Héctor López Villafranco, Griselda Günther and Zaira Correa Armenta

1. Development, society, landscape

Mexico City (19°25'N Latitude and 99°10' W Longitude) stretches over a plateau at an altitude of 2,200 meters above sea level, surrounded by a ring of mostly extinct volcanoes, two of which (Popocatépetl and Iztaccíhuatl) reach elevations of over 5 thousand meters above see level. The city is situated in the Basin of Mexico, a naturally closed depression located in the central region (CR) of the country, with an average annual temperature of 15 degrees Celsius and an average annual rain of between 600 and 1200 mm (Map II.1) concentrated along the months of May-October. The city experiences ozone formation both during the winter and the summer, as it is located at a subtropical latitude and a high altitude.

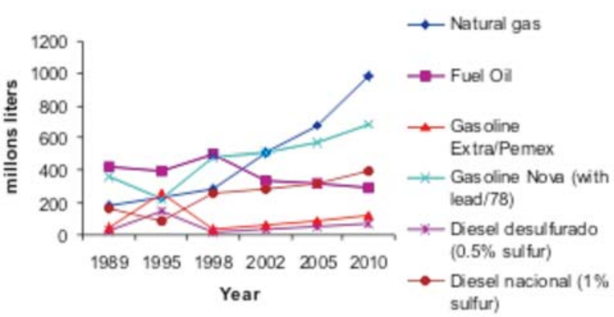
During the dry season, the basin is under the influence of high pressure or anticyclone systems characterized by light winds and cloudless skies, which lead to the creation of inversions at night and during the first hours of the morning. "Strong solar heating of the ground generates turbulent mixing that erodes these inversions in the morning producing deep boundary layers during the afternoon. Pollutants initially trapped below the inversion layer are then mixed within the convective boundary layer, which can reach altitudes as high as four km above the ground" (Molina et al 2002: 34). Such features let explain why GHG and other pollutants remain trapped within the Basin of Mexico.

Mexico City has considerably changed over the second half of the 20th Century. It went from almost three million inhabitants in 1950 to 18.2 million in 2000. The urbanized area increased 527%, from 785.4km2 in 1950 to 4,925 km^2 in the 1990s (SMA et al. 2001). Before 1950 the built-up area of Mexico City was within the territory of the Federal District (FD), but since then the area has expanded beyond those limits. Therefore Mexico City corresponded with the inner city or core area (four central delegated units within the FD) in the 1950s, the Metropolitan Zone of Mexico City (including the FD and 17 conurbated municipalities) in the 1980s, and currently the Mexico City Metropolitan Area (MCMA) (the FD and 44 municipalities) (SEMARNAT et al 2003: 34).

Map II. 1: Location of Mexico City

Yet another delimitation of city has to be considered for the purposes of this study, namely the mega-city region (related to a region based pathway of development) made of the inner city, the built-up area, five satellite cities (Toluca, Querétaro, Pachuca, Puebla and Cuernavaca), and peri-urban localities functionally linked to it through transportation corridors, labor markets and commodity markets. The mega-city region is relevant because it lets explore the increasing weight of the main city on remote locations, happening mainly through carbon relevant socioeconomic and land-use transformations such as relocation of enterprises and people to peripheral localities, methane emissions by landfills serving the city, and land use changes reducing soils ability to capture carbon.

Figure II.1: Evolution of industrial/domestic fuels in Mexico

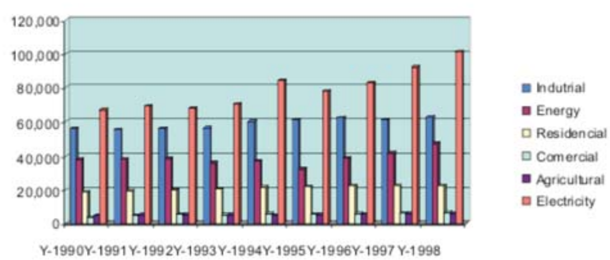


Source: Molina et al (2002: Figure 3.6)

Mexico City has historically been and is still the hub of Mexico, a middle-income country consuming increased amounts of fossil fuels, although the demand for those fuels has grown at different paces during the two decades (see Figure II.1). As can be seen in Figure II.2, CO_2 emissions increased during 1990-1998, especially after the financial and economic crisis of 1994-95. According to the most recent national inventory, releases amount to 686 thousand Gg in equivalents of carbon dioxide, nearly 2 per cent of international GHG emissions[2]. Main sources of carbon at the national scale are other internal combustion processes (219,432 Gg, 31.9%), the forest sector (161,422 Gg, 24%), transport (100,158 Gg, 14.6%), and industrial activities (43,121 Gg, 6.3%, SEMARNAT 2001: 39).

Emissions patterns illustrate on the one hand the economic structure of the country, more dominated by services (69.3% of GDP) than by manufacturing (26.1% World Bank 2004a). The shadow economy where a good share of services is concentrated gives jobs to around a fourth of Mexico's active population[3]. Although agriculture's contribution to the GDP is insignificant (4%), land use changes are a key source of GHG emissions. Mexico's Gross National Income per capita is $US 6,230, one sixth of USA's ($US 37,710 World Bank 2004b). Some components of the current phase of globalization, as well as of state reform and regional trade agreements (e.g. NAFTA) have resulted in economic growth for some sectors, like primarily export-oriented assembly and car industries, export orientated agriculture, and financing. It has meant recurrent economic crisis to the rest (middle and small enterprises, informal urban employees and poorer peasants). As a result Mexico presents a mix and daunting situation regarding poverty.

Figure II.2: CO_2 Emissions resulting from Energy-Consumption in Mexico (Tg)



Source : (SEMARNAT et. al. 2001a : Table 4.1).

> "In terms of well-being, Mexico has experienced major progress in some dimensions notably related to basic service access but much weaker in others notably on the income of the poor. Despite the gains between 1996 and 2002, particularly for the extreme poor, poverty remains widespread and is slightly below levels prevailing before the 1994/95 crisis" (World Bank 2004b: iv).

[2] Of the total carbon emissions in 1996, 514,047 Gg (75%) was CO2, 157,648 (23%) was methane, and 14,422 Gg was nitrous oxide (SEMARNAT 2001: 39).
[3] According to World Bank (2004b, Table 3.16 studying poverty) 26.6% and 20.3% of male and female labor-force respectively are employed in the informal sector, while 30.5% and 29.6% are self employed.

The economy of the central region where Mexico City is situated is rooted in a mixture of urban and rural livelihoods. Mexico-city's image and economy though are dominated by industrial and more recently financial complexes concentrating a good share of national GDP by both sectors (Table II.1), and relying on the city's relations with national and international markets. The central region is the most populated and wealthy of the country. It generates 41.9% of the national GDP and concentrates 33.8% of the total population (Hiernaux and Carmona 2003: Tables 2 and 5). Other metropolitan areas within the central region include Querétaro, Pachuca, Toluca, Puebla and Cuernavaca (Map II.1).

Table II.1: Percentage of National GDP Generated by Economic Sectors in the Federal District and the State of Mexico
(constant prices of 1993)

Federal District	1993	1995	1999
Social and personal services	32.28	33.67	30.4
Business, restaurants and hotels	22.38	20.51	21.38
Financial and insurance services	17.6	19.77	19
Manufacture	17.24	16.86	19.61
D. VIII. Metallic products and machinery	3.89	3.71	6.3
D.V. Chemicals, plastic and rubber	3.75	3.72	4.7
D.I. Foods, drinks and tobacco	3.94	4.01	3.7
State of Mexico			
Business, restaurants and Hotels	20.62	19.12	20.23
Social and personal services	17.29	17.75	14.9
Financial and insurance services	13.81	15.4	14.5
Manufacture	31.61	31.29	33.62
D. VIII. Metallic products and machinery	9.25	8.94	11
D.V. chemicals, plastic and rubber	5.86	5.74	5.93
D.I. Foods, drinks and tobacco	7.01	7.64	7.49

Source: Sistema de Cuentas Nacionales in Correa (2003, Figure 5: 122)

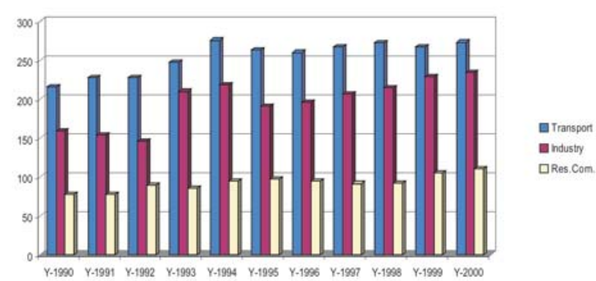
2. City's GHG emissions

Mexico City consumes about 626 Petajoules (PJ) of fossil fuels and 88 PJ of electric power, which amount for 14 and 16 per cent of the national consumption respectively (DDF 2004: 32). The main fuels consumed are gasoline, LP gas, natural gas, diesel for vehicles and industrial liquid fuels. The demand for those fuels has grown at different paces during the last decade (e.g. the demand for natural gas increased, while fuel oil's remained constant, see Figure II.1). The quality of fossil fuels has improved in all cases, and contributed to significant reductions in emissions.

Although transportation is the main consumer of fossil fuels (44%), followed by the industry (38%) and residential/commercial sectors (18%), it has reduced its share during the last decade, while the industry has increased it and the other two sectors remained stable. It seems that the energy demand of both residential and commercial sectors is inelastic even when confronted to the 1994 crisis (Figure II.3).

Notwithstanding it is difficult to find out tendencies regarding GHG emissions as the few existing official inventories have been built with diverse criteria and are fraught with inconsistencies[4], they allow for two observations: city's emissions of GHG augmented considerably during 1996-2000, while its share of national emissions decreased from 13 per cent to 7.8 per cent (Molina et al 2002 and GDF 2004). The absolute increase in emissions can be due to city's economic growth (see Table II.1), but also to an increasingly more precise and encompassing account of emissions. The relative decrease in city's share of national emissions may be explained by the recent economic emergence of other regions (e.g. cities along US-Mexico border).

Figure II.3: Energy Consumption in Mexico City 1990-2000



Source: SMA et al (2003: Table 2.10).

We would expect the dominance of emissions related to manufacturing not only because the city is the hub of the country, but also because that dominance occurs in other urban-industrial heartlands such as North-Western Ohio USA, where industry releases 39 per cent of GHG and transportation 32.5 per cent (Aryeetey et al 2003: 106).

[4] Molina's et al inventory (2002: 171) for instance includes releases by the aviation sector, while DDF (2004 Annex 7) does not. The total emissions (56.965 Millions of tons) as calculated by GDF (2004: Annex 7) do not coincide with the sum we did (60.045 Millions of tons) of emissions by different sectors inventoried by GDF (2004: Annex 7).

But that is not the case. Under academic calculations and official inventories of both total energy consumption and consumption without electricity, transportation appears as the main releaser of CO2 equivalent emissions followed by industry, and the residential sector (see Table II.2).

Table II.2: Greenhouse gas emissions in the MCMA (CO_2 equivalent)

Sector	1996[1]		2000[2]		2004[2]	
	Ton	%	Ton	%	Ton	%
Residential	5,200,000	14.9	8,526,222	14.2	9,387,604	15.0
Industrial	6,480,000	18.6	17,181,000	28.6	17,871,000	28.5
Commercial	340,000	1.0	2,928,375	4.9	3,067,960	4.9
Transportation[3]	19,300,000	55.4	20,860,291	34.7	20,943,760	33.5
Aviation	900,000	2.6	n.d.	n.d.	n.d.	n.d.
Elec. Generation	2,570,000	7.4	3,080,652	5.1	3,012,578	4.8
Solid wastes [4]	n.d.	n.d.	6,446,797	10.7	6,553,144	10.5
Agricultural	70,000	0.2	183,155	0.3	181,336	0.3
Government[5]	n.d.	n.d.	839,410	1.4	1,589,687	2.5
Total	34,860,000	100.0	60,045,902	100.0	62,607,069	100.0

1. Source: Molina et al. (2002: 171). 2. Source: GDF (2004). 3. Differently to GDF (2004), it includes Metro and trolleybuses. 4. It only refers to wastes generated in the FD 5. Differently to GDF (2004), it does not include Metro and Trolleybuses.

Table II.3: Summary of transport infrastructure in the MCMA

Type	2000		2004	
	DF	EM	DF	EM
Primary Roads	198.4 km	352 km highways	930 km	n.d.
Ejes Viales	310 km	47 km (Vías rápidas urbanas)	421.16 km	n.d.
Principal Roads	552.5 km	616 km	320.57km	n.d.
Secondary Roads	8,000 km	250	9229 km	n.d.
Metro	200 km	-	200 km	n.d.
Trolleybus	422 km	-	42214 km	n.d.
Light Rail	26 km (13 in each direction)	-	13 km	n.d.
Parking spaces	160,277 spaces (1,204 lots)	-	160966	n.d.
Traffic Signals	1,881 electronic 1,233 computerized	298	6132	n.d.
Bus shelters	2,347	290	2500	n.d.
Counter-flow lanes	13 lanes, 186 km	-		n.d.
Parking Meters	1,535		4345	

Source: Molina et al (2002: 230) and Gobierno del Estado de México, et al (2001: 10-11).

3. Transportation system

Transportation as both critical enhancer of city's development and important releaser of GHG, has been affected by processes operating at different scales, such as city's rapid and changing demographic, physical and economic growth and retrenchment of the state in its role as developer, manager and regulator of the sector **(see section II.7.2).** Furthermore, transportation has undergone different carbon relevant changes to be described in this section, such as a rapid motorization, decline of public transport, and important modal shifts from high to middle and low capacity vehicles (Figure II.5).

3.1 Transportation supply

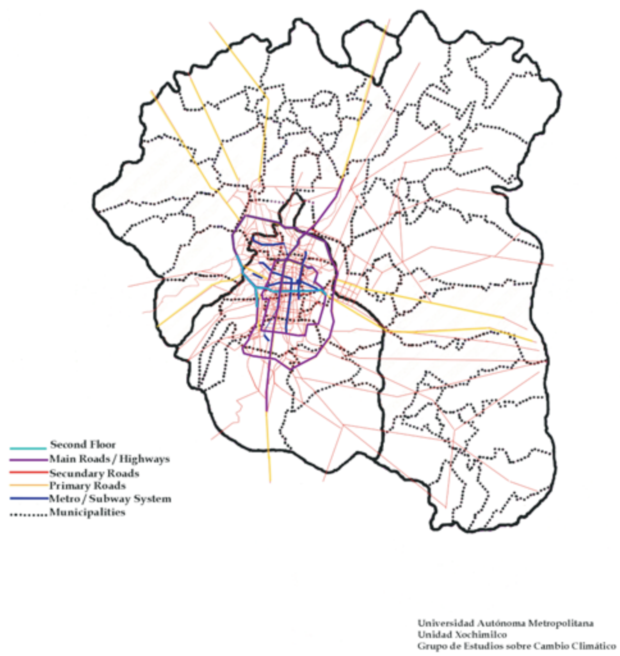
As of transport infrastructure major highways and railroads irradiate from the city, five of which function as economic corridors (Map II.2). The city has tried to keep pace with it massive expansion and built infrastructure such as the first ring road (*Circuito Interior*), a network of high capacity boulevards (*ejes viales*), a beltway (*Periférico*) and currently the controversial elevated roads (*Segundos Pisos*, see Map II.2). Nevertheless the growth of the city has outpaced such efforts. Most of the infrastructure, which also includes 1.2 thousand km of principal roads and 8.3 thousand km of secondary roads is concentrated in the Federal District (Table II.3) and is confronted to diverse limitations: there are variations in road capacities and continuity, streets are narrow and old, the city lacks adequate space to afford for left turns and underpasses at critical intersections as well. These elements contribute to congestion problems and by this to CO_2 emissions.

There are no consistent records of vehicle fleet size and composition, because of at least three reasons: the city lacks a Metropolitan registration system and there is no coordination among state authorities involved in its management; autos incur in irregularities (e.g. cars becoming taxis, and taxis becoming collective taxis). Calculations of fleet size oscillate between 3.1 and 3.5 million vehicles, the majority of which (72 to 79 per cent depending on the estimates) are private cars (Molina et al 2002: 232-237, SEMARNAT et al 2003, see Table II.6)[5]. Annual growth in the population of vehicles is of 9 per cent, although it shows a dramatic decrease during 1994-1997, the period of the 1994 crisis (Figure II.4). Notwithstanding their big proportion private transport only accounts for 18 per cent of the 29.5 vehicle trip segments daily made in the MCMA, while the rest (82 percent) is undertaken by public transport (COMETRAVI 1999).

[5] Some sources even calculate a bigger population of cars for 2000, namely 5.7 million (GDF 2001).

As of mode share, a trend is the substantial shift from high and middle-capacity transportation (e.g. Metro and buses) towards low capacity modes of transport (minibuses and taxis), as well as a slight reduction in the use of private autos (from 25% in 1986 to 19.9% in 1999, Figure II.5).

Map. II.2: Transportation Infrastructure

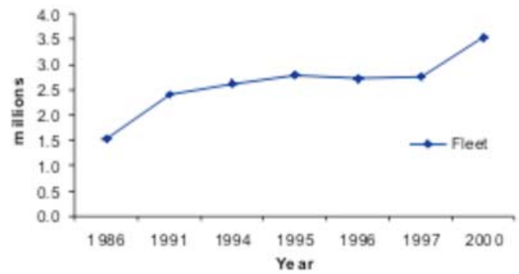


The average age of the fleet has increased from 7.3 to 10 years during last fifteen years, though an increasing proportion of cars are equipped with catalytic converters[6]. The carbon implication of this technological issue is that the older the car, the lower the engine performance, the lesser its chances to be equipped with catalytic converters and hence the more it pollutes. For instance cars fueled by gasoline older than 1974 (6.1% of the fleet) contribute 9.1 per cent of the total emissions, while cars 1998 and newer (7.4 per cent of the fleet) release 1.9 per cent of pollutants (SEMARNAT et al 2003: 103).

Data inconsistencies are also present in the records on private cars and taxis. The annual growth in the number of such vehicles is calculated to be from 4 per cent to 10 percent. The motorization rate has augmented noticeably from 78 cars per 1000 of persons in 1976 to 178 per 1000 of people in 2000 (Table II.4). The average automobile occupancy oscillates between 1.3 and 1.7; it is hence very low.

Most taxis (from 69,000 to 109,407 depending on the calculation) are not fixed and tend to age, what increases their GHG emissions. Drivers of both kinds of vehicles do not obey traffic rules.

Figure II.4: Fleet size in MCMA



Sources: GDF (1999), (2000) and (2001).

Table II.4: Passenger car p/ 1000 persons

1940	1960	1976	1986	1996	2000
27.3	51	78	91	166	178

Source: INEGI (1992), (1996) and (2000), GDF (1999) and (2001).

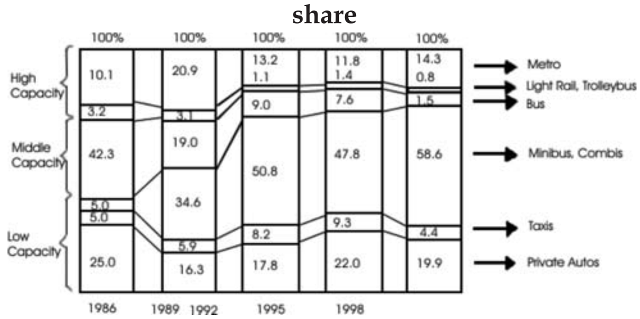
The bus system has undergone diverse changes during last two decades. In 1981, after the bankrupt of private bus companies, the government of the Federal District assumed the administration of 19 companies working within its jurisdiction, and created the state-owned *Ruta 100* bus company. Notwithstanding some positive performance, R-100 was confronted to diverse obstacles: opening of the transportation market to minibuses and collective taxis, poor public management reflected in high costs, poor maintenance and falling revenues, and pressures of labor unions. Thus it was declared bankrupt in 1995. No other big company has substituted *R-100*. As result the bus fleet has registered a sharply decline during last decades (from 42 to 1.5 per cent of the total fleet, Figure II.5).

Contrary has been the case with fixed routed collective taxis (*colectivos*), which have registered an explosion during last two decades (from 5 to 58.6 per cent of the total fleet, Figure II.5), as a result of various converging processes: the referred liberalization policy; retrenchment of the state

[6] "In 1985, 99.5 percent of the population of cars in the MCMA did not have catalytic converters. By 1999, the configuration of the population had changed considerably, with only 34.7 per cent of the car population being without a converter" (Molina 2002: 234).

reflected in both GDF poor management of the bus system and weak institutional capacity to effectively deal with the colectivos; flexibility of *colectivos* to respond continuously to demands of people in every area of the city, including the unpaved and unplanned roads within irregular settlements. Notwithstanding those advantages, *colectivos* confront diverse problems with implications for users and GHG emissions. They lack parking facilities, financing and other advantages of scale economies in operation for them to maintain, repair and replace their unities, what contributes to more GHG emissions. Drivers do not obey operating and traffic rules (what by the way is common to drivers of other modes of transportation). The high competition in the market induces dangerous driving behavior and high accident rates. All this contributes to traffic congestion and higher emissions.

Figure II.5: Tendencies in transportation mode share



Source: SEMARNAT et al (2003:46)

Other modes of transport include delivery and freight vehicles, trolleybuses, metro and the light train (Table II.5). Most trucks (79%) are privately owned and operated by their possessors; they lack facilities for the vehicles to be parked and stored. Therefore they park on the street. This, trucks' delivery activities and their driver behavior exacerbates traffic congestion. Trucks owners are short of resources for maintenance and turnover, what contributes to increase GHG emissions.

Trolleybuses, whose fleet declined during the 1990s to 344 unities, have the disadvantages of relying on the provision of overhead wires, having lower performance, and covering a tiny fraction of users' transportation demands (see Table II.5). But they have zero local emissions, because the electricity they use is generated distantly.

The *metro* has 11 lines and 243 trains extending over 197 km. Although it has been extended over last years, its use decreased 5 per cent during 1986-1999, and its mode share diminished more than 4.8 per cent during 1986-1998 (Figure II.5). This decline can be explained by diverse reasons: The *metro* does not effectively serve population moving further from the urban core; it is full and uncomfortable during peak hours; it is insecure; and their designers have failed to coordinate metro development with land development.

Table II.5: Trolleybuses, metro and the light train infrastructure

Mode	DF
System of Collective Transport-Metro	- 200 km of double roads - 11 lines - 175 stations - 302 rails - 201 rails in operation - 1,157,490 annual trips - 4.2 million passengers every day
Service of Electric Transportation: 1) Trolleybus 2) Light Rail	- 422.1 km - 17 lines - 344 unities in operation - 13 km of double roads - Between 12 y 15 unities in operation

Source: http: www.setravi.df.gob.mx reviewed in January 16, 2005

3.2 Transportation demand

Various factors interweaving city's patterns of urban development underlie patterns of transportation demand: dynamics of economic activities and population, location of residence, employment, education and recreation, and setting of transportation facilities. As will be described later, most economic activities, which used to be concentrated in the Federal District, are moving to the northern municipalities of the EM. The Federal District still concentrates commerce and service activities, and the most dynamic economic corridors are situated in the west and south of the city. Population is also moving to the outskirts of the city and to its satellites.

As of location of transportation facilities communicating the inner city with the country and the world, the Mexico City International Airport is situated in the eastern border of the Federal District and generates a high number of trips to and from it. Most travelers go into the city through northern and eastern roads coming from Mexico, Querétaro and Hidalgo, and from Mexico and Puebla respectively (Map II.2).

Main subway stations and bus terminals tend to concentrate in the northern and eastern boundaries of FD and EM. A fright terminal for non-processed food is situated in the southeast of the FD.

According to origin-destination surveys, which again vary in their results, between 20.6 and 29.1 million vehicle-trip segments per day are made in the MCMA (COMETRAVI 1999 and SEMARNAT et a. 2003). Three quarters of them are via public transport (including taxis). According to SEMARNAT (2003), the Federal District concentrates 66.5 per cent of the MCMA trips, while 33.5 percent are made within the state of Mexico. According to COMETRAVI (2001), about 57 per cent of the trips are concentrated within the Federal District, 20 per cent occur between the FD and the EM, and 23 per cent take place within the State of Mexico. As already mentioned, low and middle capacity modes dominate the landscape. Private cars, which reduced slightly their mode-share participation, are highly concentrated among wealthy sectors. Studies have found out that 50 percent of auto trips come from 23 percent of the city and half of them go to just 16 per cent of the city (Graizbord et al 1999).

Freight activity is determined by the economic prominence of the MCMA and by the existence of infrastructure. About three quarters of all rail freight enters the city via two terminals situated in the delegated unit Azcapotzalco and the municipality of Tlalnepantla. The northern and northeastern delegations and municipalities of the MCMA concentrate around 60 per cent of the industrial and commercial installations to which most freight travel goes.

As referred to earlier transportation accounts for the highest share of CO_2 equivalent emissions. Private cars, which contribute 18 per cent of the 29.5 vehicle trip segments daily made in the MCMA, release 40.8 per cent of CO_2 equivalent emissions, while public transport undertaking 82 percent of those trip segments emits 25.9 per cent. This shows that rather than private transport, which does not serve the necessities of a higher proportion of users and contributes most to GHG emissions, the city needs both a better public transportation system and governmental strategies aimed at making it more attractive. Delivery and fright vehicles release 32.6 per cent of city's GHG generated by transportation. Industrial and commercial activities' share is hence higher, and both sectors should be therefore subject to a more systematic management and control of their emissions (Table II.6).

Table II.6: CO_2 equivalent emissions inventory from mobile sources in MCMA in 2000

Vehicles	Fleet	%	Ton CO_2 eq.	Mode	Ton CO_2 eq.	%
Private cars	2556378	72.8	8,513,771	Private	8,513,771	40.8
Trolleybuses			43,470	Public	5,413,172	25.9
Metro			657,778			
Taxis	109654	3.1	2,184,838			
Combis	4859	0.1	546,547			
Microbuses	29727	0.8	1,318,721			
Autobuses	177132	5.0	661,818			
Pickups	356547	10.1	1,655,031	Freight	6,799,455	32.6
Vehicles < 3 tonnes	5021	0.1	2,944,398			
Semi trailers	74980	2.1	1,418,885			
Vehicles > 3 tonnes	96478	2.7	699,632			
Heavy-dutyLPG- trucks	29968	0.9	81,505			
CNG vehicles	n.d.	n.d.	4			
Motorcycles	72704	2.1	133,893	Unspecific	133,893	0.6
Total	3513448	100	20,860,291	Total	20,860,291	100.0

Sources: (2003: 111) and GDF (2003, Annex 7).

Diverse conclusions can be drawn from the analysis of transportation. MCMA is a key point for national transport from which highways and railroads irradiate. Notwithstanding its importance the city is congested constantly because of at least three reasons. Public investments in infrastructure have been outpaced by city's demands and requirements as hub of the country (e.g. the need of an efficient public transportation service). The existing network of roads, highways and traffic signalization is inadequately designed, constructed and maintained. Vehicle-drivers do not obey traffic rules, and these are not adequately designed and enforced by authorities. Authorities lack coordination in key issues such as traffic legislation. We have for instance two incompatible traffic regulations, one for the Federal District and one for the State of Mexico (see section II.8).

Middle to upper sectors have beneficed from changes in mode share although in a paradoxical way, as they permanently experience city's congestion. Most auto trips are originated in wealthier areas, which surely have a higher per capita contribution to CO_2 emissions by the transportation sector. Although sectors using middle and low-capacity cars (especially *colectivos* and taxis) have a smaller per capita contribution to GHG releases than middle and upper ones, they share some features resulting in higher proportion of emissions per passenger kilometer compared to high-capacity public transportation modes, such as aging of the fleet, lack of and/or not enough maintenance. This means that the fleet should be renewed, of course with some governmental subsidy, as owners of such vehicles are considered by banks to be risky.

As of public transport, although planners and scholars take for granted that Metro and buses are invariably superior to low-capacity modes, we want to explore whether this completely holds for Mexico City.[7] Buses which have almost disappeared and Metro do not reach the whole city (at least not its informal settlements); and do not satisfy in their current state the necessities of safety, comfort and speed of their users. Some times boarding points are inconvenient to people's place of residence, especially in the suburban areas. Other times the disembarkation point is inconvenient to their place of work. Thus the incentive to use middle- and high-capacity modes and even to abandon private cars is sharply reduced. Here is where low-capacity modes have been especially helpful, by moving people on demand to the embarkation points and from the disembarkation points.

The challenge confronting the city is thus to find intelligent ways of managing existing high, middle and low-capacity modes in such a way that trip time and energy expenditure are minimized. We know that this is a contested issue, but our guess is that a more organized traffic system including improved public transport, a much better travel behavior and stronger regulations (e.g. stringent age limits for vehicles) could be a useful tool for this purpose together with a much better design of infrastructure (roads), and circulation patterns.

4. Industrial and commercial activities

Industrial and commercial activities operated until the 1970s under an import substitution industrialization (ISI) scheme; they were subsided, enjoyed protected markets[8], took advantage of city's economies of agglomeration (scale and urbanization), had access to relatively more qualified workers, and were environmentally inefficient and contaminating. The ratio of industrial and commercial Gross Domestic Product in Mexico City to the national GDP augmented from 10.5 and 14.1 per cent respectively in 1950 to 34.6 and 75.8 per cent respectively in 1980 (JICA 1991: 2-12). Although we did not find city-scale data on industry's environmental performance, national studies such as Ten Kate (1993) found out that the environmental intensity of the Mexican industry increased about 50 per cent during 1950-1970 and 25 per cent during 1970-1989. During the 1970s our industry moved to more polluting activities with increased state participation such as the production of petrochemicals and fertilizers. The most polluting sectors during the 1980s were chemicals (44.1% of the total environmental intensity), metallic products, machinery and equipment (14.4%), and leather and apparel (12.1%, see Wheeler 1997).

In terms of gross output the dominant industrial sectors in the MCMA at the end of the 1970s were chemicals (21.2%), food (9.8%), electric machinery (8%), metallic products (7.8%), textiles (6.4%) and rubber and plastic (6.1% Garza 1985: 152). But city's share of national employees was different: 56 per cent for publishing and printing, 56 per cent for rubber and plastic, 53.7 per cent for chemicals, 50.2 for metallic products, 45.7 per cent for paper and 39.9 per cent for leather and apparel (JICA 1991: 2-14).

The city concentrated both most dynamic service and commercial activities and a great variety of middle and small GHG generating establishments, e.g. public baths, hospitals, restaurants, gasoline stations, bakeries, laundries, tortilla factories, sport centers and printing shops[9]. Carbon crucial transformations in industrial, commercial and services activities took place since the 1980s. These sectors registered a decline in production and employment during the

[7] We are quoting most of this point from Richard Rockwell whom I want to thank for his support.

[8] "During this era import tariffs on manufactured products reached a peak of 36.25% and import license requirements tolled about 92% (1984) of the price of products" (OECD 2004: 43).

[9] During the 1989, 98.1% of commercial and services in the FD were small and middle enterprises, which grew to 99.3% in 1999 (SECOFI, 2005). Nevertheless those enterprises are less important in terms of their contribution to city's GDP. The GDP of those sectors grew 2.2% annually along 1993-2000 (INEGI 2004).

1980s[10] related to two economic crises, the 1982 debt crisis and the following retrenchment policies of the state (JICA 1991). Carbon relevant changes during the 1990s included:

- Modifications of the most dynamic economic activities in terms of GDP, from chemicals, food, electric machinery, metallic products, textiles, and rubber and plastic at the beginning of the 1980s, to metallic products, machinery and equipment, chemical products and food, drinks and tobacco at the end of the 1990s (see Table II.1). City's share of total employment shows another panorama. Manufacturing of metallic products, machinery and equipment reduced the generation of jobs, textile and leather moved to the satellites of the city, and chemical products remained stable (Hiernaux and Carmona 2003: 72).

- Increasing economic fragmentation characterized by the coexistence of large, high-tech establishments, micro-enterprises (e.g. households and workshops) and self-employed people. Foreign companies concentrate their investments in sectors such as automobile (23.1%), chemical products (5%), drinks (4.8%), basic metals (4% Correa 2003: 112), and the pharmaceutical industry[11]. Printing and publishing are examples of middle and small enterprises that survived the restructuring, currently contribute 67% of the total industrial value and have expanded employment during last years (OECD 2004: 46). But most of the economy relies on micro-enterprises whose productivity and levels of investment are very low, working conditions poor and environmental performance low, what again has negative carbon implications. There are hence winners and losers in this process: some localities, establishments and households fully incorporated in globalized circuits through exclusive urban developments, high-tech commodities and new consumption -carbon demanding- patterns juxtaposed to more informal workshops, cheap working labor with poor standards of housing, poor quality service provision, low environmental performance and low-income consumption patterns.

- A very small decrease in industrial concentration and the relocation of industrial establishments, commercial centers and residential developments into urban corridors, urban sub-centers[12], other Mexican cities and even other countries. Situated in the north of MCMA the localities of Coyotepec, Santiago Tequixquiac and San Juan Zitlaltepec are examples of urban sub-centers increasing their share of manufacturing controlled by frequently trasnational heavy, large-scale and high-tech enterprises within metallic and chemical industries. Sub-centers in Chalco, San Martín Xico and San Miguel Coatlinchan in the southeast exemplify the emergence of small scale illegal establishments representing survival strategies of the poor (Aguilar and Ward 2003: 14). An important urban corridor, in terms of exclusive developments, destination of foreign investment, and presence of advanced services goes along Reforma-Santa Fe in the west (Hiernaux and Carmona 2003), but there are at least three more located along the roads going to the city of Pachuca, and to Chalco and Texcoco (Aguilar and Ward 2003: 14).

- Strengthening of the main city as finance and service center and as principal destination of foreign investment. According to Correa (2003: 111) in 2000 the Federal District concentrated 52 per cent of foreign investment allocated in the industry, 91.5 per cent in commerce, 97.8 per cent in financial services and 92.3 per cent in other services[13]. This relates to the increasing functional influence of the main city on remote municipalities through significant socioeconomic and land transformations of its regional periphery (ecological footprint).

[10] There was for instance a decrease in industrial "production by 3.1% in 1982 and in 7.5% in 1983. The production level /recovered/ in 1984 and in 1985, but it fell again in 1986 by 3.5%".Notwithstanding those recoveries, "the production index in 1988 was 118.4 as compared with 100 in 1980, a mere increase of 18.4 points in 8 years" (JICA 1991: 2-17).

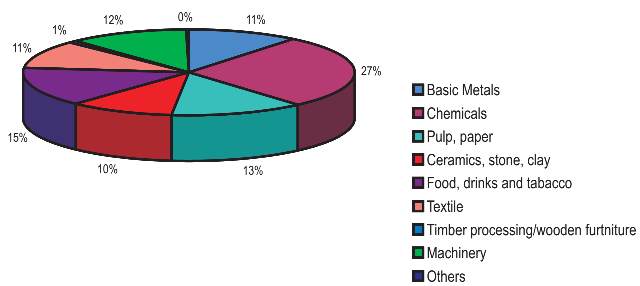
[11] Composed of 17 firms this industry generates 5.1% of Federal district employment and 12% of total manufacturing output (OECD 2004: 46).

[12]Urban corridors are " lineal development activities along the way: corporate developments, industrial parks, residential areas, and the density varies form very compact areas to low-urban density with rural landscape in the middle. Urban sub-centers in the periphery of the mega-city that may be consolidating traditional towns once dominated by agricultural activities, or the result of new (low-income) residential developments in metropolitan municipalities of rapid growth incorporated into the wider metropolitan complex for the first time. These sub-centers play the role of small cities by providing cheap labor, by concentrating a wide range of services, and, to a varying degree, serve as satellites or dormitory towns to the large city and to its metropolitan economy. These sub-centers can be relatively small localities (often between 10,000 and 100,000 inhabitants) located at the edge of the metropolitan frontier, at a distance between 30-60 km from the urban core" (Aguilar 2003: 7-8)..

[13]Paradoxically those investments exerted no multiplying impact in the local economy as transnational corporations are more related to international markets than to local ones.

GHG emissions by industrial activities grew 56.7 per cent during 1996-2000; it is an astonishing augment may be due to the fact that the 2000 inventory was more precise than the 1996 one. Of course industrial share of GHG emissions would be higher if we included its transport related releases (see Table II.6). Some of the most dynamic industrial sub-sectors in terms of contribution to regional GDP are also the most polluting, namely chemicals (27%), food, drinks and tobacco (15%), and machinery and equipment (12%). But so are also sectors generating jobs such as the textile industry (Figure II.6). Commercial activities did also increased four-times their releases and would have a higher contribution if their transportation related emissions were accounted (Table II.6). The most recent inventory has no data on which commercial sub-sector releases more GHG.

Figure II.6: GHG emissions by industrial sectors
(CO_2 equivalents)



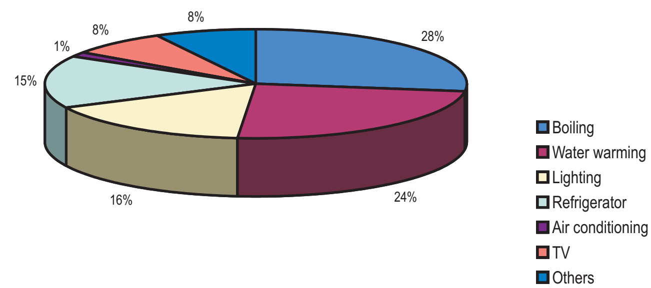
Source (GDF 2004: Annex 7).

5. Residential sector

In Mexico City there are more than five million homes generating 8.5 millions tons of CO_2 equivalent through daily activities such as boiling (28%), heating water (24%), and lighting (16%, Figure II.7). Households contribute to methane releases more through the generation of almost 6 tons of solid wastes everyday (source of 97 per cent of methane, GDP 2004: Annex 7) than through mentioned daily activities. The other households' activity emitting GHG is transportation (see table II.6).

How can those emission patterns be explained? It is traditionally stated that as population grows and the standard of living improves, the consumption of fossil fuels and emission of GHG also augment. Lifestyles are supported by industrial activities consuming vast quantities of energy and result in large quantities of GHG emissions. We did not find literature on the relationships between households-lifestyles and GHG emissions in Mexico City, nor in other urban areas. Notwithstanding this research gap we decided to explore whether that holds true for our case and present some preliminary indicators on the relationships among population growth, living standards, equity and per capita emissions of GHG.

Figure II.7: GHG emissions, residential sector, 2000
(CO_2 equivalents)



Source (GDF 2004: Annex 7).

Population has shown a minor decrease in growth (Figure II.8). Taken in aggregate Mexico City is the wealthiest of the country, and it has a good share of the national consumption of energy, which has increased 36.6 percent during 1990-2000[14], while per capita consumption remained constant. As of living standards, the MCMA is statistically endowed with the highest levels of access to basic urban services (water, sanitation and electricity), education and health (OECD 2004: 53-57).

Nevertheless poverty is a problem in the city. The very and moderately poor in the FD account for 50.4% of the population, 70.9% in the EM. General wages of the city have declined more than elsewhere in the country, from 25.9 (1994) Mexican pesos in 1986 to 11.4 (1994) Mexican pesos in 2000 (OECD 2004: 52-53). Social segregation is multidimensional and has a spatial face. An important proportion of basic geo-statistical areas (AGEBS) with high levels of exclusion are located in the periphery of the city, frequently in settlements of recent creation lacking adequate infrastructure, such as in the southeast of the city,

[14]Annual consumption of energy in the MCMA grew from 215.7 Pj in 1990 to 618.2 Pj in 2000 (SEMARNAT et al 2003: 49).

especially in the Valley of Chalco (Solis cited in OECD 2004: 53-54). Central delegations of the FD have levels of access to basic urban infrastructure of almost 100 per cent, higher than the national average, while municipalities in the State of Mexico (e.g. Tepotzotlán, Villa del Carbón) are confronted to levels below that average. The delegation Benito Juárez has the highest percentage of people with basic education (91%), while in municipalities such as Chalco this level drops to 60%.

It can be suggested that high levels of social segregation in the MCMA, which are related to a differentiated contribution to both energy consumption and GHG emissions, should be included in the analysis of the relationship among population growth, increased standards of living, and higher GHG emissions. Although there are no precise data to proof such statement, we could use an indirect indicator. According to the latest information (WB, 2004b: 163), the bottom 20 per cent of the population in urban areas gets 4.5% of the total income, while the share of the top 10% is of 38.8%. It then may be that both have a respectively similar contribution to emissions. There is one more direct indicator, already mentioned. Private cars are highly concentrated among wealthy sectors (50% from the trips going to and coming from 16% and 23% of the city respectively), but only cover 18 percent of the 29.5 trip segments.

6. Land use changes

Land use changes have been directly driven by the urban growth, processes of suburbanization and in recent years the polycentric expansion of the city (see section II.7.1). A crucial factor in this context is the increase in the number of households[15], via irregular settlements for the poor and real state development for high income families (Table II.7). Dwellings increased their share and total amount of urban area during 1987-1997 and occupy three fifths of the urbanized area of MCMA, while recreation and open spaces reduced their participation (Table II.7).

Nowhere are equity issues more present than in the households of Mexico City. According to a study by the government of the FD (El Universal Newspaper 2/02/05), 69 per cent of the population registers low to high levels of exclusion. High-income residential developments enjoy high quality services and a better quality of life, as they are isolated from people, noise and traffic. Lacking the money and public policies to compete for serviced land and adequate housing, the urban poor are forced to establish their households both in substandard rental- units or illegal-semilegal settlements located in risk-prone areas of protected zones with inadequate infrastructure and low quality services (Pezzoli 2000).

Protected and natural areas have been affected by urban growth. There is uncertainty regarding rates of deforestation. According to data from the FD between 290 and 495 hectares have been deforested during 1973 -2000 with an approximately rate of annual deforestation of about 1.7 per cent (SEMARNAT et al 2003: 47). Remaining forest is the "reservoir" of 3.89 millions of tons of carbon (SMA et al 2003: 47). We found no calculation of GHG releases historically generated by land use changes.

According to carbon inventories agriculture and cattle contribute a tiny proportion (0.3%) of CO_2 equivalent emissions (Table II.2). They also release NO_2 and CH_4 (0.3 and 0.6 per cent of total emissions respectively SMA 2004 Annex 7), because of diverse reasons. The enteric fermentation process of bovines produces higher amounts of CH_4 than other cattle. Common agricultural practices of local farmers include burning of agricultural waste and unchecked fires aimed at renewing pasture lands. Forest fires are common during the dry season from December till April and are determined not only by agricultural practices but also by "the type of vegetation, the thickness of organic topsoil, topographical characteristics of the site, closeness to roads, amount of combustible materials and" climate variability and change, e.g. ENSO (SEMARNAT et al 2003: 45).

[15]Households are "a nexus of social relationships that provide crucial linkages between producing and maintaining access to the material means of sustaining life, managing environmental resources, and passing on life chances to succeeding generations" (Pezzoli 2000: 66).

Table II.7: Comparison of Land Uses between 1987 and 1997 in the MCMA, DF and the Contiguous Municipalities (area listed in km^2)*

	1987			1997		
	MCMA	DF	Contiguous Municipalities	MCMA	DF	Contiguous Municipalities
Total Area				5294.4	1483.2	3811.2
Urbanized Area	1181.1	554.0	627.1	1460.3	710.2	750.2
Residential	687.3	272.0	415.3	911.2	368.4	542.8
Mixed Uses				172.1	149.1	23.0
Industry	96.7	29.4	67.3	78.1	14.5	63.7
Commercial and Service				58.1	19.9	38.2
Facilities	57.5	50.7	6.8	106.5	63.1	43.5
Recreation and Open Roads	187.1	49.4	137.7	110.1	71.1	39.1
Primary Roads	152.6	152.6		24.2	24.2	
Non-urbanized Area				3834.1	773.1	3061.0

* Area: $1km^2$ = 100 hectares
Source: Molina (2002: 74)

7. Greenhouse gas emissions drivers

Four processes operating at different spatial and temporal scales drive GHG emissions in Mexico City. The first one, the transit from a city-based to a polycentric pattern of urban development, is the essential structure interweaving processes such as population growth and technological dynamics. The second relates to some components of the current era of *globalization* (e.g. relocation strategies by enterprises) resulting in carbon relevant processes such as increasing commuting distances for people and freight transport. The other two are more political and policy-related and refer to the State reform and to city's institutional settings.

Table II.8: Percentage of National Industrial GDP and Population located in Mexico City

Year	GDP	Population
1930	26.95	6.22
1940	33.07	7.37
1950	39.14	11.55
1960	44.36	14.78
1970	48.16	17.93
1980	47.05	20.54
1990*	32.59	18.52
2000*	29.02	18.36

Reference years for the GDP of 1990 and 2000 are 1993 and 1998.
Sources: INEGI (1997), CONAPO (1998), Hiernaux and Carmona (2003: Figure 1), Garza (1987: Table 4.7)

7.1 Urban development pathways

The beginning of the 1980s saw the transition from a city-based to a polycentric pattern of urban development in Mexico City and other urban areas in Latin America (Aguilar and Ward 2003, Cohen 2004). Two features of the city-based model operating during the import substitution industrialization (ISI) period were concentration and agglomeration. Mexico City became a dominant consumption market and concentrated the most dynamic industrial and urban activities and decision making, becoming thus the primary metropolis of the country due to high rates of economic growth, its big captive market and attraction of migrant labor. Urban growth was fueled by economic and demographic dynamics. As can be seen in Table II.8, the city concentrated almost half of national industrial GDP during 1950-1980, while population increasingly located there, though not at the same pace economic activities did.

The carbon relevant results were:

- ☞ A contiguous and apparently uncontrolled urban growth outwards with two tendencies: The core area continued to be densely populated by working class people. While suburban areas grew up through both legal middle-income developments and irregular self-build settlements (Gilbert 1996, Aguilar and Ward 2003, Maps 1 and 3).

- ☞ Industrial growth of sectors such as food (23.2% of city's GNP), chemicals, plastic and rubber (15.6%), machinery and metallic (30.6%), and textile (10%, Hiernaux and Carmona 2003: 72). Manufacture companies were still located in the core area of the city, but the north (Azcapotzalco, Tlalnepantla, Naucalpan, Ecatepec) increased its share. Those activities experienced during the 1980s technological problems, such as inefficiency in the consumption of energy and high levels of contamination (see section II.2).

- ☞ Although the city was one of the best served of the nation in terms of urban infrastructure, services and transportation, it experienced recurrent deficits between the demands of those services on the one hand and state's ability to satisfy them on the other.

Diverse transformations sweeping around the world (e.g. new era of globalization and state reform, see section below) contributed to a new, region-based pattern, of urban development, with a "polycentric urban expansion of urban centers and sub-centers following a network pattern that tends to sprawl along major highways and/or railroad lines radiating out of the urban core. In this pattern mixed land uses are created in an expanded region, where traditional agriculture is found side by side with new housing projects, industrial states, large modern factories, recreational sites, and all sorts of suburban developments" (Aguilar and Ward 2003: 7, Maps 1 and 3).

Distant towns and locations are functionally linked to the main city which exerts a deep influence in their land use transformations and activities, in their consumption of energy and production of food. All this processes have three carbon relevant consequences:

- ☞ Passengers tend to travel longer distances to move from the locations of residence to their education, employment and recreation facilities (See Table II.9).
- ☞ Freight transport tends to move products to longer distances not only within MCMA, but also at the broader regional level, i.e. between Mexico City and its satellites.
- ☞ The city increases hence its ecological footprint on its satellites and surely on areas serving their carbon related needs (e.g. energy and food).

Table II.9: Commuting distances and times by public transportation

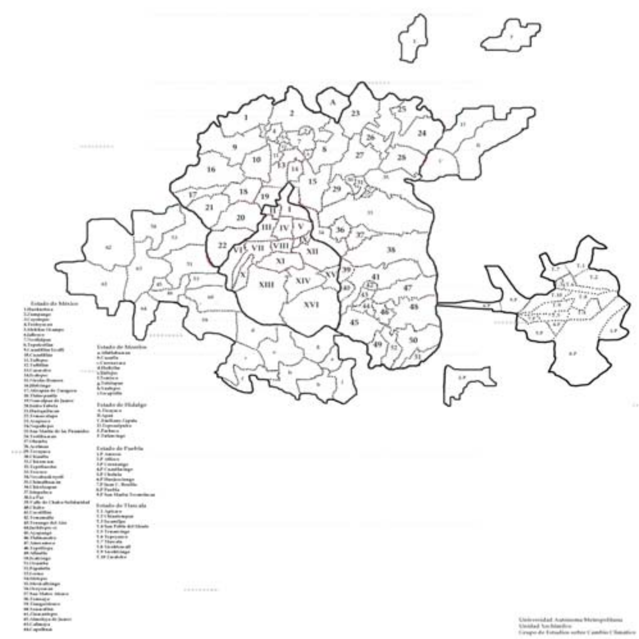
	1987			2000		
Mode of transport	Distance per trip (km)	Speed (Km/h)	Average time per trip (min)	Length of trip (km)	Speed (km/h)	Average time per trip (min)
Buses	3.5	16.8	12.5	5.6	16.7	20.1
Trolleybus	2.4	14.0	10.3	4.1	14.6	16.8
Minibus	ND	21.0	-	4.9	15.7	18.7
Metro	7.1	39.0	10.9	9.0	36.0	15.0

Source: OECD (2004: 34).

The region-based pattern of urban growth is related to the existence of three areas within the megalopolis: a) an *urban core* representing the old city (Mexico City), b) an intermediate ring and suburban built-up area corresponding to the continually constructed-space urbanized during the ISI development period, and c) the meta-region i.e. the corona extending beyond the boundaries of the metropolis.

Within the current pattern of urbanization the city experiences, on the one hand, a slight decline in industrial concentration and urban growth as a whole.

Map II.3: Mexico City Metropolitan Area



After generating almost half of the industrial GDP in 1980 the local industry for instance contributed 29 per cent in 1998 (Table II.1),. But not all sectors show the same behavior. As can be seen in Table II.1, financial and commercial sectors are more important in the Federal District, while manufactures in the State of Mexico have a higher share of the national GDP. The city continues to be the hub of the country, the main destination of foreign investment[16], and advance service and commercial activities as well. According to Hiernaux y Carmona (2003: 75), 60 percent of the 500 largest companies of Mexico are located in the city, have a national and international reach and belong to commercial and financial sectors. Mexico City is therefore a global city ranking 21st among world cities in 2000 (OECD 2004: 34).

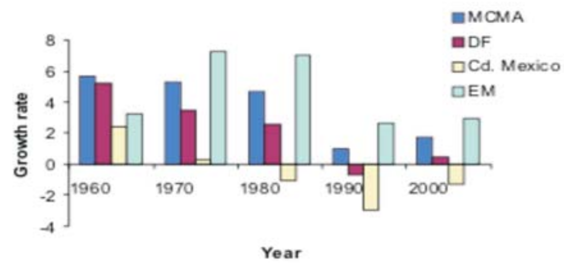
[16] After concentrating 64 per cent of foreign investment in 1994 Federal District and State of Mexico concentrated 61 per cent in 2000 (Correa 2003: 110).

Notwithstanding its position within the national economy, Mexico City is confronted to paradoxes when compared internationally. According to a cross country comparison of productivity and competitiveness of metropolitan regions (OECD 2004), city's real GDP per capita, a robust indicator of productivity, positions it 63 out of 66 metropolitan areas[17]. Three indicators of two intermediate drivers of GHG emissions, economic and social organization, relate statistically to city's real GDP, namely labor productivity[18], activity rate, and employment rate. "On average 72.3% of the difference in GDP per capita between the MCMA and the other metropolitan regions is explained by lower average labor productivity, 22.3% by a lower activity rate and the remaining 5.4% by a higher employment rate" (OECD 2004: 39).

City's low productivity relates to features appearing as crucial constrains of a carbon relevant restructuring of its economy, namely: a) low levels of human capital and research, of innovation and technology, and b) lack of competition of the economy creating an environment in which enterprises have reduced incentives to introduce new technologies and working methods.

The processes of territorial restructuring run parallel to another of economic fragmentation in which the most dynamic and globalized activities coexist with informal ones. In the meta-region for instance the globalized metropolitan expansion occurs within urban corridors concentrating corporate developments, industrial parks and residential areas. While urban sub centers, some times consolidating traditional towns once dominated by traditional activities, other times resulting from new (irregular) residential developments, concentrate a wide range of "services", function as dormitory towns for the city and as providers of cheap labor. (See section II.1).

Demographic dynamics which again do not match necessarily with economic ones experienced diverse changes during last two decades. The first is a slight decline in demographic growth. The MCMA experienced rates of population growth of 1.6, while population augmented 1.8 at the national level during the 1990s. There has been a visible decline of population in the core area (Mexico City in Figure II.8).



Source: INEGI, 1990, 1991, 1995, 1996, 2000

Working and middle class populations have migrated to metropolitan areas, nearby towns and to other parts of the country; urban periphery and peri-urban areas have hence undergone higher levels of population growth (Figure II.8). Those dynamics have been a key driver of city's pathways of urban growth and by this on city's trajectories of carbon emissions (e.g. increased commuting distances).

7.2. The weight of global processes

Two carbon relevant transformations took place in interconnected ways at global and national scales during the decades of 1980 and 1990: the consolidation of a new globalization era and the "reform of the state" (Gwynne and Kay 2000, Harris 2000). Different developments define globalization unevenly sweeping around the world. The first is the growth of investment, capital, money and financial services fostered by economic institutions such as the World Bank and the International Monetary Fund.There has been an expansion of trade promoted by private transnational corporations, government policy makers of industrialized countries and collective institutions such as the World Trade Organization. Regional trade zones have been established such as the North American Free Trade Area (NAFTA) and the European Community. Private businesses and the factories and farms they control have been relocated and reorganized with new production strategies such as "just in time".

[17] It is questioned in the OECD study whether it makes sense to compare Mexico City with metropolitan regions such as Boston and San Francisco with GDP per capita five times higher than that of Mexico City and with fewer population. But the comparison makes sense precisely because Mexico City's economic environment is no longer national, but international (OECD 2004: 62).

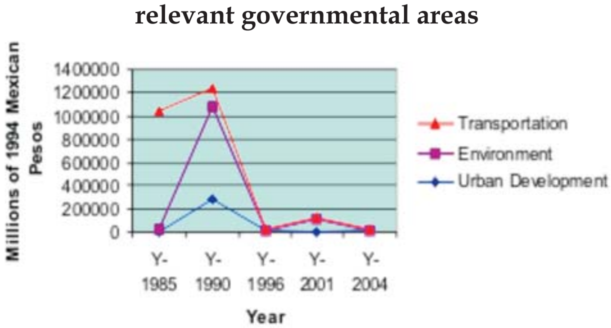
[18] Lower average labor productivity is the result of poor factors of production (e.g. skills, physical capital, human capital) and to a lesser extent of concentration on low productivity activities.

New technologies, (particularly high-tech electronic and biochemical tools, techniques and services) have been invented and diffused. Last but not least, “dozens of state-nations around the world have 'democratized'” and politics has been liberalized (Schaeffer 2003: 2-3).

The reform of the state focuses on five main areas: fiscal management and privatization of state firms aimed at reducing budget deficits, liberalization and deregulation of labor markets, and of trade and financial markets (Gwynne and Kay 2000). We will briefly describe what both globalization and state reform have meant for Mexico City's development pathways and emissions trajectories.

Globalization and trade liberalization are related to the re-localization of enterprises, to the reorganization of production and labor as well. Both are aimed at getting access to the “big market” (USA) rather than to Mexico-City's one. For instance the automobile industry has subsidiary offices in the Federal District, and at the same time production facilities such as Volkswagen in Puebla one of Mexico City's satellites manufacturing mainly for US and Canada. According to informal interviews with policy makers, the automobile industry, as main foreign investor in the city, exerts a strong influence on carbon-relevant decisions such as governmental regulations on emissions levels, and catalytic converters, as environmental authorities firstly “negotiate” with them the standards for vehicle emissions control technologies. The result has been that Mexico has standards lying more than two years behind the federal regulations of the United States (Molina 2002: 43).

Figure II.9: GDF's public expenditure in carbon relevant governmental areas



Source: Secretaría de Finanzas del GDF 1987, 1990, 1997, 2001, and 2004.

Regarding the Mexican state-reform, the reduction of budget deficits included not only the decentralization of responsibilities to state and local authorities but also the slashing of public expenditure in carbon relevant areas such as public transportation [19]. They comprised much reduced budgets and staff for sectors such as environment, urban planning and transportation, which find it increasingly difficult to undertake their by the way too many functions, subunits, and programs to allow effective policies (See Figure II.9). Aimed at eliminating inefficient and insolvent enterprises, thereby reducing public expenditure, privatization of state firms (such as the Ruta-100 Bus-System) is together with decreased public expenditures, one of the drivers of the shift in mode share from Metro and buses to minibuses and low capacity modes (Figure II.5).

Decentralization in Mexico City is related to the consolidation of a “balkanized” management structure (Aguilar and Ward 2003) of city's carbon related issues. Although the Environmental Metropolitan Commission, the Metropolitan Commission for Human Settlements and the Metropolitan Commission for Transport and Roadways have been created to deal with environment, land use and transportation respectively, they are confronted to monetary constrains, lack of staff continuity, insufficient decision making power, and other factors limiting their institutional capacity. Equally important are political factors (e.g. presence of diverse political parties governing at state and municipal level) which have resulted in the inability to embrace the city as a whole (see section II.8).[20]

Trade liberalization in Mexico was intended to make economies more competitive and outward looking. The goal of financial reform was to reduce government intervention, allowing for the operation of free markets increasingly influenced by global investors and speculators.

[19]Public expenditure on transportation for instance decreased 4.5% during 1981-2004. Some caveats on this data are to be mentioned: authorities constantly change the criteria to classify expenditure items. Therefore we made our own classification. Source (Commission of Road and Policy of Urban Transport and Planning of the Development of the Communications and the Transport 1981, 1982, 1983, 1985, 1987, 1988, 1989, 1990, 1992, 1993, 1996, 1997, 1999, 2000, 2001, 2003, 2004).

[20] The Federal District for instance is currently governed by a left-party the Party of the Democratic Revolution (PRD), while the Party of the Institutionalized

Together with the referred growth in investments and industrial relocation patterns taking place at the global scale, trade liberalization and financial reform impacted Mexico City. Both contributed to a process of both re-industrialization and location of financial and commercial activities along corridors such the Reforma-Santa Fe going from the urban core to the west (Hiernaux and Carmona 2003).

8. Carbon related policies

In this section we explore how policy makers have framed carbon emissions in Mexico City. We try to find out how they have articulated their policy goals to the design of strategies and actions. And which features of their institutional capacity let us explain the effectiveness - or not - of those policies[21]. We will focus on three policy areas deeply related to carbon: environment, transportation and land use. Two periods can be distinguished in the perception and management of GHG emissions in Mexico City: A prior one in which rather than being framed as such GHG releases were related to health considerations (1971-1982). During the second period lasting till the end of last century air pollution became a key public concern. Although we won't present in detail what happened since then, we can say that the beginning of the 21st Century has seen the consolidation of a more integrated framing of GHG emissions, in which more dimensions (e.g. energy, transport, urban growth) and scales (local, global) are included in the analysis, and climate change gets more attention although air quality is by far the main focus of interest and action (See for instance SMA 2004).

8.1. Prior management structure

During the first period 1971-1982, environmental, transportation and urban policies followed their own and in many ways diverging paths in terms of problem definition, design of policy strategies, and institutional capacity.

Health concerns dominated understanding and action in the environmental field, with the creation within the Secretariat of Health of the Sub-secretariat of Environmental Improvement under the administration of López Portillo,[22] which was in charge of measuring and regulating atmospheric emissions. The Federal Law for the Prevention and Control of Environmental Pollution (LFPCC) was passed in 1971, and focused on air pollution in terms of smoke and dust produced by "burning of rubbish, refineries, thermoelectric plants, mobile sources and asphalt plants" (Regulation 1971 of the LFPCC, art. 6th). Article 11th of the LFPCC focused on air-pollution's impacts on health and human life, but the Law did not include any consideration of civil responsibility (Regulation 1971 of the LFPCC).[23]

Local authorities of the Federal District designed and implemented diverse environmental strategies, instruments and actions. First centers for non-obligatory verification of vehicles were created in 1975-1976 by the General Directorate of Policy and Traffic of the FD.[24] The Government of the State of Mexico did not design any environmental regulation during the period. The first coordination authority at Metropolitan level, the Intersectorial Commission for Environmental Regulation, was founded in 1978 to control atmospheric pollution and elaborate the Coordinated Program to Improve Air Quality in the Valley of Mexico (1979)[25] and the Emergency Plan to Manage Events of Contamination in the Valley of Mexico.

Urban planning properly began during the 1970s[26] with the design of two laws and the creation in 1978 of the Coordinating Commission for Land and Cattle Farming in the Federal District (COCODA), responsible for rectifying the urban biases in planning by fostering rural development. The first Law of Urban Development of the Federal District (LDUDF, 1975) laid the basis to make mandatory the design of a comprehensive citywide plan and subplans.

[21]Following Willems (2003: 5), we understand institutional capacity as the features giving institutions the "ability to perform functions, solve problems and set and achieve objectives".
[22]First actions aimed at regulating air quality were undertaken during 1966-1967, and included the first atmospheric monitoring network operated by the Directorate of Industrial Health within the Secretary of Health.
[23] Regulations and Mexican Official Standards (NOMs) focusing on atmospheric pollution were issued to further develop the LFPCC.
[24]Monitoring centers measured CO y HC of vehicles which had been sent by policemen who found they were ostensible polluters.
[25] The program intended to control vehicular and industrial emissions, but it was not successful (Molina et al 2003:41).
[26] Prior to this, the concern was "economic planning that comprised a process of mutual adjustment led by a central guidance cluster of four major institutions: the Presidency, Ministry of Finance, Central Bank, and National Finance Institution" Pezzoli (2000: 166).

The already mentioned General Law of Human Settlements (LGAH, 1976) formally allowed for a consistent state intervention in the planning of city's settlements, as it included the principle of coordinating different levels of urban government. The Commission for the Conurbation of the Center of Mexico (CCCC)[27] published in 1978, within its Guidance Plan, an integrated study on regional infrastructure and environmental indicators.

All those actions had though, minimal impacts both on urbanization pathways and Metropolitan co-ordination, and served more as an ideological tool to enhance state control than as an effective effort. Environmental policies and city planning were constrained by the structure of city government (States and the Federal District, for instance had different legal and fiscal systems contributing to undermine city's capacity to deal at Metropolitan scale with any issue). Authorities' capacity was also affected by factors such as low budget (around 1 per cent of the federal budget) and almost inexistent decision-making power of environmental authorities. The institutional structure was made of diverse agencies with competing and overlapping responsibility for urban planning. Another limiting factor was the legal regime, a cross cutting issue explaining why land-use regulations are constantly negotiated, contested and changed in the city.

Transportation policies were mostly undertaken by organisms of the Federal District (DDF), such as the Secretary of Public Security responsible for transit management, concessions, permits and licenses, and COVITUR (Commission for Highways and Urban Transportation) involved in transportation and infrastructure planning. Rather than on environment, the main focus of transportation policies was on state intervention in the construction and management of infrastructure. It was a kind of "offer-oriented" or "predict and provide" scheme also dominant within the water sector. Transportation authorities were also responsible for the regulation of traffic (Islas 2000: 228-231). The nature of state interventionism is established in the Laws of General Highways of Communication of 1942 and 1995, according to which the state is responsible for providing transportation services, although it can grant them to private providers (Islas 2000: 236).

Authorities could undertake during the period first institutional steps aimed at managing carbon related issues, but those actions resulted in meager outputs. Different characteristics defined and limited the institutional capacity to deal with GHG emissions. A plethora of organisms at the federal, state and local level were involved in the management of transport, urban planning and environment, i.e. Sub-secretary of Environment, Ministry of Human Settlements and Public Works, as well as Department of Federal District and Government of the State of Mexico with their delegations and municipalities. Those agencies tended to focus on and react to specific issues, and could not address the array of causes driving them. They lacked appropriated harmonization of their programs and responsibilities, financial provisions for them to work together and as in the case of the environmental authorities, to work at all. Notwithstanding the existence of the Conurbation Commission of the Centre of the Country, governance features of the city (e.g. different fiscal and administrative systems of their entities) did not allow a metropolitan coordination of sectoral strategies. This headed for a "balkanized" management of city's carbon related issues, for the lack of a metropolitan organism able of embracing the city as a whole.

8.2. Emergence of environmental concerns, regimes' integrators?

Air quality as environmental focus

The passage in 1982 of the Federal Law of Environmental Regulation inaugurates a new, second era.[28] Air quality and pollution control become the main public concern, slowly related to broader dimensions in terms of problem definition, as can be seen by comparing how the problem is perceived by the designers of two programs: the Comprehensive Program against Air Pollution (PICCA 1990-1994) and the Program to Improve Air Quality in the Valley of Mexico (PROAIRE I 1995-2000). But there is

[27] Governmental bodies of the Federal District and the six states located within the Basin of Mexico were represented within CCCP.

[28] According to the Federal Law of Environmental Regulation local governments were in charge of enforcing regulations on atmospheric emissions by the transportation sector (particularly passenger cars). The Secretary of Urban Development and Ecology (SEDUE) was responsible for industrial emissions and coordinating efforts aimed at maintaining certain average and peak limits of atmospheric pollution at the regional level.

no consideration of carbon and climate change issues as such.

In terms of problem definition or framing rather than to a "simple cause-effect relation", like the ones stated in prior programs (e.g. burning resulting in air pollution), emissions of air pollutants are related in PICCA to diverse physical and technical factors, such as volume and quality of fuels, state of burning equipment, technologies for emissions control, state of land cover in surrounding rural areas, the thermal inversions characteristic of the Basin of Mexico, and chemical interactions affecting the atmosphere of the Basin (DDF 1990: 6-7). Socioeconomic or institutional drivers though were not included in the analysis.

PROAIRE I did introduced more socioeconomic dimensions. Its designers focused on the quality of the atmosphere, and stated that it depends on the quantity of pollutants, their physical/chemical reactions, as well as meteorological dynamics and the urban structure of the city. Later encompasses five factors: technology of vehicles and production facilities, urban and transportation structure, and amount of both commodities produced and energy consumed (DDF et al, 1996: 45). The designers applied a more economic neoclassic like analysis to explain air pollution. For them industrial, service, commercial and transportation sectors are utilitarian beings generating both "positive" and "negative" externalities, i.e. commodities and pollution respectively. Later is an externality because such activities affect without cost the load capacity of the atmosphere, and the health of the population (DDF et al., 1996: 71-72). This was the first program to offer health data, and relate epidemiological information to average and peak levels of pollutants.

There was also during the period a broadening in the scope of strategies to manage air quality. In the 1980s, actions incorporated the passage of the Law of Environmental Protection (1982) and of a more encompassing Environmental Law (LGEEPA 1988) that defined air quality related responsibilities for the three tiers of government similar to those issue in the Federal Law of 1982 (See section II.8.1). Both Federal District and the State of Mexico maintained authority over emissions from commercial enterprises, private cars, and public transportation, while SEDUE retained control over the industry and coordinating efforts. LGEEPA included new policy instruments such as ecological regulation of the territory, environmental impact assessment and environmental standards (NOMS).

Measures to reduce air pollution in the 1980s included the Coordinated Program to Improve Air Quality in the Valley of Mexico (PCMCA, 1979), "21 Measures to Control Air Pollution in the MCMC" (1986), "100 Actions needed to reduce pollution" (1986-1988), the Metropolitan Index of Air Quality IMECA (1986), and the Program to Manage Episodes of Atmospheric Contingencies (1988). Those actions relate to five issues (Table II.1), namely:

☞ *Institutional capacity*. An automatic air-system of 25 measuring stations began its operations in 1986 and was expanded during the period. Laws, rules and norms to control air pollution from automobiles and stationary sources were passed, and environmental standards tightened. Actions included the Global Study of Air Quality in Mexico City (EGCA) and the System of Epidemiologic Vigilance.

☞ *Production*. Economic instruments were designed to finance and induce pollution-control measures, as well as industrial relocation out of Mexico City. Economic instruments including credits (1980), fiscal stimulation (1987), and reductions of total taxes (1985) were abolished after some years (JICA 1991: 2-54). Authorities also presented the prospects for the construction of two industrial parks to relocate industries affected by the 1985 earthquake.

☞ *Technologies* received the highest priority with three actions: conversion of about 2000 state-owned buses to run on new, low emission engines; reduction of lead content and addition of MTBE in gasoline; and gradual substitution of heavy fuel oil by natural gas in major industrial facilities and two power plants (Valle de Mexico and Jorge Luque).

☞ *Behavior* was subject to two actions: Vehicle Verification Program of private cars (1988), and introduction of the No Driving Day ("*Hoy no circula*")[29] to reduce both traffic and emissions in days of critical ozone concentrations.

- *Transport* was targeted with one action: the extension of non polluting urban vehicles.

- *Consequences* for people. The already referred contingency plan was developed and enforced to avoid health consequences of air pollution; it included reduction of industrial activities on high pollution days and the No Driving Day.

Because of the economic crisis, and institutional constrains (such as lack of coordination among the Department of the Federal District, the Government of the State of Mexico and SEDUE), information about air pollution, its drivers and consequences was scarce, measures to reduce vehicular and industrial emissions announced in the PCMCA were not implemented, the construction of industrial parks not undertaken and the referred economic instruments abolished. Contrary was the case with actions focusing on institutional capacity, technologies and behavior which were implemented, have been strengthened and are currently part of policies aimed at managing air-pollution.

The already mentioned PICCA and PROAIRE I agglutinated the efforts to manage air quality during the 1990s. Former intended to reduce emissions of lead, SO_2, particulates, hydrocarbons, and NOx (DDF 1990: 42-43). The main objectives of PROAIRE I were to decrease the emissions of hydrocarbons, dioxide of nitrogen, and particulates; to diminish peaks and levels of pollutants, and augment the compliance with IMECA standards (Metropolitan Index of Air Quality); and to modify the overall distribution of pollutants (DDF et al 1996: 130). To accomplish them designers of PROAIRE I decided to focus not only on two targets traditionally addressed by PICCA (reduction of emissions by economic activities and vehicles, ecological land-restoration), but also to improve the transport system and integrate it to a new urban order, i.e. to integrate environment, land use and transportation issues (DDF et al 1996: 136-138). Most strategies to fulfill the objectives of both programs focused on following areas:

- *Technology.* Actions to improve the quality of gasoline, diesel and other fuels; introduction of two-way and three-way catalytic converters for new gasoline vehicles starting in 1991 and 1993 respectively, and of alternative fuels (LPG and CNG) for vehicles;

- *Production*. Measures comprised vapor recovery in distribution systems; shutting down of the refinery "*18 de Marzo*"; relocation of major industrial plants outside the Basin of Mexico; inspection of the most polluting industries; substitution of fuels; improving of combustion processes and of policy instruments (see actions addressing institutional capacity below);

- *Behavior* related actions encompassed inspection and a program for maintenance of cars through a centralized system, and use of the No Driving Day to induce fleet modernization;[30]

- Measures within *transportation* included introduction of 3,500 *R-100* governmental Buses, expansion of electric transport, replacement of old taxis, establishment of age limits for taxis and microbuses in the Federal District, and improvement of highway-systems;

- *Land use* was subject to strategies of urban and rural reforestation, fire prevention, and human settlement control in rural and conservation areas;

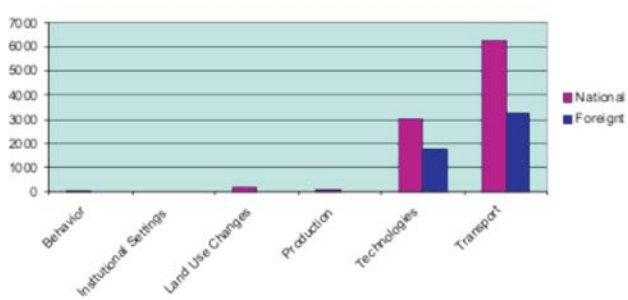
- Five measures relate to *institutional capacity*: design of emissions standards for vehicles, expansion and consolidation of the monitoring system (RAMA), promotion of air-quality research activities, implementation of a "System for Epidemiologic Surveillance", and evolution of instruments targeting industrial, commercial and service activities. Economic instruments such as fiscal incentives and tax exceptions continue to be part of such instruments.

[29] Implemented in 1989 by the Federal District, it forbad the circulation of all private vehicles one day a week according to the number of their license plates.
[30]This has been possible through the "extension of the program for public transport vehicles; the creation of the "Double no Driving Day" (Doble Hoy no Circula); and the exemption of new vehicles (the "double zero" sticker. Molina et

> While during the 1980s command and control instruments such as inspection of compliance with emissions standards were dominant, in the 1990s industrial regulations were "simplified" with the introduction of: a) a single environmental license for new enterprises, b) an annual reporting, c) self-regulation schemes, and d) Environmental Audit Programs. Those changes have the advantage of making "easier" (with less bureaucracy) for the enterprises to comply with regulations. But they run the danger of further weakening already faint regulations, as there is evidence that enterprises need not only economic incentives market and competence but also a sort of governmental and social pressure to undertake actions (Romero Lankao 2001).

A first approach to the issues receiving more attention in terms of perception and design of policy options during the 1990s shows a broadening in the scope of both dimensions included in the governmental perception of why and how emissions occur, and actions undertaken to manage air quality and by this carbon related emissions. But if we look for the issues receiving not only discursive attention but also financing, then that broadening becomes more apparent than real. Only two issues, technology and transportation, received most of the financing of the three environmental programs (PICCA 1990 - 1994, PROAIRE 1995-2000 and PROAIRE 2002-2010) for which we have information (see Figure II.10).

Figure II.10: Millions of Pesos Allocated by PICCA, PROAIRE I and PROAIRE II to Manage Carbon Related Issues (Millions of Mexican Pesos)



Source: PICCA (1990), SEMARNAP (1996), SEMARNAT (2003)

Many changes affecting institutional capacity took place in the second period. Organisms responsible for environmental issues were within and/or autonomous to Federal ministries during 1982-1994,[31] while the Secretariat of Environment Natural Resources and Fisheries (SEMARNAP), a cabinet-level authority, was created in 1994, which in 2000 became Secretariat of Environment and Natural Resources (SEMARNAT). The action highlights the importance given to air quality, GHG emissions, and other environmental issues. Federal authorities have been confronted though to management problems, such as insufficient human and financial resources for them to manage the myriads of environmental issues within their responsibility. SEMARNAT lacks the political and decision making power and staff continuity for them to adequately address their mandate (Tudela 2003).

Several measures were undertaken to foster institutional capacity at the Metropolitan, state and local level. Local environmental authorities extended their jurisdiction within the Government of the Federal District. At first they exerted limited tasks of vehicular verification, emissions inventory and management of environmental contingencies within the Directory for Pollution Prevention and Control, in the General Directory Urban Regulation and Ecological Protection (DGRUPE, 1985). The General Coordination for Prevention and Control of Environmental Pollution was created in 1990 and absorbed DGRUPE's responsibilities, while the Secretary of the Environment was founded in 1995, what again underscores the importance given to environmental issues at state level.

The Government of the State of Mexico got involved during the period in the management of air pollution through the creation in 1982 of the State Commission of Ecology, responsible for the program of vehicular verification designed by the Commission of Ecology of the Federal District. Then again the Secretary of Ecology of the State of Mexico is founded in 1991 with jurisdiction on emissions control from commercial activities and transportation.

[31]The environmental organism during 1982-1992 was the Sub-secretary of Environment within SEDUE. Two autonomous offices, the National Institute of Ecology (INE) and the Attorney General for Environmental Protection (PROFEPA) operated within the Secretary of Social Development (SEDESOL) during 1992-1994.

When passed in 1988, the General Law of Ecological Equilibrium and Environmental Protection forced local governments to issue state-level laws and municipal regulations. As a result both the Law of Environmental Protection of the State of Mexico and the Federal District were published in 1991 and 1996 respectively (Metropolitan Commission of Transportation and Highway, et al. 1990)

Regarding networking capacity, the Metropolitan Commission for the Prevention and Control of Environmental Pollution in the Valley of Mexico was created in 1992, and designed the PICCA, which offered a regional framework for pollution control. The Metropolitan Environmental Commission (CAM) was created in 1996 to coordinate the different levels of government managing all kind of environmental issues. Although CAM has succeed in achieving agreements among the three tiers of governments on programs dealing with air pollution in the Valley of Mexico such as No driving Day or the Vehicle Verification Program, it has not been able to fulfill its mission, namely to coordinate actions aimed at addressing the range of possible contributing factors of such emissions, as it lacks enough authority and decision making power, human resources, financing, and continuity of its staff for it to undertake its coordination role at the regional level and counteract the balkanized nature of managing in the city (Molina et al 2003: 54).

8.3. Urban planning and the “politics of containment”

Having its origins in the 1970s as a governmental strategy to intervene in human settlements, with the purpose of fostering economic growth, urban planning in the Metropolitan Area of Mexico City (MCMA) experienced two transformations during the 1980s: strengthening of ecological protection as argument for the primary zoning of the city, and consolidation of the politics of containment (Pezzolli 2000: 163-190). Ecological arguments are, since then, increasingly embedded in the establishment of laws, rules, programs and plans aimed at controlling and containing the horizontal expansion of irregular settlements. Containment actions include evictions, and have been also prompted by ecological disasters (explosions, flooding).

Those changes were not accompanied by any modification in the balkanized management structure of urban planning. Different agencies were in charge of drafting their respective programs. For instance, four programs were designed by the authorities of the Federal District during the period. The official name of three enacted in 1980, 1987-1988 and 1996, and also called Master Plans, was General Plans for the Urban Development of the Federal District. The fourth was the Program for the Urban Restructuring and Ecological Protection of the Federal District (PRUPE, 1983).

The Master Plans sought to control urban growth especially in the South of the Federal District , to densify urban areas by optimizing the occupation of zones presently underutilized, and induce population growth to locations inside the areas adequate to urban uses. As the Master Plan did, the Program for the Urban Restructuring and Ecological Protection of the Federal District (PRUPE) wanted to control urban growth, and to warranty ecological equilibrium by powering state intervention with option to sanctions and fines. The 1987 1988 Master Plan divided the Federal District in two zones: one for urban development and one for ecological protection and rural development. It established 38 Especial Zones of Controlled Growth (ZEDECS). The 1996 Master Plan proposed to densify the central delegations of the Federal District, slow down population growth in the Valley of Mexico, while fostering it in the surrounding cities located within the megalopolis.

Two programs were launched at the Metropolitan level. First, the Program for the Development of the Metropolitan Area of Mexico City and the Central Region (1983) which sought for a greater governmental control of urban growth “by more intensively exploiting investments and by establishing ecological and agricultural reserves vital for the city” (Pezzoli 2000: 175).

The second, the Program for the Ecological Regulation of the Metropolitan Area of the Valley of Mexico (1998), has two goals: to become an instrument for the coordination of all actors involved in the spatial and economic development of the MCMA and to reduce population growth within its most dynamic delegations/municipalities by both densifying population growth in the central-city area and fostering it within the regional ring of Megalopolitan cities (GDF 2003: 52-53). This program was designed within the framework of the Human Settlements Metropolitan Commission, created in 1995 through an agreement among the FD, the EM and the Secretary of Social Development (SEDESOL), with the intention of developing a more cross-sectoral coordination of urban sprawl.[33]

Although we still need to better review urban planning programs designed by the state of Mexico, we can state that zoning and state intervention as strategies to manage urban growth were confronted to some limitations. When the programs were launched, irregular settlements already existed in the buffer and even ecological zones, what made their inhabitants violate a number of laws and regulations, put them in an illegal status, opened the doors to processes of social control and negotiations between participants, gave greater relative power to the implementing bureaucracies, and allowed for unilateral actions to take place. The effects of the programs were minimal as irregular settlements continued to expand in both buffer and protection zones, as can bee seen in land-use dynamics of the south area of the Federal District (SMA 2003). The ineffectiveness of urban regimes results from the fact that the programs did not target the real mechanisms of land allocation and urban growth in Mexico City. As in other Latin American Areas housing has increasingly taken place through informal self-help practices outside legal regulations (Gilbert 1996, Pezzoli 2003), as high costs of legal land and low levels of income make these the only way for most dwellers to get access to land.

8.4. Transportation: between state intervention and liberalization

Contrary to what happened till 1997, when transportation policies were mainly proposed by organisms of the Federal District (Islas 2000: 228), organisms belonging to other governmental levels have been increasingly involved in managing this issue since then: the Government of the State of Mexico, the Metropolitan Commission for Transport and Roadways (COMETRAVI), and the federal Secretary of Communications and Transport (SCT).

The SCT intends to build a "megapolitan" ring connecting the satellite cities of Toluca, Jilotepe, Tula, Pachuca, San Martín, Cuautla and Cuernavaca. It plans to establish diverse toll-facilities in the region aimed at allowing intercity traffic to bypass the congested parts of the city. Another measure is the establishment of "logistics platforms" or freight distribution centers intending to lighten fright traffic congestion (Molina et al 2003: 273). The governments of DF and EM also intend to construct roads, highways, bridges parking and traffic signals, to expand the elevated train and extend the Lines 7, 8 and 12 of the Metro. One of those developments, the controversial elevated highways (*segundos pisos*) is underway, and has a strong political component: The major of the Federal District, Andrés Manuel López Obrador, from the leftist PRD, intends to compete for the presidency in 2006, and builds the *Segundo Piso* to attract the support of middle and upper class constituencies.

Data gathered so far let us conclude that the management of city's transportation issues is confronted not only to features of our legal regime (administrative mechanisms and negotiations between authorities and their targets), but also to injunction and policemen' inability to make drivers obey the law. Two other contradictory processes are also relevant: on the one hand the need for coordination and on the other hand a decentralization ethos.

Injunction as temporal protection against the order of any authority has been used by taxi drivers and owners of illegally imported vehicles to illicitly circulate with this protection temporally emitted by a judge or tribunal.

This has contributed to the explosive growth of the so called "*chocolate*" or illegal cars, not only by private owners but also by taxi and *colectivo* - drivers.

As of the contradictory tendencies to decentralize and coordinate, on the one hand responsibilities such as provision of services (e.g. *Ruta-100* Buses) and management of local traffic have disappeared and been transferred to local authorities respectively.

[33] Since its creation in 1995, the Metropolitan Commission of Human Settlements has been particularly active in urban planning. It has elaborated the Program of Urban Development in the Valley of Mexico's Metropolitan Area, the Program of Priority Actions in the Huixquilucan Cuajimalpa Metropolitan Integration Strip, the Program of Priority Actions in the Azcapotzalco Tlalnepantla Metropolitan Integration Strip, the Bases to Evaluate the Program of Urban Development in the Valley of Mexico's Metropolitan Area, the Technical Reaches for Actualization of the Program of Urban Development in the Valley of Mexico's Metropolitan Area, the Metropolitan Program of Land Supply and Regularization of Land Property, finally the Study for the Formulation of Programmes for the Advantage of Empty Lots. (OECD, 2004:107)3

Transportation was deregulated and the state rolled back from his interventionist role (what contributed to processes such as the proliferation of the "*peseros*" or "*colectivos*".[34] On the other hand attempts have been undertaken to create sector-specific regional mechanisms and management organisms, such as the Metropolitan Commission for Transport and Roadways (COMETRAVI). The institutional capacity of this organism though is limited by lack of a permanent source of financial resources (such as a trust fund), and by the more consultative than executive nature of its decision making power.

9. Concluding remarks

Mexico City, as the hub of the country, has increased its consumption of energy and its carbon emissions during last years. Contrary to what happens in other urban-industrial heartlands (e.g North-Western Ohio USA), where industry is the main emitter, transportation is the main releaser of CO_2 equivalent emissions followed by the industry and the residential sector.

Transportation has been affected by processes operating at different scales, such as city's demographic, physical and economic dynamics and retrenchment of the state in its role as developer, manager and regulator of the sector. It has undergone different carbon relevant changes: rapid motorization, decline of public transport, and important modal shifts from high to middle and low capacity vehicles. Authorities have tried to keep pace with city's massive expansion and built transport infrastructure. But the growth of the city has outpaced such efforts. Most of the infrastructure is concentrated in the Federal District, and is confronted to diverse problems (e.g. variations in road capacities and continuity, narrow and old streets, lack of adequate space to afford for left turns and underpasses at critical intersections). These elements contribute to congestion problems and by this to CO_2 emissions.

The average age of the fleet has augmented, though an increasing proportion of cars are equipped with catalytic converters. This technological issue results in key carbon problems, as the older the car, the lower the engine performance, the lesser its chances to be equipped with catalytic converters and the more it pollutes. Private cars have a high share of the total fleet (72.8%), but only contribute 19.9 per cent of the 29.5 vehicle trip segments daily made in the MCMA. Private autos release 40.8 per cent of CO_2 equivalent emissions, while public transport undertaking 82 percent of those trip segments emits 25.9 per cent. This allows for a management recommendation. Rather than private transport, which does not serve the necessities of a higher proportion of users and contributes most to GHG emissions, Mexico City needs both a better public transportation system and governmental strategies aimed at making it more attractive. Delivery and freight vehicles release 32.6 per cent of city's GHG generated by transportation. Industrial and commercial activities' share is hence higher than officially acknowledged. Both sectors should be therefore subject to a more systematic management and control of their emissions.

Middle to upper sectors have beneficed from changes in mode share, but permanently experience city's congestion. Most auto trips are originated in wealthier areas, which surely have a higher per capita contribution to CO_2 emissions by the transportation sector than officially accounted. Poorer sectors using middle and low-capacity cars have a smaller per capita contribution to GHG releases than middle and upper sectors. But features such as aging of the fleet, lack of and/or not enough maintenance result in higher proportion of emissions per passenger kilometer compared to high-capacity public transportation modes. This calls for subsidies and other policies aimed at renewing the fleet.

Diverse characteristics of public transport (e.g. lack of safety as well as low comfort and speed) make it unattractive for users. This sharply reduces the incentive to use middle- and high-capacity modes. Here is where low-capacity modes have been especially helpful, by moving people on demand to the embarkation points and from the disembarkation points.

Industry, city's second emitter, has also been transformed during last years. Some of the most dynamic industrial sub-sectors (chemicals, agribusiness and machinery), are also the most polluting. Manufacturing experiences an increasing economic fragmentation, and a very tiny process of de-concentration and relocation of some production stages, not of corporations' subsidiaries. Fragmentation may result in a differentiated

[34] According to Molina et al (2002: 243), "originally *colectivos* were shared sedan taxis operating on fixed routes; over time the fleet evolved into vans (i.e. 12-seaters) and now minibuses (up to 25-seaters)".

contribution to carbon emissions by big, middle and small companies. It may also be related to a differentiated capacity to comply with carbon related regulations. Industrial de-concentration contributes to the functional influence of the main city on remote municipalities (ecological footprint).

As of the residential sector, we also suggest that high levels of social segregation in the MCMA are linked to a differentiated contribution of households to both energy consumption and GHG emissions. The equity issue should hence be included in the analysis of the complex relationships among population growth, increased standards of living, and higher GHG emissions. Land use changes have been driven by urban growth, especially by the increase in the number of households. Households occupy three fifths of the urbanized area both in irregular settlements for the poor and real state developments for high income families.

GHG emissions by transportation, industry and households have been driven by diverse transformations operating at diverse scales (e.g. new era of globalization and state reform). Those changes have also contributed to a new, region-based pattern, of urban development. Distant towns and locations are functionally linked to the main city which exerts a deep influence in their land use transformations and activities, in their consumption of energy and production of food. All this processes have following carbon relevant consequences: increase in commuting and in freight transportation distances, and broader ecological footprint of the city on its satellites and on areas serving its carbon related needs of energy and food.

Notwithstanding the city keeps its position within the national economy, it is confronted to a big paradox when compared internationally: it has a low productivity. This relates to features appearing as crucial constrains of a carbon relevant restructuring of its economy, namely: a) low levels of human capital and research, of innovation and technology in carbon related issues such as consumption or production efficiency, and b) lack of competition of the economy creating an environment in which enterprises have reduced incentives to introduce new technologies and working methods.

Demographic dynamics experienced diverse transformations during last two decades. The first is a slight decline in demographic growth. There has been a visible decline of population in the core area. Working and middle class populations have migrated to metropolitan areas, nearby towns and to other parts of the country; urban periphery and peri-urban areas have hence undergone higher levels of population growth. Those dynamics have been a key driver of city's pathways of urban growth and by this of city's trajectories of carbon emissions.

Globalization and trade liberalization are related to the re-localization of corporations and the reorganization of production and labor as well. The presence of such corporations lets us explain why some carbon relevant policies are not locally decided. The automobile industry for instance exerts a strong influence on governmental regulations on emissions levels, and catalytic converters. The result has been that Mexico has standards lying more than two years behind the federal regulations of the United States.

Diverse efforts have been undertaken to manage carbon related issues in Mexico City. Agencies have been set, laws and regulations issued. Air pollution has been the main public concern. More dimensions (e.g. energy, transport, urban growth) and scales (local, global) have been recently included in the analysis. But if looking for the issues receiving not only discursive attention but also financing, then that broadening becomes more apparent than real.

Only two issues, technology and transportation, received most of the financing of last environmental programs.

Environmental policies, transportation and city planning are constrained by the organizational structure of city government. States and the Federal District, for instance have different legal and fiscal systems contributing to undermine city's capacity to deal at Metropolitan scale with any issue. The institutional structure is made of diverse agencies with competing and overlapping responsibility for urban planning, environment and transportation. Those agencies tend to focus on and react to specific issues, and can not address the array of causes driving them. They lack appropriated harmonization of their programs and responsibilities. They have insufficient financial provisions for them to work together and as in the case of the environmental authorities, to work at all.

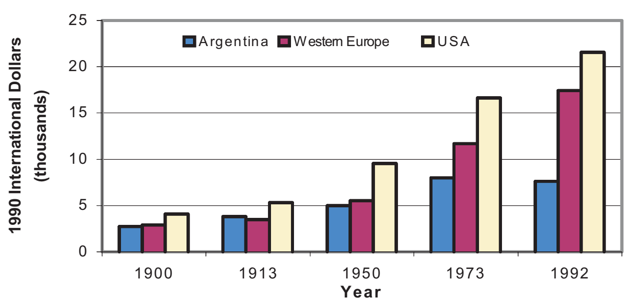
III. Mendoza and Buenos Aires

Enrique Puliafito, Mariana Conte Grand*, Bárbara Civit, Fabián Bochaca, Fabián Gaioli and Pablo Tarela

1. National context

Argentina used to be one of the leading countries of the world, as regards economic development and standards of living. The 20th century began with great perspectives, since Argentina was governed by a model based on free trade (the country was one of the main exporters of crops, as it is relatively abundant in land). This can be proved by the data on economic indicators shown in Figure III.1 At the beginning of the last century, Argentina's per capita GDP (measured in 1990 International Dollars) was similar to those of the Western European countries. As well, the economic standard of living in the United States of America did not vary much from Argentina's welfare, being USA's per capita GDP (only) 49% higher. However, as time went by, the gap between these countries and Argentina expanded, as the latter's output was considerably overcome by the Western European countries and USA in the last measure (their per capita GDP was 129% and 183%, respectively, above Argentina's record in 1992).

Figure III.1: World economy, per capita GDP



Source: Maddison (2005).

After the "modernization" of the economy during Carlos Menem´s presidency in the 1990, several public enterprises were privatized, the degree of openness significantly rose and prices became stable. This led to a "boom" until 1998, after which the economic activity began a declining process. In 2001, Argentina suffered its worst financial collapse. In December of that year US$ 20,000 millions flew away and deposits were "frozen" in financial institutions. After that, unemployed but also Argentina´s middle class protests led to the resignation of the President Fernando de la Rúa. Following that decision, Argentina had 3 presidents in 1 week. The resigning one, Adolfo Rodríguez Saá and Eduardo Duhalde. The second one declared the defaults of US$ 80,000 millions of Argentina's sovereign debt. Then, latter ended with the convertibility of the peso and dollar (which had been the basis of the stability of the 90s), but led the country in peace to new elections in April 2003.

In the 2001-2002 "crisis" the exchange rate regime was disrupted, prices went up and there used to be great uncertainty about the future of the country. However, in a favorable international context, and with the new president (Nestor Kirchner) Argentina's economy has recovered as shown in Table III.1 (real GDP grew about 9% in 2003).

Table III.1: Argentina's real GDP growth rate (1994-2003)

Period	Average growth rate (%)
1994	5.84
1995	-2.85
1996	5.53
1997	8.11
1998	3.85
1999	-3.39
2000	-0.79
2001	-4.41
2002	-10.89
2003	8.84

Source: INDEC (2005) and Secretaría de Programación Económica (2005).

1.1 Socioeconomic and demographical dynamics[1]

As regards to the leading sectors of the economy, manufacturing together with the provision of services were the main activities, accounting for more than 40% of Argentina's GDP (Table III.2). Transport, electricity, gas and water, finance, mining and services emerged as the most dynamic sectors, having average annual real growth rates above that one of the overall economy.

* I would like to thank Darío López Zadicoff and Rong Quian for their research assistance, Sebastián Auguste and Guillermo Bermúdez (Fundación FIEL) for their suggestions regarding urbanization rates. The views and opinions expressed in this publication are those of the authors and are not necessarily those of the Universidad del CEMA.

[1] Some of the data are displayed for 1980, 1991 and 2001, because these are periods in which national census took place.

Agriculture did not appear as one of the most important sectors neither exhibited as a dynamic activity during 1980-1999. In fact, its average real growth rate was the only one to be negative in the sample analyzed (Table III.3).
On the other side, regarding income distribution, the data displayed on sixteen urban agglomerates[2] in Argentina (Table III.4) show that inequality had slightly grown between 1992 and 1997.

Table III.2: Argentina's GDP by sectors

Sectors	Share of real GDP (%, average 1980-1999)
Industry	21.2
Services	20.7
Finance	17.6
Commerce	16.2
Agriculture	8.6
Construction	6.2
Transport	5.9
Electricity, gas and water	1.9
mining	1.7

Source: INDEC (2005).

Table III.3: GDP growth rate in Argentina (breakdown by sectors)

Sectors	Annual real growth rate (%, average 1980-1999)
Transport	5.48
Electricity, gas and water	5.15
Finance	3.64
Mining	2.74
Services	1.70
TOTAL	1.68
Commerce	1.35
Construction	0.20
Industry	0.07
Agriculture	-0.84

Source: INDEC (2005).

Table III.4: Income distribution in Argentina

Share of population (% cumulative)	Share of income (%, cumulative) 1992	1995	1997
10	1.6	1.3	1.2
20	4.3	3.8	3.5
30	7.9	7.1	6.6
40	12.2	11.1	10.5
50	17.4	16	15.3
60	23.8	22	21.4
70	31.6	29.4	28.9
80	41.5	39.2	38.7
90	55.6	54	53.5
100	100	100	100

* Adjusted income (per equivalent adult income and household scale economies) see FIEL
Source: FIEL (1999).

As displayed in Table III.5 the population in Argentina grew at an average annual rate of 1.41% and 1.05% in the 80s and in the 90s, respectively. Of approximately 36 million inhabitants, almost 14 million people live in the Buenos Aires Metropolitan Area (38% of the total population).[3] The fourth most populated location, Ciudad de Buenos Aires (after Great Buenos Aires, Córdoba and Santa Fé) hosts about 8% of the total people living in Argentina, while Mendoza appears in the fifth place with 4.35% of the population (INDEC 2005). However, if we consider population relative to surface, Ciudad de Buenos Aires owns the highest density (having almost 14,000 habitants per km^2), while the city of Mendoza has about 2800 habitants per km^2.

Table III.5: Population and population growth rates in Argentina

Year	Population	Average annual growth rate (%)
1980	27,949,480	
		1.41
1991	32,615,528	
		1.05
2001	36,223,947	

Source: INDEC (1995).

When taking into account the population growth rate in the different areas, Ciudad de Buenos Aires appears to be the only area which lowered its number of habitants in the 1980-2001 period (-0.68%), influenced by the decline of population between 1991 and 2001 (-0.26%) due to migration to suburban areas closed neighborhoods (called "countries") due to improvements in road infrastructure but also to security reasons. Finally, the most populated argentine provinces (Buenos Aires, Córdoba and Santa Fe) show remarkable low population growth rates (around 1%), while Mendoza´s population growth rate for the whole period was 1.32%

[2] Tierra del Fuego, Río Gallegos, Comodoro Rivadavia, Buenos Aires, La Plata, Neuquén, Santa Rosa, Mendoza, Córdoba, Rosario, San Juan, Paraná, San Luis, Tucumán, Salta and Jujuy.
[3] Many indicators are displayed for this zone.

Argentina has experienced a significant increase in its urban population during the last decades, especially in 1980-1991 when urban population grew at 2% (annual average rate). Moreover, the urban to rural ratio showed a remarkable rise. While in 1980 for every person who lived in the country there were 4.8 people living in the city, in 1991 for every 1 "rural" person cities hosted 7.6 people (see Table III.6). This result was not only a consequence of the growth of cities, but also was explained by the constraint of the country. Although the 1991-2001 interval also showed an increase in the urban to rural ratio, the rise was slighter due to the fact that urban population grew at a moderate rate and, as well, the country also expanded.

Table III.6: Urban and rural population in Argentina

year	Urban population	Rural population	Average annual rate of growth (%)		Urban to rural ratio
			Urban	Rural	
1980	23,142,169	4,807,311			4.8
			2.02	-2.15	
1991	28,832,127	3,783,401			7.6
			1.16	0.24	
2001	32,347,985	3,875,962			8.3

Source: INDEC (2005).

1.2 GHG inventory and recent emission trends in Argentina

The information on Argentina's Greenhouse Gases (GHG) inventory and emission trends, reported in this chapter has been presented by the Argentine Government as Country Report to the United Nations Framework Convention on Climate Change (IPCC) under the title of *"Revision of the First National Communication Inventory"*, Secretariat for National Resources and Sustainable Development, October 1999[4]. We will proceed to present only a short summary of this National IPCC Report (Arg-1997) to understand emission trajectories of the two selected urban centers, Buenos Aires and Mendoza.

Before we go into the details, we will introduce an important parameter. The GHG have different capacity to increase the greenhouse effect in the atmosphere, based in their radiative impact and their atmospheric life time. To compare all gases, we need to introduce a parameter called global warming potential (GWP), where the reference gas is carbon dioxide CO_2 with a potential value of one. Table III.7 presents the GWP for main gases. For instance, one molecule of methane impacts 21 times more than a CO_2 molecule. The equivalent weight (emission) of an ensemble of GHG is normally given in millions of metric tons of carbon equivalent (MMTCE).

Table III.7: Global warming potential for some gases

(IPCC 1996, for a 100 years horizon)

Gas	Global warming potential (GWP)
Carbon dioxide	1
Methane	21
N_2O	310

Source: IPCC (Arg. -1997).

Figure III.2: CO_2 emissions by end-use sector

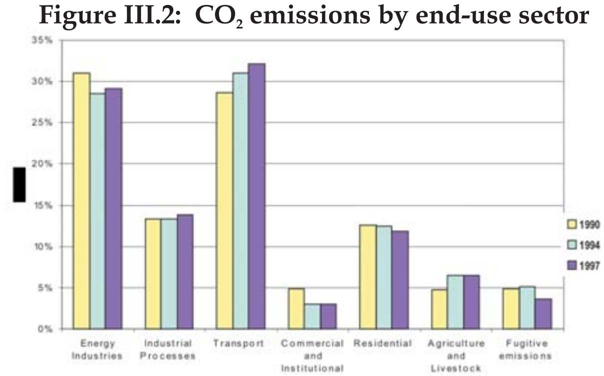
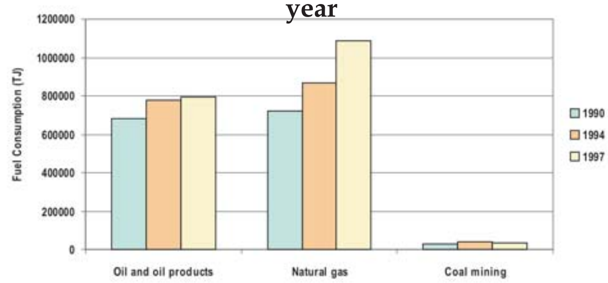


Figure III.3: Fuel consumption in TJ by fuel type an year



Source: Arg-(1997)

[4]This document presents the inventory for 1997 and gives an updated revised version of emissions for 1990 and 1994. The interested reader may find detailed information on the emissions and trends for carbon dioxide, methane, nitrous oxide, hydrochlorofluorocarbons, perfluorocarbons and sulphur hexafluoride, and ozone precursors such as carbon monoxide, nitrogen oxides, N2O, and Non-Methane Volatile Organic Compounds. Hereon, we will reference this document as (Arg-1997).

1.3 GHG emissions by sectors

By analyzing Figure III.2 it is possible to draw the following general comments:

a) Energy production has a growing participation in GHG emissions, accounting for 50% of total emissions for the year 1997. Most of these are Carbon Dioxide emissions. Emissions are the result of fuel consumption, electricity generation and transportation.

b) Emissions from Agriculture and Livestock have a very significant share, latter amount to roughly 35% of the total, and are mainly methane emissions, but nitrous oxide emissions are also important. Agriculture produces nitrous oxide emissions from soil management, while methane emissions from rice cultivation are relatively small.

c) Manufacturing contribution is relative small, and comes mainly from the iron and steel production, as well as cement.

d) Emissions from waste management are as important as the industrial sector. This sector has a relative increasing role from the urban perspective.

E) GHG emissions increased by 13.7 percent during the 1990 -1994, and by 6.2 percent during the 1994- 1997, resulting in a total increase of 20% for 1990-1997. It should be mentioned, that there was a strong recession during 1990, and year 1992 showed the beginning of a significant economic growth, which led to an increase in GHG emissions, although at a lower rate. This economic recover has slowed down since 1998 and produced a steep decline in the trend of the GHG emissions. On the other side, lower emission rates relate to a more efficient thermal generation of electricity (combined-cycle plants); the replacement of vehicles with more efficient ones, and the reduction of the cattle population.

Figure III.3 shows the fuel consumption by fuel type. The fuels used in Argentina are mainly oil products and natural gas, roughly in an equivalent proportion, with a negligible contribution from mineral coal. Natural gas has an increasing participation in the fuel market, both for energy production and transportation. Energy industries utilize natural gas (combined-cycle technologies), followed by oil. Manufacturing also uses mainly natural gas, and to a lesser extent, oil. Natural gas is also the main fuel for the commercial, institutional and residential sectors. Transportation uses oil products, and a smaller yet growing proportion of natural gas. Agriculture and forestry utilize almost exclusively oil products. Note that emissions from the energy industries are separated from the transportation emissions. CO_2 emissions are by far the most important GHG from the energy production sector.

Emissions from the industrial sector arise from the consumption of fossil fuels, and from the process itself. CO_2 examples are the cement and lime manufacturing, limestone and dolomite use, ammonia production, iron and steel production, ferroalloys production and aluminum production.

Of the wide variety of hydraulic cements produced in Argentina, the type known as Portland cement is by far the most important, and the data presented in the country inventory (Arg-1997) refer solely to this type. Limestone is the main element in its manufacture, this being the only source of CO_2, which constitutes its principal component. CO_2 emissions result from the production of clinker. Another gas arising from the manufacture of cement is SO_2.

GHG within the **transportation sector** relate to vehicles moving goods and passengers in all transport modes. Most of these emissions arise from the combustion of oil products, with a smaller but increasing contribution from natural gas. While emissions in the residential, commercial and institutional sectors come from the combustion of natural gas; a smaller portion, in oil products, and an almost negligible one, in biomass consumption.

Agriculture and livestock are responsible for 65% of total methane emissions, the principal source being enteric fermentation in domestic livestock, especially bovines. The digestive process of animals releases methane produced by microbes present in the digestive system. Ruminants have a digestive system in which the rumen is an important source of methane emissions. Bovine cattle are responsible for 95% of these emissions. The management of livestock manure produces methane emissions due to anaerobic decomposition, especially in liquid-based manure systems. In Argentina, only swine manure is significant in terms of methane emissions. Other less significant sources are rice cultivation and the burning of agricultural residues. Most of the CO_2 emissions of the sector are originated by the use of vehicles and energy production.

Nitrous oxide is produced naturally in soils through the microbial processes of nitrification and denitrification. Agricultural activities may add nitrogen to soils, thus increasing the amount of nitrogen available for nitrification and denitrification. Some crop residues are difficult to decompose, which has made their burning a common practice. Other crops, such as sugar cane, are burned previous to their manual harvesting. These practices are currently declining, and they constitute minor sources of emissions.

Forestry contributes to the net sequestration of carbon. In managed forests, plantations contribute to the uptake of carbon, while native forests have an almost balanced net flux. The conversion of forests to agriculture produces emissions of the same order as those of managed forests, but in a smaller proportion. Finally, the natural regeneration of forests in abandoned lands produces a significant uptake of carbon. Except for plantations, there are considerable uncertainties associated with emissions and sequestration of carbon.

Fugitive emissions from methane found in mineral coal are relatively small, given the existence of a single coal mine. Gas and oil systems produce a significant amount of fugitive emissions through venting. Also emissions arise from the production, processing, transportation and distribution of natural gas. CO_2 emissions arise from flaring and from the combustion of CO_2 contained in natural gas, which either cannot be used productively or is flared at oil and gas production facilities. Methane is the main component of natural gas. Fugitive emissions occur during the production, processing, transport and distribution of natural gas. Given that natural gas is present in oil wells, the processes involving oil also produce emissions. The economic growth between 1990 and 1997 resulted in an expansion of oil and gas activities, which in turn produced an increase in fugitive emissions. Methane emissions from coal mining originate in the release of the gas trapped in the coal. The release of methane continues during the post-mining process. In Argentina, there is only one underground mine, which produces sub-bituminous coal. Local demand is therefore completed with imported coal. These emissions are negligible.

Waste from most of the organic matter generated or utilized by man is deposited in large disposal sites, which can be of two types: open dumps or sanitary landfills. Open dumps are large accumulations of garbage that are generally deposited in the open, where the conditions for the formation of methane are more difficult. On the other hand, in sanitary landfills there is a systematic treatment of waste, which includes compaction for a better use of available space, thus fostering the necessary conditions for decomposition in the absence of oxygen, and the consequent generation of methane and its emission into the atmosphere. Treatment systems of liquid waste (human sewage and industrial wastewater) are also significant sources of methane and nitrous oxide emissions.

2. The city of Mendoza

The Province of Mendoza, located west of the national territory, and adjoining the Andes Mountain Range, is one of 23 provinces making up the Argentine Republic. Its most distinctive feature is that most of its territory about some 250.000 km^2 is arid or semiarid, with annual rainfalls ranging 220mm, the main exception being the man-made oases (Northern Oasis, Central Oasis and Southern Oasis) which have developed through the exploitation for irrigation and drinking of its main five rivers, all of them with annual modules lower than 50m3 where almost the totality of Mendocinians live. The total irrigated oases area does not exceed 3% of the provincial territory and is equivalent to that of the Great Buenos Aires Metropolitan Area. Almost 70% of Mendoza's population is located in the Northern Oasis, the largest of them with around 900,000 inhabitants, a population concentration ranking fourth amongst the Argentine cities.

Furthermore this urban center (33S, 68W, 750 m. a. N. s. l.) is the main city in western Argentina and the capital of the Argentine Province of Mendoza, located 1050 km west from Buenos Aires and only 380 km east from Santiago de Chile. It is formed by six municipalities: Mendoza, Las Heras, Guaymallén, Godoy Cruz, Luján and Maipú with an urban extension of approximate 370 square km and an average population density of 2800 hab/km^2.

The Province of Mendoza participates around 4,5 % of the national GDP[5], while the metropolitan area reaches the 2,5 %.

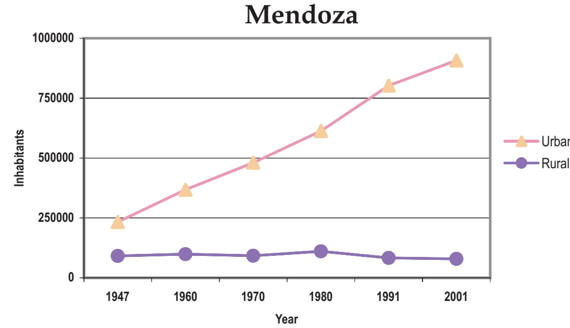
As many other regions, the city faces expanding urbanization, with traffic congestion, increase in air pollution, and loss of green or agricultural space (Puliafito 2003). The main industrial sources relevant to carbon emissions are located in three areas: a) an oil refinery, a petrochemical industry and a power plant; situated SW of the city; b) two cement industries and other minor sources on the north edge; and finally c) the agro and food production mostly located on the east side. Pollution emitted from private and public vehicles is the main responsible for worsening the air quality in the downtown (central) area. Particulate and gaseous emissions of pollutants from industries and auto-exhaust are responsible for rising discomfort, increasing airway diseases, decreasing productivity and the deterioration of artistic and cultural patrimony in this urban center.

2.1 Socio-demographic dynamics

One of the most significant facts constitutes population aging. (A population considers itself aged when the proportion of its inhabitants of 65 years and more, surpasses 10%.) That proportion had changed in Mendoza, from 4.2% in 1960 to the 7.7% in 1991, and to 9.8% as projected values for the 2010. The evolution of the population of Mendoza, between years 1970 and 2000, presents a constant disminution in the population growth. In the first decade (1970 - 1980) this rate was of 21%, one decade later descended to little more from 19%. The growth considered between the two censal years (1991 and 2001) has been only of 12.6%. This diminution of the intercensal growth also appears associated to social, economic and cultural factors tied to migratory processes and urbanization. Figure III.4 shows urban population growth to the detriment of rural population. Table III.8 summarizes key social and economic indicators for the Mendoza metropolitan area, while the proportion of the provincial participation to the national GDP has remained about constant, the city has increased its participation, accentuating the centralization and the urbanization process.

The urbanization rate of the Province is higher than 80%. The group of municipalities that form the geographic surroundings of the Great Mendoza reaches 8 urban inhabitants by each rural one, representing 89% of urban population. In comparison, in two extended municipalities of the south oasis, San Rafael, and Malargüe there are only 3 urban ones by each rural. The districts of the north oasis represent the most important poles of development of the Province, and of greater concentration of urban population.

Figure III.4 Urban and rural population in Great Mendoza



Source: DEIE: Direction for Statistics of the Mendoza Province; INDEC Argentina National Statistic Office.

The Great Mendoza tends to grow rapidly throughout the years, promoted by the concentration of resources and investments. In the XIX Century Mendoza had less than half of the Province population but today has reached two thirds. This tendency appears to be steady for the comming years or decades and will deepen the nonwished effects of urban concentration: increased pressures on services, atmospheric pollution, insecurity, health, housing and transporation; increased costs of services and loss of competitiveness, which will lead to a loss in the quality of life.

The urbanization process has followed well established patterns, (Molina 1998, Furlani et al., 1996) namely:

[5] Tables and figures on socioeconomic and demographic aspects have been elaborated from data available at several Public National Institutions such as: INDEC Instituto Nacional de Estadísticas y Censos (National Institute of Statistic and Census), National Minsitry of Energy; and Provincial Institutions: DEIE Dirección de Estadísticas, Prov. de Mendoza (Statistic Department of Mendoza), Ministry of Economy and Production, Secretariat of Agriculture, Livestock, Fisheries and Food, Secretariat of Industry, Commerce and Medium and Small Enterprises, Ministry of Environment and Public Works. We will reference it as source INDEC and DEIE. Most of this data are available at their official web-page.

- Centralization: We can distinguish a functional centralization of industrial, administrative and commercial. This centralization allows identifying a series of advantages that generate important privileges for urban centers. For the industrial and financial activity, the main municipalities are Mendoza, Godoy Cruz, Guaymallén and Luján, all within the metropolitan area under study. Considering the academic and research activities, also Capital and Godoy Cruz appear as important sub-centers.

- Accelerated growth: The evolution of the three greater cities of the province allows for the observation that the population has tripled itself, in the course of 50 years (between half of century and today). This acceleration in the growth rate can be considered partially as a product of economic growth, but also evidences the crisis of the rural sector, producing massive migration to the urban centers.

- Non-planned growth: The lack of urban planning, especially by massive construction of residential homes. This growth has two main disadvantages: it does not help densify the existing urban areas; neither shows it a rational location pattern, for example, taking advantage of the existing services and so on. On the contrary population distribution is dispersed, eccentric, associated only to the main roads and city access. The only possible explanation is that these lands where chosen by their low prices, in order to provide homes to middle-class families.

At present there is a big competition to urbanize agricultural zones of high value like the wine-producing areas. Productive zones with denomination of origin (DOF) for wines are being parceled out and destined completely to establish new urban developments. In the last 20 years the Great Mendoza has shown a diminution of the cultivated surface of 13,269 has (20%).

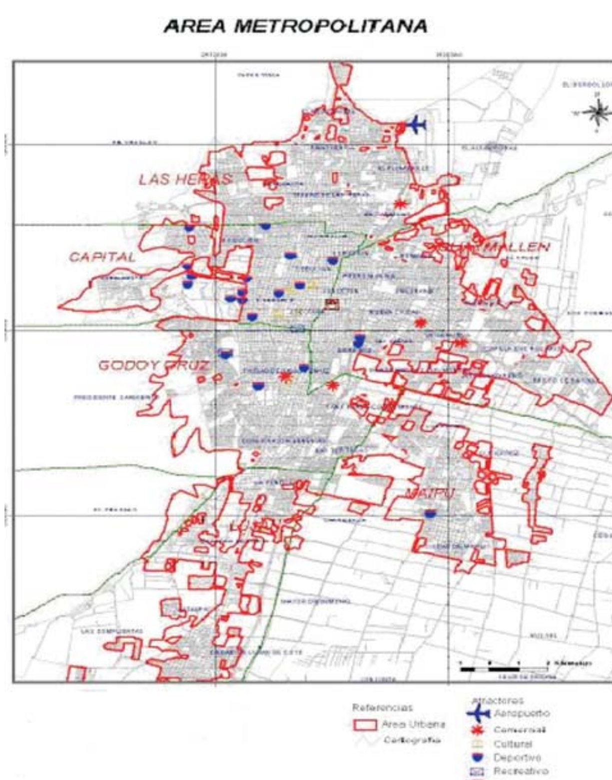
The residential construction between 1990 and 2000 showed visible quantitative and spatial changes in demographic dynamics. Two processes of growth have been identified: 1) spatially discontinued growth in the periphery of already existing residential urban centers; 2) construction of rural districts in more or less isolated places, that generate new establishments of population, accelerating the process of territorial fragmentation and demanding new (concentrated) services such as schools, health centers, and urban services like paving, sewers, electricity, water, telephone, etc, typical from urban way of life.

Table III.8: key socio-demographic indicators

Demographic aspects	Units	1970	1980	1990	2000
Population growth, city	%/Ann.		3.50%	2.60%	1.60%
% Participation provincial population to Nation	%	4.20%	4.30%	4.30%	4.40%
Urban % in Great Mendoza city	%	79.80%	85.50%	88.00%	91.50%
Urban population % to national population	%	2.00%	2.20%	2.40%	2.50%
Economic aspects					
% Participation Province in GDP nation	%	3.6	3.6	3.63	3.56
% Participation City in GDP Province	%	58	61	62	64
GDP per capita of the city	U$S	5,614	5,610	4,084	5,396
Income distribution (city level)	U$S	468	467	340	458
Urban aspects					
Urban density in the city	Inhab. / Km2	1,893	2,252	2,577	2,768
Urbanized area	Km2	317	336	357	376

Source: DEIE: Direction for Statistics of the Mendoza Province; INDEC, Argentina National Statistics Office.

Map III.1: Urban development and municipalities



Source: Ministerio de Ambiente y Obras Públicas, Gobierno de Mendoza.

2.2 Main economic activities

The main primary economic activity of Mendoza is agriculture followed by energy production. Agriculture is concentrated in oases, which occupy 3.5% of the surface of the province, conditioned by water shortage. Table III.9 shows the evolution of the economy in the last 10 years. Table III.10 shows the emplyment participation according to main economic activities.

Table III.9: Main economic sectors 1991 and 2000 (GDP)

Position	Sector	1991	Sector	2000
1	Manufacturing Industry	28,8%	Manufacturing Industry	22,4%
2	Others community, social and personal services	15,6%	Trade, restaurants and hotels	20,0%
3	Financial intermediation	13,8%	Financial intermediation	18,4%
4	Trade, restaurants and hotels	13,6%	Others community, social and personal services	13,4%
5	Agriculture, forestry and fishing	8,4%	Mines and quarries	8,2%
6	Mines and quarries	8,3%	Agriculture, forestry and fishing	6,7%
7	Construction	4,8%	Transport and Communication	5,5%
8	Transport and Communication	4,3%	Construction	3,4%
9	Electricity, gas and water	2,4%	Electricity, gas and water	2,1%

Source: DEIE: Direction for Statistics of the Mendoza Province; INDEC Argentina National Statistic Office.

Manufacturing is the sector with greater relative importance (22,4%), followed by commerce (20%), financing (18,4%), and social, communal and personal services (13,4%, Table III.9). There have been changes in contribution and relative importance of each sector's GDP between 1991 and 2000. Manufacturing continues to be the one with greater relative weight in the provincial productive structure, but its contribution was reduced from a 28.8% in year 1991 to a 22.4% in 2000. Commerce increased its participation from 13.6% in 1991 to a 20% in 2000, passing from the fourth to the second place.

Table III.10: Employment participation in economic activities (2002)

Employment by line of activity	2002
Industry	11.90%
Construction	6.00%
Commerce	24.40%
Finances services	8.00%
Social services	33.50%
Domestic services	6.40%
Transportation	6.80%
Others lines	0.10%

Source: DEIE: Direction for Statistics of the Mendoza Province; INDEC Argentina National Statistic Office.

Agriculture is part of the whole agri-business sector (e.g. production, commercialization). The agricultural production is not intensive. Investments have not been sufficient. (To produce in a desert (arid) area requires guidelines and assistance). And production unities do not respond to a minimum scale necessary to assure industrial competitiveness (Table III.11). In other cases, the products do not respond to the qualities demanded in the markets. The causes are varied: lack of information necessary to take financial decisions, deficiencies to transform the productive schemes, cultural behavior that rejects changes and intends to persist in old schemes.

Table III.11: Main agriculture production

Product	Production in Thousand tons		Participation in country stock	
	1991	2001	1991	2001
Grape	1,334	1,558	67%	65%
Garlic	50	104	67%	77%
Apple	154	176	16%	12%
Potato	83	134	5%	5%
Pear	36	76	13%	13%
Onion	83	63	17%	11%

Source: DEIE: Direction for Statistics of the Mendoza Province; INDEC Argentina National Statistic Office.

In the case of the fruit sector, specially the fruits to sell in fresh (except for the pear), the producing varieties have not moved to the taste of the world-wide consumers. In the case of the vegetable sector, garlic is the only product that still is very important, although its persists certain deficiency in improving the qualities of packing and marketing to accede to more demanding markets. There is a counter-productive dependency on Brazil. The fine wine production has been one of the most dynamic sectors. Investments made by foreign and local companies in the past allowed to access new international markets, contributing to the growth of exports for the last ten years. Investments focused on technology, development of markets and products, introduction of adapted cultures and varieties, elaboration of products to satisfy the different markets.

The oil and energy sector has undergone a deep transformation since the privatization of Yacimientos Petrolíferos Fiscales, the Argentine national oil company. About 60% of its shares were sold to the Spanish Repsol oil company. The process of investment in exploration has stopped, the rate of production is falling systematically diminishing the reserves. Recently this tendency has been reverted expecting new investments in this sector (Table III.12).

On the other hand, the energy sector has become a capital intensive sector, reducing employment levels. The energy sector represents almost 50% of the Provincial exports (Table III.13).

Table III.12: Provincial energy production

Oil	1998	1999	2000	2001	2002
-Production (thousands of m3)	6,692	6,220	5,956	6,020	6,670
-Production (millions of u$s)	501	640	1.017	903	962
-Production (Prov / Country)	13.6%	13.5%	13.3%	13.3%	15.2%
Gas					
-Production (millions of m3)	804	831	871	848	1,533
-Production (millions of u$s)	35	36	43	43	77
-Production (Prov / Country)	2.1%	2.0%	1.9%	1.8%	3.4%

Source: DEIE: Direction for Statistics of the Mendoza Province; INDEC Argentina National Statistic Office.

Commerce and services have been very dynamic and were under the greatest transformations in 1990-2000. Banks, telephone companies, insurance agencies, big shopping centers, have dynamized the sector. Citizens enjoy better quality of products and services, thanks to the economic opening and the competition. On the other hand, this has produced a high rate of unemployment, showing the necessity of greater investments in education and cultural change for this sector. This is the sector that registers the highest indices of rotation of employees and the greater index of informal work. After the financial crisis and with new exchanges rates, the tourism sector has become very dynamic too, with new investments.

Table III.13: Exports by item (2002)

Export item	Millions u$s	Part. (%)*
Petroleum oil	162	19%
Gasoline	133	15%
Wine of fresh grapes	104	12%
Diesel	101	12%
Fresh garlic	36	4%
Grape must and grape juice	32	4%
Special naphtha	31	4%
Fresh grapes	24	3%
Polypropylene	21	2%
Fresh plums	30	3%
Parts of hydraulic turbines	21	2%
Fresh pears	16	2%
Olive prepared or preserved	16	2%
Butanes, liquefied	15	2%
Fresh apples	9	1%
Tartaric acid	8	1%
Champagne	6	1%

Source: DEIE: Direction for Statistics of the Mendoza Province; INDEC Argentina National Statistic Office.

2.3 Patterns of energy consumption

There are five sectors emitting carbon[6]: energy production and manufacturing, agriculture, and the service, residential and transportation sectors as well.

- ☞ Energy production and manufacturing. Two main activities stand up: on one the side the oil refinery with production of gasoline and other fuels, which are not only consumed in the city, but exported to the rest of Argentina and to some of the neighbor countries; on the other side the petrochemical industry, a ferroalloy industry, a power plant, mainly fed by natural gas, and a cement production facility.

- ☞ Agricultural sector. Mendoza has an important agricultural activity focusing on wine and olive oil production, fruits and vegetables. All of these products feed local, national and also international markets.

- ☞ Services. In this area we may include the business sector, the educational and institutional activities as well.

- ☞ Residential sector. As already mentioned, it has become a key driver of urbanization in Mendoza.

- ☞ Transportation of goods and passengers, a very important activity linking the above ones.

Table III.14: Net energy consumption in Tera Joules, by sector and fuel type

Sector	1980		1990		2000	
	TJ	%	TJ	%	TJ	%
Energy production	15133	34.20%	17540	36.20%	17385	34.00%
Residential	5022	11.40%	6970	14.40%	9676	18.90%
Rural	1293	2.90%	1198	2.50%	1307	2.60%
Industry	8812	19.90%	8320	17.20%	6051	11.80%
Transport	12978	29.30%	12838	26.50%	14143	27.70%
Service	982	2.20%	1569	3.20%	2527	4.90%
Total	44219	100.00%	48435	100.00%	51089	100.00%

Source: Arg (1997); Mza (2000)

[6] The energy consumption information of the Mendoza Province has been taken from a Report named "Prospectiva a largo plazo de la demanda energética total y por fuente en la Provincia de Mendoza" by Lavanderi, R., García, C., Heredia, S. and Yañez, S., presented to the Consejo Federal de Inversiones (CFI) November 2000. Hereon will be cited as (Mza, 2000). We are thanked to Ing. Carlos García and Ing. Santiago Heredia for facilitating this report. Other sources of information has been the Argentina Country Report to the IPCC, (Arg, 1997) and data from the DEIE: Direction for Statistics of the Mendoza Province; INDEC Argentina National Statistic Office, SEA: National Secretary of Energy, Argentina. The estimations of energy consumption and greenhouse emissions for the Mendoza Metropolitan Area has been done by the authors of the present report.

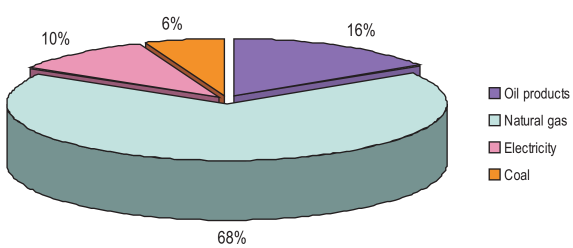
Table III.15: Net energy consumption in Tera Joules, by sector and fuel type (cont.)

Fuel type	1980		1990		2000	
	TJ	%	TJ	%	TJ	%
Natural Gas	3418	6.50%	1968	3.50%	2400	4.10%
Other Primary Sources	264	0.50%	523	0.90%	1391	2.40%
Distributed Gas	2912	5.50%	13446	23.90%	21342	36.20%
Liquid Gas	1617	3.10%	1476	2.60%	1557	2.60%
Refinery Gas	2575	4.90%	4006	7.10%	5088	8.60%
Gasoline C	3034	5.70%	2144	3.80%	2021	3.40%
Gasoline E	3082	5.80%	2945	5.20%	2522	4.30%
Kerosene	740	1.40%	563	1.00%	279	0.50%
Jet Fuel	1001	1.90%	370	0.70%	72	0.10%
Gas Oil	7716	14.60%	8425	15.00%	8651	14.70%
Diesel Oil	2534	4.80%	456	0.80%	0	0.00%
Fuel Oil	11892	22.50%	7016	12.50%	2781	4.70%
Residual Carbon	6285	11.90%	5864	10.40%	2265	3.80%
Electricity	4671	8.80%	5976	10.60%	7571	12.80%
Non Energy.	1116	2.10%	659	1.20%	352	0.60%
Other Second.	76	0.10%	381	0.70%	721	1.20%
TOTAL	52935	100.00%	56219	100.00%	59013	100.00%

Source: Arg, (1997); Mza (2000).

Tables III.14 y III.15 show the energy consumption by fuel type and sector. Two sectors arise as main consumers: energy, which includes the energy production and transformation, and transportation. Analyzing the economic indicators, Mendoza has two main activities agriculture and energy production; manufacturing industries are mainly associated to agriculture products, as seen before. Agriculture consumes mainly electricity or gas-oil to pump underground water and for freight transport. Manufacturing industries (such as the wine industry) are low energy consumers, with the exception of the Ferro-alloy and cement fabrication located in the periphery of the metropolitan area. Figure III.5 shows the consumption of the energy production sector discriminated by fuel type. In the last decade, natural gas participated with around 68% of the used fuel.

Figure III.5: Fuel consumption for the energy production sector



Source: INDEC (2005).

Table III.16 shows the energy consumption of the residential sector by fuel type. Again, natural gas arises as main fuel for domestic heating and cooking. Electricity for households is provided either by hydropower and/or by a power plant normally fed with natural gas. Argentina has a National Electric Interconnected System, so that generation of the electricity may be located thousands of kilometers away. Table III.17 shows the number of households consuming both distributed gas and electricity. It shows a high percentage in the Capital (central downtown) area and less in the northern district of Las Heras. This also shows a higher standard of living in the central and southern metropolitan area (Capital, Godoy Cruz and Luján) and less in the northern part of Las Heras.

Table III.16 Energy consumption of the residential sector by fuel type

Fuel type	1980		1990		2000	
	TJ	%	TJ	%	TJ	%
Oil products	646	12.90%	475	6.80%	264	2.70%
Natural gas	3,553	70.70%	5,344	76.70%	7,799	80.60%
Electricity	820	16.30%	1,150	16.50%	1,614	16.70%
Coal	3	0.10%	1	0.00%	0	0.00%
Total	5,022	100.00%	6,970	100.00%	9,676	100.00%

Source: Mza (2000).

Table III.17: Number of users of the distributed natural gas and electricity (1991)

Place	Urban Population	Distributed Natural Gas		Electricity	
		Amount	%	Amount	%
Great Mendoza	802,438	186,514	81.40%	233,214	87.20%
Capital	121,739	39,146	96.50%	41,018	98.40%
Godoy Cruz	179,468	43,327	84.50%	57,639	94.40%
Guaymallén	205,953	42,987	73.10%	53,533	76.40%
Las Heras	150,073	26,804	62.50%	34,170	66.90%
Luján	61,332	15,683	89.50%	22,135	93.80%
Maipú	83,873	18,567	77.50%	24,719	86.60%

Source: Mza (2000), DEIE.

2.4 Transportation

The second GHG emitter in Mendoza is transportation. Table III.18 shows the statistics for public transportation in terms of amount of passengers and traveled distances during 1994-2000. In the bottom of the same table it is computed the yearly incorporation of new cars of the private and public fleet, as well as the total vehicles circulating in the city.

Complementing this information, Table III.19 shows two source-destiny surveys, performed in years 1986 and 1998. As it can be seen from both tables, there is a decrease in the use of public transportation, and consequently an important increase in the use of private cars, as well as in the motorization rate. The daily trip demand using particular cars reaches 39% in 1998, whereas in 1986 it was only of 30%. The use of vehicle grew in significant form reaching more than 200,000 unities for the area of the Great Mendoza. Several important problems are associated to the use of particular vehicles: a) high demand for space needed to circulate, and for parking in the central area; b) high amount of accidents, and the associated dead rate; and c) increased pollution by gases and suspended particles. The use of cars, on the other hand, has favored the preferences to live in residential districts away from central business area, searching for better quality of life. Another consequence is the installation of new big shopping malls and supermarkets also in the new residential areas, accentuating urban sprawl.

Table III.18: Transportation key indicators

Public Transport city Mendoza	Unit / year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total passengers	Mill. pass./ann.				167	156	151	150	149	147	139
Commuting distance	Mill. Km/ann.				82	79	80	80	80	78	77
Urban Passengers (annual)	Mill. pass/ann.				141	133	129	125	122	120	114
Distance per urban bus	Thous. km/bus-ann.				94	99	90	90	87	86	81
Suburban Passengers (annual)	mill. pass/ann.				26	24	22	25	27	27	25
Suburban trip annual km	mill km/ann.				16	15	15	16	18	17	16
Distance per suburban bus	Thous. km/bus-ann.				101	96	95	90	85	87	88
Public Transport	Veh.			626	627	628	629	630	631	632	633
Freight	Thous. veh. / ann.			23	28	30	33	37	41	44	47
Private vehicles	Thous. Veh.	145	156	170	188	203	217	234	252	265	287

Source: DEIE (2000).

Table III.19: Daily trips in Mendoza Metropolitan Area (1986 and 1998)

Description	1986	Relative to total trips	1998	Relative to total trips
Public Bus (diesel)	398,190	50.50%	493,597	34.80%
Trolley bus (elect)	16,230	2.10%	14,915	1.10%
Taxi (diesel-GNC)	7,030	0.90%	18,023	1.30%
Corporative Bus	5,362	0.70%	5,898	0.40%
School Bus		0.00%	13,396	0.90%
Private Car	200,000	25.40%	354,731	25.00%
Share private car ride	43,000	5.50%	210,000	14.80%
Motorcycle		0.00%	35,138	2.50%
Bicycle	37,490	4.80%	102,665	7.20%
Walk > 1km	72,169	9.20%	111,123	7.80%
Other	9,106	1.20%	59,742	4.20%
Total daily trips	788,577	100.00%	1,419,228	100.00%

Source: DEIE (2000).

Table III.20 shows the energy consumption in Tera Joules. Two main groups arise from these tables as mayor consumers: private cars (46.2%) and the freight sector (44.9%). In comparison the public transportation consumes only 9.3%.

Table III.20: Energy consumption of the transport sector for year 1999 (Tjoules)

Type	NCG	MC	ME	CJ	GO	EE	Total	% Total
Auto	1,495	1,139	2,306	0	1,545	0	6,485	46.2
Taxi	10	0	0	0	60	0	70	0.5
Public buses / trolleybuses	15	0	0	0	859	11	884	6.3
Buses	0	0	0	0	242	0	242	1.7
Airplane	0	0	0	29	0	0	29	0.2
Freight < 2 TN	699	613	108	0	2,980	0	4,400	31.3
Freight > 2 TN	0	66	0	0	1,860	0	1,925	13.7
TOTAL	2,219	1,818	2,414	29	7,545	11	14,036	100

NCG: natural compressed gas, MC regular gasoline, ME special gasoline, CJ jet fuel, GO Gas-oil, EE. Source: Mza (2000), DEIE.

In the next Table III.21 we summarize these results through a series of important indicators concerning energy use and transportation.

Table III.21. Main indicators of the energy use

Energy use		1970	1980	1990	2000
Fuels (Fuel oil/Natural gas, gasoline, electricity)	Tjoules		52935	56219	59013
Net energy consumption total	Tjoules		44219	48435	51089
Energy intensity (kj per unity of GDP)	KJ/U$S		15252	17673	12117
Private passenger transport energy use per capita	MJ/cap		9649	7581	7208
Public transport energy use per capita	MJ/cap		1888	1483	1410
Energy use per private passenger KM	J/(km.pass)			2.4	0.9
Energy use per public passenger KM	J/(km.pass)			0.1	0.2

Public buses are operated by a reduced number of private companies through a state concession, renewed each 10 years. In the last years, the government had increased the trolley lines from 22 to 45 km. This service counted in 1994 with 920 units, with buses of about 4 years old. Since then the public transport suffered a strong deterioration in the quality of the service, produced by decreased public transport demand and lack of adaptation to new needs. This has resulted in decreased quality of service and increased contamination due to bus aging (buses are more than 10 years old). Companies present serious financial problems by loss of credit and work capital.The public system is based 95% on diesel buses, while only a small percent is based on electric trolleybuses. These electric trolleybuses are operated directly by a Provincial State Company.

During 1999 a multi-modal system formed by electric trains and trolley buses was proposed to replace the old diesel buses system. Unfortunately due to the financial-economic crisis in Argentina the project was no longer feasible. At present a new public transportation system is being discussed but based on diesel buses (or alternatively by compressed natural gas), keeping a proportion on trolleybuses and much modest participation of electric trains. In the mean time, there is a growing discomfort about the public system, both from the users themselves and also from environmental NGOs. The delay in designing appropriate public transportation systems, as well as the discussion of the role of private companies, users and government, is pushing the users to use their own private cars and alternative transportation. Taxi services, school buses, contracted bus services (i.e. tourist buses, corporative services, etc) had encountered serious adaptation problems, competing for customers and also for space in the urban areas. Due to the deterioration of public systems, and the need to respond to new demands, lately a new mode of transportation is being developed: small buses (10-15 passengers), which offer a point-to-point service (i.e. students from urban centers not served directly by the public transport).

From an energy consumption perspective, we can see in table III.21 that a passenger using private transportation consumes about 1 J per traveled kilometer, while using public systems he only consumes 0.2 J. Despite the uses of old diesel buses the per capita and per kilometer consumption of the public system is almost five times better. Given the present tendency to use private car, and the location of new residential/business in the periphery of the metropolitan area, it is expected that the energy consumption will increase. Carbon emissions will also augment, but at a lower rate, especially due to incorporation of new vehicle technology. Most of the automotive park in Mendoza does not have catalytic converter. The incorporation of new technology will help partially to compensate for the increase in the number vehicles and the number and length of the daily trips. The use of natural compressed gas as an alternative fuel for vehicles, in general, decreases the emissions of CO, hydrocarbons and suspended particles, but increases the methane emissions.

2.5 Emission patterns

In this section we will describe the main emission patterns in the metropolitan area[7]. In Figure III.6 it can be seen that not only energy production and transportation are the main emitters but also that both emissions have increased in time. A second group is formed by the industry and residential sectors. As already discussed before, energy production, industry and the residential sector are based mainly on natural gas. While most fuels consumed by transportation are fossil fuels and a tiny percentage is natural gas.

Figure III.6: Emission of CO_2 by sector in thousands of metric tons (Th Tn)

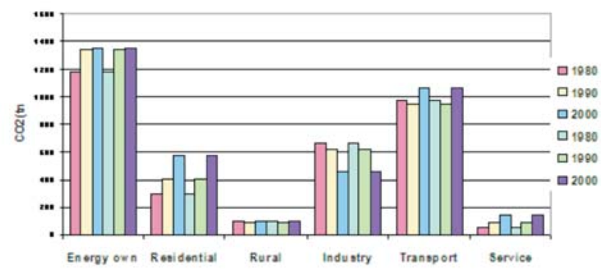


Table III.22: Carbon monoxide emissions (Tn)

Sector	1980	1990	2000
Energy own	235	267	269
Residential	47	64	91
Rural	776	721	784
Industry	3,868	3,633	2,656
Transport	64,888	63,532	70,713
Service	15	24	39
Total ES	69,829	68,240	74,553

CO emissions generated by incomplete combustion process are closely related to CO_2 emissions. These are more evident in transportation and small industrial companies. Bigger industrial companies and the energy production have a better control on the CO emissions. Nitrogen Oxide emissions are produced mainly during high temperature combustion processes. The use of natural gas as main fuel also produces high NOx emissions. This is clearly seen in the sectoral analysis presented in Table III.23, where the main emitters are industry, transport and energy production.

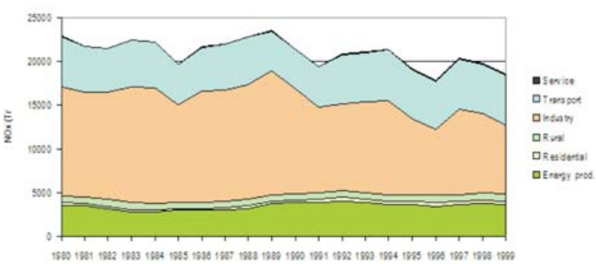
[7] The emission of greenhouse gases was calculated by the principal author of this report following IPPC recommendations, and based on the sectoral energy consumption. The selected emission factors are the same used for the Argentina country report (Arg-1997).

Figure III.7 shows the evolution of such emissions. Despite the increase in energy consumption, technological improvements are producing a decline in NOx emissions. Only transportation emissions are growing, but as will be seen from the air quality point of view, this is due to the increasing amount of vehicles and the aging of the automotive park.

Table III.23: NOx emissions

Sector	1980		1990		2000	
	Tn	%	Tn	%	Tn	%
Energy own	3,117	14.40%	3,546	16.60%	3,581	18.80%
Residential	246	1.10%	331	1.60%	473	2.50%
Rural	776	3.60%	721	3.40%	784	4.10%
Industry	12,336	56.80%	11,585	54.30%	8,471	44.40%
Transport	5,191	23.90%	5,083	23.80%	5,657	29.60%
Service	48	0.20%	74	0.30%	124	0.60%
Total ES	21,714	100.00%	21,340	100.00%	19,090	100.00%

Figure III.7: Evolution of NOx emission by sector in thousands of metric tons (Th Tn).



The main source of Methane emissions is transportation (mainly through the use of natural gas) followed by urban waste and residual water treatments. Another important sector is agriculture in the suburban and neighbor's areas. Since these activities are not proper urban, the impact of methane emissions from the urban perimeter is concentrated in waste and residual water. Here we can compare per capita emissions of the city with the country per capita emissions, and see that emissions from energy uses are the main sources, while from the country perspective, emissions from the agriculture and live stock contributes with almost 40% of the GHGs emissions. If we were to analyze the city from a metabolic approach, we should then include the emissions produced outside the boundary of the city where goods are consumed.

Table III.24: Methane emissions (Tn)

Sector	1980	1990	2000
Energy	12	14	14
Residential	6	8	12
Rural	14	13	14
Industry	12	12	8
Transport	1,947	1,906	2,121
Service	1	1	2
Total Sec. Energy consum.	1,992	1,954	2,172
Waste + Rwat	9,642	13,013	18,579
Agriculture	1,024	951	1,035
ES+agr+was	12,659	15,918	21,786

In relation to methane emissions are the nitrous oxide (N_2O) emissions, which are mainly produced by the urban domestic waste and food and protein consumption. Table III.25 shows an estimation of such emissions based on the annual production of urban domestic waste. It must be noted that the per capita consumption of proteins has increased in the last years, as it is shown in Table III.26.

Table III.25: Nitrous oxide (N_2O) emissions (Tn)

Year	Population	Domestic waste	N_2O Emissions
		Tn / Ann	Tn/ Ann
1980	605,623	149,789	36.26
1981	619,218	151,323	38.09
1982	633,119	152,896	39.97
1983	647,331	154,542	41.92
1984	661,862	156,282	43.94
1985	676,720	158,140	46.03
1986	691,911	160,288	48.18
1987	707,444	162,378	50.42
1988	723,324	164,519	52.72
1989	739,562	166,700	55.11
1990	756,164	169,134	57.58
1991	773,113	165,471	60.13
1992	790,494	175,996	62.76
1993	808,239	180,207	65.49
1994	826,383	183,779	68.3
1995	844,934	186,809	71.21
1996	863,901	188,205	74.21
1997	883,294	189,045	77.31
1998	903,122	193,247	80.52

Table III.26: Protein consumption in Argentina

Product	Per Capita consumption (Kg/Inhab. /ann.)			Protein (%)	Per Capita protein (Kg/Inhab. /ann.)		
	1990	1994	1997		1990	1994	1997
Liquid milk	67.73	77.22	80.99	0.033	2.235	2.548	2.673
Powder milk (non fat)	0.546	1.053	0.585	0.31	0.169	0.326	0.181
Powder milk	2.639	3.406	3.77	0.31	0.818	1.056	1.169
Hard cheese	1.443	1.924	1.82	0.3	0.433	0.577	0.546
Semi hard cheese	4.121	4.394	4.03	0.2	0.824	0.879	0.806
Soft cheese	6.37	7.54	8.45	0.125	0.796	0.943	1.056
Yogurt	5.161	8.801	7.8	0.041	0.212	0.361	0.32
Poultry	6	10.2	26.4	0.205	1.23	2.091	5.412
Pork	0	12.6	10.332	0.205	0	2.583	2.118
Beef	86.4	75.6	66	0.21	18.144	15.876	13.86
Fish	22.08	20.64	31.56	0.175	3.864	3.612	5.523
Other dairy products	2.73	3.9	3.51	0.00792	0.022	0.031	0.028
Eggs	11.592	12.264	12.432	0.125	1.449	1.533	1.554
TOTAL	30.196	32.416	35.246				

Source: Arg (1997).

Table III.27 shows a set of efficiency indicators. As it can be seen, although energy consumption and CO_2 emissions have increased in the two decades, both energy intensity and energy per capita have decreased, so did CO_2 emissions and per capita intensities. Compared to the country mean values, for example for year 1990, inhabitants of Mendoza have an energy intensity of 13,000 kJ/U$S vs. 7,500 from mean Argentina, in the same direction the CO_2 emissions intensity of Mendoza population is 817 g/U$S vs. 475 from country mean values. These numbers show that demans of urban areas are higher than country mean values.

Table III.27: Efficiency indicators

	Unit	1980	1990	2000
Population city	Inhab.	723,229	884,940	986,341
GDP city	Mill U$S	4,474	4,285	6,368
Energy consumption by sectors (1980-2000)	TJoules	44,219	48,435	51,089
Energy intensity (kJ per unity of GDP)	kJ/U$S	11,832	13,121	9,267
Energy per capita	TJ/inhab.	61,141	54,733	51,797
CO_2 emissions	Gg	3,270	3,500	3,689
CO_2 Emission intensity	g/U$S	730.97	816.774	579.283
CO_2 Emission per capita	Tn/inhab.	5.286	4.493	4.087

2.6 Air quality analysis

Three aspects dominate the air quality in the metropolitan area: orography, meteorology and emission patterns. Mendoza is located at the east side of the Andes Mountains reaching an average height of 5,000 m with peaks up to 7,000 m. This natural barrier has a strong influence in the meteorological conditions determining the air pollution situation. The city is located in an arid to semi-arid zone of low rainfall (120-240 mm/a), which occurs specially during the summer months (November to March). In winter time the occurrence of strong thermal inversion layers contributes to a higher degree of pollution. Due to its closeness to the mountains, Zonda winds similar to Föhn or Chinook winds, prevail in the higher layers mostly during the winter months (May to October) with high probability of frost, which contributes to a higher degree of pollution due to the occurrence of strong thermal inversion layers. The area presents low relative humidity (50%), low incidences of fog and few days with covered skies (65-75 days/annum). Another important feature for the description of the air pollution is the day-night variation, characterized by a typical valley-mountain circulation. From the first hours after sunset to early hours after sunrise, there is a clear wind flow from WSW, while in daylight hours the circulation is ENE. Strong solar heating on the valley side causes an up-slope wind flow at daytime (ENE). At night due to rapid radiational cooling on the valley slope, the circulation switches over causing the air masses to move down the mountain from WSW. This strong night cooling and day heating produces an important variation in mixing heights and inversion layers (Puliafito 2003).

Table III.28: Annual mean values of monitored air quality

Year	Ambient Concentrations Annual mean values					
	PST (ug/m3)	NOX (ppm)	SO2 (ppm)	Pb (ug/m3)	O3 (ppm)	CO (ppm)
1987	302.3	0.044	0.005	0.0029		
1988	331.3	0.046	0.004	0.0021		
1989	290	0.031	0.027	0.0021		
1990	225.5	0.047	0.008	0.0004		
1991	138.6	0.026	0.002	0.0003		
1992	84.1	0.02		0.0002		
1993	83.5	0.021		0.0003		
1994	72	0.028		0.0003		
1995	72.8	0.025		0.0003		
1996	54.9	0.034	0.002	0.0003	0.0251	
1997	66.8	0.04	0.004	0.0003	0.0224	
1998	77.2	0.033	0.003	0.0003	0.017	
1999		0.03			0.009	0.657
2000		0.052			0.02	0.412

Source: Mendoza Government, University of Mendoza.

The main human activities contributing to air pollution are the transportation sector (mobile sources) followed by the industrial sector and the residential sector. The main industrial activities (fixed sources) are: an oil refinery, a ferroalloy plant, a petrochemical industry and a power plant; situated SW of the city; and two cement industries and other minor sources on the north edge. Table III.28 shows annual mean values for the main contaminants. Ambient concentration measurements of air pollutants have been monitored since 1970 in the metropolitan area of Mendoza by the Ministry of Environment and Public Works through its Direction for Environmental Control. In the urban area of Mendoza, around 15 stations monitor daily mean values of Total Suspended Particles (TSP) - by filter capture and reflectometry-, daily mean values of nitrogen oxides NOx -by colorimetric Griess-Saltzmann, and once a week 24 h mean values of lead Pb -by colorimetric ditozone-, and sulfur dioxide SO_2 -by colorimetric West and Gacke modified by Pate-. Also, the University of Mendoza (Institute IEMA) measured black carbon and PAH poliaromatic compounds (Aethalometer GIV reflectometry), surface ozone (O_3), nitrogen oxides (NOx), Carbon monoxide (CO), using a set of Horiba instruments (series APO350E for O_3 and APN360 for NOx and CO).

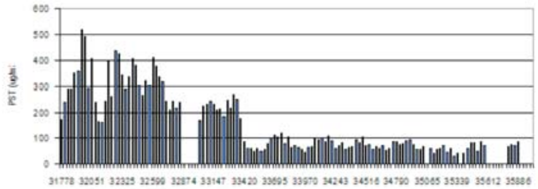
Figures III.8 and III.9 show monthly mean-value series of Total Suspended Particle and Nitrogen Oxide in a downtown area. It is interesting to note the deep decrease of the particulate matter after middle 1991, and also in a softer way in the NOx measurements. This breaking point is due to a change of the transportation system during 1991. A better distribution of public transportation, together with better buses and improved technology and fuels, contributed to a better air quality of the downtown area. Between 1992 and 1996, the private automotive park was increased with new vehicles, partially due to a good dollar-peso exchange rate that allowed users to buy new cars, and partially due to an official incentive to change old cars by new ones. Through this incentive called "*Plan canje*" (Exchange plan), the State subsidies the automotive companies for each old car accepted as payment for a new car. This policy contributed to an important increase and replacement of the automotive park. The increase of the NOx measurements after 1996 is due to the increase (and aging) of the number of circulating vehicles. As a summary of the air pollution situation we may say:

- *Particulate matter*: In the south industrial area, the ferrous alloy and the coal burning processes are main emitters, especially because they function without any filtering device to their dust emissions. Maximum hourly immission values may reach 1500 g/m^3 and more than 200 g/m^3 daily mean values close to the sources. Ten kilometers away, at a residential part of the city annual mean values of 30 to 40 g/m^3 can be obtained, especially during the winter months. According to our calculations and the monitoring measurements, the influence of the industrial sources over the city, do not exceed the air quality standard with the exception of the areas close to the industrial area. Map III.2 shows maximum daily values in the metropolitan area.

- *Sulphur dioxide*: The main source of SO_2 is the refinery, reaching maximum hourly values at the urban areas of the city of 100 g/m^3, and more than 400 g/m^3 in Lujan. Most of it is vented through the torch. Lately the refinery has incorporated a desulphuration Claus plant to reduce its SO_2 emissions. The city has maximum 8-hour values of 100 to 200 g/m^3, and mean annual values of 20 to 40 g/m^3, depending on their relative location. According to the local air quality standard, only some areas close to the refinery exceed the norms.

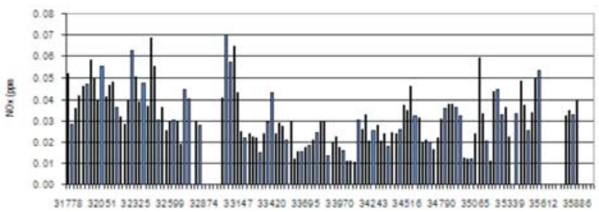
- *Nitrogen oxides*: The power plant in the SW is the main NOx emitter from the industrial sector, but ambient concentrations values do not exceed the local standard (100 g/m^3 for 1 year and 200 g/m^3 for 24 h). Mean daily values reach de 20 to 40 g/m^3 and annual mean do not exceed 5 to 10 g/m^3, due to industrial sources. NOx values at the urban areas are mainly produced by vehicle exhaust.

Figure III.8: Monthly mean values of particulate matter measured in downtown Mendoza



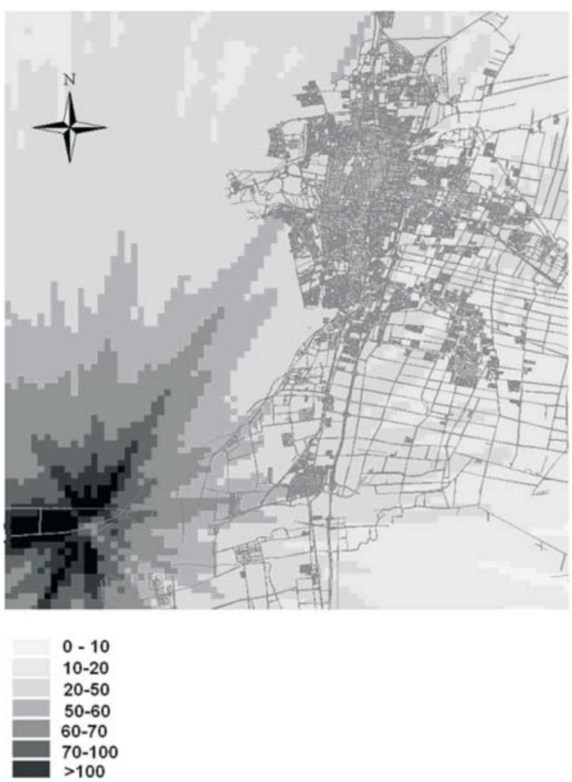
Source: Puliafito, (2003).

Figure III.9: Monthly mean values of NOx measured in downtown Mendoza



Source: Puliafito, (2003).

Map III.2: Calculated maximum daily mean values of total suspended particles (μg/m³ for the metropolitan area of Mendoza



2.7 Institutional settings

As said above, the city of Mendoza is located in an arid to semi-arid zone of low rainfall, therefore its people has a clear oasis culture, where great care is given to the management of its limited resources, especially water and space, and to the development of on appropriate habitat based on a steady effort. Hence environmental preservation and sustainable development is a consequence of a long cultural survival process. The General Water Law from 1884, still in force, and the Irrigation Department created in 1916, which is responsible for managing the irrigation water resources, is a clear example of this environmental culture. We should also mention, as important milestones of the end of the nineteen's and beginning of the twenty's century, the development of sanitary works, the creation of a 450 ha park and public tree fostering in the urban area. Its many trees and green spaces could be identified as a natural way to moderate desert climate and to improve urban life quality.

A century later, this visionary urban planning showed to be insufficient to stop the progressive degradation of the natural environment, and to solve the up rise of new conflicts. Increasing urbanization problems, with traffic congestion, air pollution, and loss of green or agricultural space, placed additional pressure to the administration of natural resources and existing infrastructures. This situation finally pushed the society to a broader discussion. As a consequence new environmental laws were passed by the Provincial Congress and in 1989 an Environmental Ministry was incorporated to the Provincial Executive Power.

Lots of efforts were done to rearrange the institutional relations within the same Provincial State, the Municipalities and the Federal State, regulating the application of Provincial and Federal Laws or national decrees. The main objective of this Ministry was to act and coordinate with municipalities, enterprises and scientific institutions, in the following fields: a) environmental information; b) development and up-dating of legal, institutional and techno-economics instruments for environmental protection; c) development of public environmental awareness;

d) natural flora and fauna preservation; e) environment control and sanitation; f) urban regulation and environmental development; g) urban services with direct environmental incidence (drinkable water, sewers, parks, and public transportation); and h) housing.

The environmental policy was based on prevention (instead of acting on the consequences), participation (protection and improvement do require permanent consultation with the population, in order to know their hopes and expectation), and political and technical cooperation (the solution of environmental problems requires interdisciplinary and new technology). Only through a vast cooperation among public offices, research institutes and non-governmental organizations is possible to solve many of these problems and to prevent for continuous deterioration of urban life quality. Environmental legislation enforcement, has been very active in pollution reduction and control, especially in the following carbon relevant areas: a) atmospheric pollution by mobile sources; b) pollution by urban solid domestic residues; c) atmospheric pollution due to stationary sources; d) contamination by oil exploitation; and e) contamination by mining exploitation.

During the 1990s the government issued important environmental laws such as the Environment Preservation Law Nº5961, which establishes different legal instruments, such as the Principles of Environmental Policy, Environmental Report and Plan, Environment Provincial Council, Jurisdictional Protection of Diffuse Interests and Environmental Impact Evaluation. Several interjurisdictional agreements were designed between the province and the municipalities; between the province and the national, and among different provinces were needed. Other milestones were the organization of several decentralizing Agencies for controlling the privatized companies such water and electricity (Puliafito, 2004).

But this environmental state of the art of the city is challenged again by the international pressure on climate change topics, which are demanding a new understanding of the role of cities, the increasing urbanization and their influence on the emissions on greenhouse gases.

2.8 Concluding remarks

The present study on carbon emissions aims to help urban planners to reshape their policies to a more de-carbonizated city. As a summary of the many tables and figures presented above, we can see that the burn of fossil fuels in their different forms, energy production, industry and transport, continues to be the main CO_2 emitter. Food production is relevant at the country level (emissions of CH_4 and N_2O), but does not appear directly as a main source in the urban areas. But from a carbon point of view and considering an urban metabolism approach (material flow analysis), that is, considering all the net flows of material and energy needed to sustain the city, other sectors begin to appear as relevant as the energy sector like the construction sector (cement and iron production and stocking) and the food sector.

Environmental national-level policies of the last 20 years can be characterized as discontinued and partial, mainly affected by political changes and unrest. So it is difficult to foresee a clear signal. However, from the carbon perspective, some political decisions appear to be significant to reduce GHG emissions: a) the deregulation of the electric market operated in the 1990s b) the participation of independent actors such as generators, distributors and consumers, regulated by a common group (CAMMESA) and controlled by the Federal State, produced the renovation and the incorporation of new technology in the energy production sector, especially the combine cycle generators operated by natural gas.

On the other side during the same period, because of the economical and financial situation of Argentina, the oil companies offered better fuels, and also many industries had the opportunity to renew and change to a more efficient technology, which turns to produce lower carbon emissions, as it can be seen from the national context explained in the chapters above.

Moreover country is economic growth in the 1990s also induced the incorporation of many new vehicles, with better technology. The impact of this decade was the increase of the per capita income and consequently an increase of the per capita consumption, but with a better performance in terms of energy intensity.

These national measures affected the same way to the Mendoza area, both in energy production, emissions and consumption. At the local level several policy measures have been adopted in the last 10 years, especially in the transportation system. On one side, the environmental sector pushed for a more efficient electric public transportation system, and several projects were proposed to replace the old diesel buses, as commented above, but the latter economic crisis of the 2000' excluded the possibility to implement such an ambitious project.

At present an increasing amount of the Mercosur production, mainly from east Argentina and Brazil is exported to the Asian markets through the Pacific Harbors. The main road to this harbor is through the Andes pass near Mendoza. Therefore, in the last 5-8 years much of the public works effort (budget) was conducted to improve and increase the length of highways and paved road from Mendoza to the Pacific Harbors (Valparaiso, Chile). The same argument is used for the export of local agricultural products to the Asian markets.

As a consequence, at present four projects are being financially considered: a) to extend the highway to the east border of the Mendoza province (about 100 km of 2-3 lanes highways), b) to extend the highway towards the southern oasis of the province (about 30 km of 2-3 lanes highways), c) to improve the mountain pass (tunnels and snow covers for the freight transport), d) to reconstruct the railroad between Mendoza and Valparaiso for freight operations.

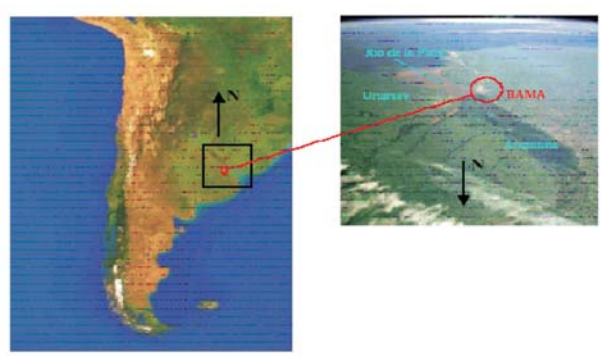
In this context, the priorities at local level are to improve the freight transport between Brazil and Chile, as a mean to promote Mendoza as an important local market, and to increase the export of local production, and third priority is to promote Mendoza as Tourist Center. All these aspects need increased road and construction infrastructure. Urban public transportation and other carbon relevant areas will therefore continue to struggle to get more financing for several more years.

3. The city of Buenos Aires

Buenos Aires (34º S, 58º W) is the Capital City of Argentina, has a "star shape" and in its center the Plaza de Mayo, place of its foundation in 1580 (see Map III.3). It hosts about three million people (2001 record: 2,768,772 inhabitants) in its 203 km^2 surface. It owns five subway lines and seven train lines, as well as 136 public bus lines. One and a half million cars are registered in the city and its highways are 31 km long. Together with 19 municipalities of Buenos Aires, Buenos Aires City is part of Gran Buenos Aires (GBA).

This geographical boundary is not trivial for much of the information to be displayed is given for GBA or AMBA (Area Metropolitana de Buenos Aires). The INDEC defines the Buenos Aires Metropolitan Area (BAMA) as comprising the City of Buenos Aires (the Federal Capital) and the following 24 adjacent districts ("*partidos*" in Spanish) in the Province of Buenos Aires, while Great Buenos Aires (GBA) includes only 19 of such districts.

Map III.3. Buenos Aires´ location



Source: ICAP (2002).

3.1. Socio demographic dynamics

Table III.29 summarizes the main socio-demographical indicators for the city. As seen in the national section of this report, the city of Buenos Aires has one of the highest numbers of inhabitants of the whole nation (around 3 millions for the city and approximately 12 millions if surrounding areas of the Greater Buenos Aires are also considered). The most populated neighborhoods are Palermo, Caballito and Recoleta and the densest ones are Almagro and Balvanera.

Table III.29: Buenos Aires City: key indicators

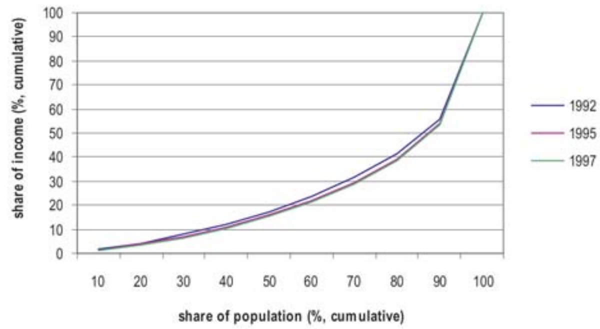
Indicators	Units	1980	1991	2001
Population	(inh)	2, 922,829	2,965,403	2,768,772
Population growth rate	(annual average, %)		0.13 (1980-1991)	-0.68 (1991-2001)
Share of total national population	(%)	10.5	9.1	7.6
GDP	(nominal, US$ million)	44211	42597	65650
GDP per capita	(nominal, US$)	15126	14365	23711
Share of total national GDP	(%)			24.4
Population density	(inh/km2)	14614.1	14827.0	13679.6

Source: INDEC (2005) and GCBA (2005).

Population growth rates have decreased (see Table III.29) due mainly to an intra-urban migratory process that led to the abandonment of downtown as the living place, which was replaced by houses in “closed neighborhoods” (called “countries”). This is in general a phenomenon that affects middle and high class people. Part of this happened due to an increase in criminality driven at least partially by economic crises and abrupt changes in the income distribution.

As an illustration of that fact, Figure III.10 shows that the income distribution in GBA followed the same behavior as the country as a whole. There was a subtle increase in inequality (1988 Lorenz Curve is always above 1998 Curve), as, for example, while the highest tenth of the population had been related to 47 percent of income in 1988 the same share portion of GBA's inhabitants was associated to almost 50 percent of total output in 1998.

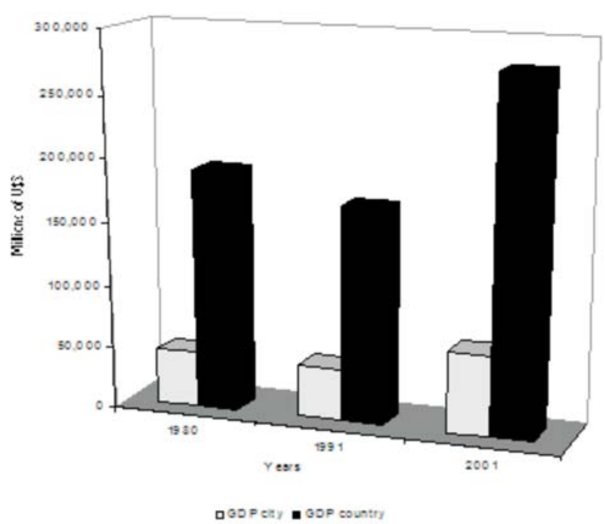
Figure III.10: Income distribution in GBA



Source: FIEL (1999).

Finally, in terms of GDP, the city contributes with approximately 25% of Argentina's GDP. As it is shown in Figure III.11, in its dynamic, the city's GDP follows that of the country as a whole.

Figure III.11. Buenos Aires' and Argentina's GDP



3.2. Energy consumption

Energy consumption behavior has been mainly determined by population growth and affluence, related to a more intensive use of electricity (air conditioner, computers, etc.) and natural gas from the pipeline. Table III.30 shows the evolution from 1990 to 2000. The industrial sector reduced its share, what can be related to the decline of the sector and the increasing importance of services.

Table III.30: Total energy consumption in Buenos Aires City (Energy consumption in thousands of TEP)

Type	Year		% (2000 vs 1990)
	1990	2000	
Residential	1,003	1,245	24.2
Commercial and Public	589	633	7.6
Transport	1,721	2,481	44.2
Industrial	855	677	-20.8
Total	4,168	5,037	20.9

Source: Balance Energético Nacional, Secretaría de Energía (2005) and own calculations based on Corredera and Rosenfeld (2004), where Buenos Aires contribution to energy consumption is estimated from national values

From now on, the data on energy consumption is divided in two main categories: electricity and transportation. Electricity is produced for residential, commercial, public, and industrial use, from fuel consumption in thermal power plants. Among them, the most important increase was produced in the residential sector, due to a significant population growth and an associated increase in the use of household appliances and lightening because of imports advantages (as a consequence of convertibility of the currency, 1 dollar = 1 peso) and the very low price of electricity (as a consequence of deregulation of the electricity market during the 90´s, product of a deregulation wave).

Industry had a moderate growth (mainly due to an increased consumption of non-electric energy), since the city underwent a period of changes, privileging services instead of industrial production, so that the population growth was not followed by an industrial growth. Imported products became more competitive than national ones in deregulated markets.

In 2000, 18% of total Argentine electricity generation was carried out inside BAMA (14.6 TWh out of 81.1 TWh). There are four active stations in BAMA (all thermal: Buenos Aires, Puerto, Costanera, and Dock Sud), comprising 18 different thermal units. Combined cycles have been installed in recent years and accounted, in 2000, for about 65% (9.5 TWh) of the BAMA-generation (compared to 35% in 1999). Three fuels are consumed by thermal power plants: fuel oil, natural gas, and gas oil. Table III.31 shows a significant percentage increase of gas oil, but anyway keeping a low penetration in the electricity generation matrix. The most important fuel used for these purposes is natural gas, due to the low price of this fuel as a consequence of its abundance and of a privileged tax policy (we will discuss with more detail). Clearly, the heavy reliance on natural gas in combustion has many environmental advantages compared to a more petroleum-based combustion. Natural gas is less carbon-intense than petroleum-products, that is, CO_2-emissions per energy unit is lower. Additionally, natural gas almost exclusively contains methane (CH_4) and will therefore be less harmful the local environment than petroleum-products containing for example sulfur.[8]

As regards electricity consumption by sector, residential and commercial uses are dominant, the latter showing a remarkable increase in the 1990-2000 period. The energy intensity of industries is the lowest of the sample (see Table III.31).

[8] However, it has to be considered that methane is an effective greenhouse gas (21 times more effective than CO2). If fugitive emissions of methane exceed 5% of methane-consumption, it is, in terms of greenhouse gas emissions, no different than burning oil (see in that respect ICAP, 2002).

Table III.31: Electricity consumption and energy intensity in Buenos Aires

Sector	Consumption in	Year		% Increase (2000 vs 1990)	Intensity in	Year	
		1990	2000			1990	2000
Residential	MWH	2,058,822	3,357,505	63.1	GJ per unit of GDP	516,139	511,295
Commercial	MWH	833,199	3,755,798	350.8	GJ per unit of GDP	208,880	571,949
Industrial	MWH	1,074,504	955,330	-11.1	GJ per unit of GDP	269,374	145,482

Source: Secretaría de Energía (2005).

In terms of Buenos Aires' energy consumption profile, total consumption for the transportation sector has increased significantly in the 90's. During the selected period the transport sector has been responsible for 39% of total energy consumption of Argentina, being half of its consumption in gas oil and one third in gasoline.

According to Weaver (1998), more than 95% of CO, 75% of NOx, 60% of PM, 50% of SO_2, and 70% of VOC emissions arise from transportation circulation. The city of Buenos Aires mainly owns a gasoline powered transport fleet. However, if the city's boundaries are taken into account, gas oil and compressed natural gas (CNG) vehicles acquire relative importance, partly because of its preferential tax policy that favors its consumption due to costs savings in long-distance trips (we deal with this issue below). Since 1984 the Secretariat of Energy has promoted the substitution of liquid fuels to improve urban air quality. As a result, the number of light vehicles propelled by CNG (converted from gasoline vehicles) has increased from 64 units in 1984 to 630,548 in 2000 (approximately 50,000 taxis).

Considering the number of private cars, taxis and buses in GBA, GNC powered vehicles' share in the total fleet exceeds that one of Diesel Oil motorized transport (see Tables III.32 and III.33).

Table III.32: Fossil fuels consumed by transportation (2000)

Fuel	Ciudad de Buenos Aires	GBA
Gasoline	818,865	906,321
Diesel Oil	112,717	107,459
GNC	51,220	233,741

*private cars, taxis and buses
SOURCE: ICAP (2002).

Table III.33: Per capita passenger transport energy use

Fuel	AMBA (public** transport)		Argentina (private*** transport)
	1990	2000	2000
CNG	0.017	0.109	0,005*
Gasoline	0.410	0.348	0.087
Diesel Oil	0.382	0.641	0,008*
Jet Fuel	0.006	0.127	--
Electricity	0.002	0.004	--
Fuel Oil	0.002	0.004	--

Source: ICAP (2002).

3.3 Waste

The dominant systems of waste disposal in Argentina are landfills and open dumps (before that, waste was incinerated but that method was forbidden in 1976 during Argentina´s military regimen). Nowadays approximately 65% of the urban population has its waste disposed in landfills surrounding the city (managed by CEAMSE *Cinturón Ecológico Area Metropolitana de Buenos Aires Sociedad del Estad*o). But more than two million tons of waste have been left on 600 hectares of dumps in the populated metropolitan periphery, with the subsequent effect on the environment.[9]

Concerning solid waste, its production grew significantly during the 1990-2000 decade in part due to population increases and in part also to GDP growth. As a result, per capita solid waste increased, showing that solid litter augmented at a higher rate than population (see Table III.34).

Table III.34: Solid waste generation in Buenos Aires

Year	Total (tones)	Total per capita
1990	1,014,283	0.09
2000	1,953,375	0.17

Source: INDEC (2005) and CEAMSE (2005).

[9] For a history of solid waste in the city, see *Fundación Metropolitana* (2004).

3.4. Emissions patterns

Auto-transport is the major source of air pollution in Buenos Aires (see Borthagaray et al 1999 in that respect). Table III.35 includes data from a US IM240 dynamic cycle for mobile emissions (for both new 0-km units and used cars), estimating emission factors for vehicles by Pollutant (CO, NOx, CO_2, PM and VOC), vehicle class (private cars, taxis, less than 2 Tons trucks, buses, omnibuses and more than 2 Tons trucks), and mean circulation velocity (from "slow" for secondary streets to "fast" for highways), as done under ICAP (2002), and is presented below. Although only two pollutants are relevant in terms of GHG emissions (CO and NOX), they let show that transportation is the main emitter, with 95.5% and 87.4% of CO and NOX emissions respectively (see Table III.36).

Table III.35: Emission data record (AMBA 2000)

Pollutant	Sector (Tn)				Total (KTn)	K tn per million inh	Tn per urban hectare
	Electric generation	Industry	Transport	Other			
CO	5,930.00	3,084.89	2,951,110.04	126,875.07	3,087.00	264.07	7.96
CO2	16,510.00	1,412.32	42.55				
NOx	8,809.39	3,411.39	111,995.20	3,784.01	128.00	10.95	0.33
SO2*	5,591.00	5,721.00	21,789.00	910.00	34.01	2.91	0.09
PM 10	776.87	706.05	15,664.53	5,558.59	22.71	1.94	0.10
HC	131.42	76,958.99	229,430.07	12,479.52	319.00	27.29	7.96

Source: Gaioli and Tarela (2002) and Weaver (1998).

The city does not suffer from any phenomena as volcanic eruptions or wood flames, has eliminated waste incineration by law, carbon has almost no role as residential heating, and it possess few industries in its territory (apart from a petrochemical pole in an area called Dock Sud). Hence, besides transportation, the second major source of pollution is a couple of thermal electricity plants located near the Río de La Plata.

3.5. Air quality

Given the emissions we dealt with in the previous section, it is important to say that the City of Buenos Aires has several advantages with respect to pollutants dispersion, leading to a relatively better air quality than the other cities we are analyzing in this report. To begin with, Buenos Aires is not located within mountains as is the case of Santiago de Chile and Mexico City. That fact, together with the existence of strong winds (Norte and Pampero) and rains (Sudestadas) provide a natural cleansing system. Accumulation of air pollutants from one day to the next is not a common feature of Buenos Aires. However, air quality is poor in several places some days at peak hours, and, in particular, between buildings and in high circulation roads.

Records on air quality are rather scarce and discontinuous for the City of Buenos Aires, where there is no monitoring network in place. A brief summary of them is provided here. In 1985 and 1986, through the WHO's Global Environmental Monitoring System (GEMS), concentrations of SPM were measured in two places in the city. For some of the measurements the average and the daily maximum concentrations exceeded the WHO guidelines. In 1994 a sampling campaign was made in 19 stations for NOx and SO_2, between May 25 and July 13 (Aramendía et al., 1995). The higher values corresponded to the downtown area, but are below maximum tolerable limits.

Currently, there is a monitoring station located in the central area of the city that measures only CO. The curve of the daily variation of CO concentrations shows two maximum peaks, corresponding to the morning and evening rush hours. The greatest peak is the one between 8:00 and 11:00 a.m., while during weekends and holidays it decreases. For the period between December 1998 and May 1999 the 8 hours average time of sampling showed concentrations that for working days exceeded frequently the WHO guideline (Tarela 1998).

The first systematic study carried out in the city, using a continuous monitoring station, was performed during one year in one of the principal avenues near downtown (Bogo et al 1999). Results indicate that vehicular traffic is the principal source of CO and NOx. The monthly averages of CO and NO decrease from winter to summer in correlation with the increase of the mean wind speed and average temperature. And, concentrations during Saturdays are approximately between 70% and 90% with respect to workable days, and around 50% in the case of Sundays. Further measurements performed close to the Rio de la Plata River show long-term pollution levels quite below for those of the downtown area.

The City Government has a monitoring station in another site where average concentrations of NOx, SO_2 and particles do not exceed the limits established by local legislation for long periods of time (GAIA 2001).

In Table III.36, we provide a summary of all existing (known) information on air quality for the city of Buenos Aires.

Table III.36: Air quality measurements for the city of Buenos Aires

Pollutant	units	Year	
		1980	2000
O_3*	ppb	n.d.	13.8 to 16.2
NO_2*	ppb	n.d.	12 to 41
Nox*	ppb	n.d.	16 to 190
CO**	ppm	n.d.	2.1 to 11.5
SO_2*	ppb	n.d.	2 to 7
TSP*	µg/m3	n.d.	21 to 83
PM10***	µg/m3	n.d.	25 to 52
Lead	µg/m3	0.3 to 3.9****	0.019 to 0.22*****

Source: * Aramendia et al (1995), ** Tarela (2002), *** ICAP (2002), **** CNEA (2001), ***** Ozafrán in ICAP (2002).

3.6 Institutional aspects

There are several aspects related to management that are key to understand air pollution in the city of Buenos Aires. Sometimes, policies are of a direct type (for example, setting emission standards for vehicles) and others are more indirect. We selected here all those government measures that can have any sort of impact on air pollutants. Those include mainly four categories of policies: emission standards, pricing incentives, those related to traffic improvements and to modal substitution, as well as land use legislation. We considered both national and local policies.

3.6.1 Gas emission standards

According to national decree # 779/95 (art. 33), vehicles must not exceed the conveyed limits on pollution (gas, noise and radiation emission). Beginning January 1 1998, each new vehicle (light - passengers) has to respect the following gas emission standards (see Table III.37).

Table III.37: Air quality standards (light vehicles)

Pollutant	maximum admitted emission	
	light vehicles	Buses and heavy emisión
carbon monoxide	6,2g/km	4,0g/km
Hydrocarbons	0,5g/km	1,1g/km
nitrogen oxide	1,43 g/km	7,0g/km
fragmented material	0,16 g/km* - 0,31 g/km**	
Carbon monoxide (slow motion)	0.50%	
hydrocarbons (slow motion)	250ppm***	

*Affecting vehicles owning a Diesel powered engine (reference mass < 1700 kg.)
**Affecting vehicles owning a Diesel powered engine (reference mass > 1700 kg.)
*** Affecting vehicles owning Otto engines
Source: INFOLEG (2005).

The producer must guarantee (in writing) the maximum values limit for light vehicles, at least for the initial 80,000 km or five years of use (the first to take place). Beginning January 1 1998 and January 1 2000 (urban buses and heavy vehicles owning diesel powered engines, respectively) gas emissions had to respect the standards in Table III.38.

The producer must guarantee (in writing) the maximum value limits for heavy vehicles, at least for the initial 160,000 km or five years of use (the first to take place). In addition, according to resolution # 1237/2002, complementary to the preceding decree, gas emission by heavy vehicles owning GNC powered Otto engines must be in accordance to the stablished values.

Table III.38: Air quality standards (GNC powered heavy vehicles)

Pollutant	Maximum admitted emission
Carbon monoxide	4.0 g/km
Hydrocarbons (total)	2.2 g/km
Hydrocarbons (methane free)	1.1 g/km
Nitrogen oxide	7.0 g/km

Source: INFOLEG (2005).

3.6.2 Taxes

According to municipal decree # 240 (title V, article 238), the taxable base of vehicles is to be annually determined by the *Secretaría de Hacienda y Finanzas* (the tax is associated with the validation of the vehicle plate, "*patente*"). For every fiscal period, the value to be considered is 95% of the value the vehicle had at October of the previous year.

Annual tax rates are 3.52% and 3.53% for small and big cars, respectively. Vehicles exceeding 12 years of use are exempted from paying (which lacks any logic from the point of view of the environment, and is based only on supposed equity reasons since it is assumed that poor citizens own the oldest vehicles). Vans, ambulances, "pick ups" and buses owning GNC powered engines are affected by a 50% reduction in the tax for 2 years after the vehicle has been equipped with the GNC device, as long as it is intended for commercial use.

According to national law # 23966 (decree #820/2000 for liquid gas), current fuel tax rates are exhibited in Table III.39 (for liquid gas GLP-, notice that the "ordinary" tax rate is 21%).

Table III.39: Fuel tax rates

Type	Rate
Petroleum gas (virgin)	62 %
Petroleum gas (natural)	62 %
Gas Oil	19 %
Diesel Oil	19 %
GNC	16 %
GLP (VAT)	12 %*/19 %**/3.5 %***

* Transactions involving Gas Licuado producers (or fractioning firms) registered in the "Registro de productores de Gas Licuado" or in the "Registro de fraccionadores de Gas Licuado"
** Transactions involving Gas Licuado fractioning firms not registered in the "Registro de fraccionadores de Gas Licuado"
*** transactions involving Gas Licuado distributors and other buyers, being the seller a fractioning firm registered in the "Registro de fraccionadores de Gas Licuado"
Source: INFOLEG (2005).

Whenever a vehicle registered between January 1 1979 and December 31 1999 was sold (being its current value above $4000), the "*impuesto docente* ley #25053" ("educational tax") was to be paid. The tax rates were 1% and 1.5% for small and big cars, respectively, with some involuntary logic from the point of view of the environment. That tax was paid only by some contributors and there was a general denial to pay it. As a result, the tax was derogated and those who did not pay were not sanctioned.

3.6.3 Vehicles rotation: "*Plan Canje*"

The idea of vehicle rotation plans is to phase out older cars and replace them with newer ones. The "Plan Canje" national regulation can be found in decrees #35/99, #208/99, #397/99, #926/99 and #1220/99, being this legislation repealed by decree #271/2000. The "*Plan Canje*" gave several benefits so as to induce people having old vehicles to replace them by newer units (its functioning is described in Table III.41).

The *Plan Canje* was in fact a measure targeting a support to the local automotive industry, which was suffering a strong crises due to the low internal demand and the Brazilean crisis, and not for environmental reasons. But, there was clearly a positive result obtained from it since several thousand units of old cars were retired from the market as a consequence of *Plan Canje*.

3.6.4 Conventional traffic flow improvements

Two conventional improvements are exclusive lanes and bikes and strategies targeting education. In Buenos Aires, there are exclusive lanes from 8 AM to 20 PM for occupied taxis and public buses (only in working days) in the four main streets of downtown (*avenidas* Córdoba, Pueyrredón, Entre Ríos and Callao). The city has also several bike paths and numerous lanes which prioritize bikers.

As of strategies focusing on education, according to law #24449 (December 23 1994, named "Transit Law"), complementary to law #23348, students attending Kindergarten, primary school and secondary school are intended to receive education on transit facts. As well as this, technical schools and universities are encouraged to offer studies on transit issues. Information on ways so as to avoid accidents is to be provided and certain (public) buildings are to be affected to the learning and practicing of driving skills. Finally, advertising which induces people to act against the end of this law is to be banned. This may appear trivial but it has been proven that driving behavior (sudden stops or high velocities, for example, are drivers of higher pollution).

3.6.5 Promotion of modal substitution

This is a key factor to promote cleaner transportation. In the case of the city several improvements have been underway in the last few years.

Five subway lines are currently operating in Buenos Aires (A, B, C, D and E), with an extension of 44 Kms. Authorities intend to build four new lines (in the "first stage", line H and in the "second stage" lines F, G and I). Further developments are depicted in Table III.41. The operation has been privatized under a sole firm (*Metrovías S.A.*). As a result, the participation of subways in the number of trips has gone from 3% of the region to 4%.

Table III.40: City of Buenos Aires subways planned developments

First stage	Line A	This line currently travels from Plaza de Mayo to Primera Junta (Caballito). The expansion of line A has already begun. As four new stations are to be built (Puan, Carabobo, Flores and Nazca), this line will add 2882 meters to its journey. By 2007, Carabobo station is going to be finished and twelve months later, with the opening of Nazca station, line A will travel from Plaza de Mayo to Floresta.
	Line B	Two new stations are to be constructed (Echeverría and Villa Urquiza), adding 1600 m to its current voyage (10150 m). Line B owns 15 stations in the present (including Tronador and Los Incas, assembled in 2003) and is frequented by 65 million people every year.
	Line D	Its expansion is to be encouraged. As well as this, a parking is to be put up.
	Line E	The construction of new stations (reaching Plaza de Mayo) is expected.
	Line H	Its building has been taking place since January 2001. Its projected longitude is 11000 m and line H is going to link the south of the city to the north of the Buenos Aires. A preliminar inauguration is likely to take place by the end of 2006 (3344 m).
Second stage	Line F	Having a 8600 m extension, line F is going to be linked to the current lines and to the ones to be put up in the future
	Line G	Line G will approach the north-west of Buenos Aires, linking densed populated areas to non-residential locations (commercial, industrial) through its 7300 m rail
	Line I	It will communicate the north, center and south of Buenos Aires. Line I is expected to be linked to the other lines far from Buenos Aires Downtown, so as to de-compress the area. As well as this, its rails are going to communicate Caballito, Villa Crespo and Palermo between each other.

Source: own elaboration based on GCBA (2005).

The network for the city is formed by seven main lines (Sarmiento, Mitre, San Martín, Belgrano Norte, Belgrano Sur, Urquiza y Roca), with an extension of 833Km.

Decree # 1143/91, established the institutional frame to privatize two of the passenger train lines (S.B.A.S.E. and FE.ME.SA.). It was conveyed that the concession would take place for ten years (and could be renewed for ten additional years). The concessionary was expected to get paid for its services by users (prices would be established by an organism to be settled by the Executive National Power). The concessionary is subsidized by the government.

On the other hand, the Metropolitan line was fragmented in diverse services, independently privatized. The process of selection and allocation of the lines has been taking place until 1995. The concessions were given for ten years (upgradeable for ten additional years), excepting the *Urquiza Subterráneos* de Buenos Aires line whose concession was twenty years long (also with the possibility of renewal).

As a consequence of privatizations, nowadays, much more passengers travel by train (there was an increase: it went to represent 4% to 6% of the total trips). The reason of that improvement come from factors as the low tariff (maintained even after privatization), the increase in frequencies (with more reliability), better quality of trains and also improvements in the level of security.

3.6.6 Land use related strategies

There is a *Código de Planeamiento Urbano* of the city, which determines clearly the maximum height of new buildings as a function of the street width and other parameters, as well as the use that can be given to land. Moreover, there is nowadays a debate to modify that code to create more flexibility in what can be built and what not in order to generate incentives to recycle old buildings (*Plan Urbano Ambiental 2000*). Not always are those codes respected, as is usual in developing economies. More study should be performed on this issue.

IV. Santiago, Chile

Alejandro León, Mercedes Ibañez and Paulina Romero

1. National context and urban development

Chile is divided administratively into regions, provinces and municipalities. The present case study is referred to Santiago, the country's capital city. Santiago is located in the Metropolitan Region, and comprises 32 municipalities. However, the conurbation expands beyond the traditional city limits. Therefore the city is referred to as Greater Santiago, which includes the municipalities of the Province of Santiago in addition to the municipalities of San Bernardo and Puente Alto.

The political, economic, and social events occurred in Chile have affected the development of the city of Santiago and the way in which the surrounding natural environment has been used. The different policies that have been implemented under different governments have had an impact on the city's expansion. In turn, population growth, affluence, and the city's physical expansion have all resulted in higher carbon emissions, as it will be shown below.

1.1 Import substitution, the entrepreneurial State, and the environment: 1964-1973

In 1939 the Chilean government created the Corporación de Fomento de la Producción (CORFO), aimed at creating an industrial base to substitute imports. Following this development model, the city of Santiago increased both its area and population. It changed from 113 sq km and 950 thousand inhabitants in 1940 to 228 sq km and almost 2 million in 1960. Migratory flows within the country were heavily influenced by the industrialization policy, because cities started to attract hand labor. Moreover, stagnation of agricultural production increased the rural-urban flow.

To mitigate the impact of the migratory process, the government designed an Intermunicipal Regulatory Plan (IRP) in 1960 (Hajek 1998). This plan was aimed at recovering the old neighborhoods, the vacant lots, and promoting the creation of suburbs around the central city, especially in areas of low-quality soil. The plan's objectives were, alas, never fulfilled, but it was useful in the sense of promoting the idea of city planning.

The Ministry of Housing and Urbanism was created in 1965. This agency is in charge of planning the urban development of cities in Chile. Several instruments other than the IRP have been thus created, such as municipal regulatory plans, and urban development plans. All of them attempt to organize urban land-uses. This ministry has the responsibility of determining city limits, which have evolved throughout different governments to Santiago's current shape. The ministry created in 1968 the Corporation for Urban Improvement, in charge of remodeling deteriorated areas through construction of taller buildings, thus avoiding excessive growth of the city. During the 1990s, this corporation was charged with the responsibility of managing a subsidy created to enhance repopulation of the historic downtown.

1.2 Free market, primary-sector-based exporting economy 1973-1989

During the mid 1970s, the new government applied a new economic model, which was based on economic deregulation and promotion of international trade. These policies affected urban growth through the 1979 National Policy for Urban Development. This policy considered the urban soil as a non-scarce good that, therefore, could be traded freely in the market.

As a consequence of this policy, the government eliminated all the restrictions that the old way of planning had designed. The 1979 presidential decree #420 formally modified the city's 1960 Intermunicipal Regulatory Plan, stimulating urban growth according to market-based preferences. This allowed for the social and spatial stratification of the city (Hajek 1998).

Thus, since 1979 the expansion has added 23 thousand hectares to the city limits, increasing, for example, commuting time, and by this, GHG emissions. The diversity of disadvantages that emerged with the unregulated market of urban land called for changes to the National Policy. A new Presidential Decree (#131, March 1985) “adjusted” the policy, which specifically considered urban soil as a scarce good, thus subject to State planning (Hajek 1998).

In spite of amendments to specific policies, the practical result is that the city grew beyond expectations, concentrating population and economic activity. Hence, the conditions for a carbon-emissions raise were set out in the second half of the 20th Century.

1.3 Transition to democracy during the 1990s

The National Commission for the Environment (CONAMA) was created in June 5, 1990, with the purpose of defining the framework for a national environmental policy.

This constitutes the first piece of legislation that includes the environmental dimension in urban development projects. CONAMA, together with the Ministry of Health, oversee air pollution issues, especially within the Metropolitan Region (where Santiago is located). Hence, the first regulation aimed at controlling emissions was issued in Chile after 1990. This year a new democratic government succeeded the military regime.

Thus, the application of Law #19,300 known as *Bases Generales del Medio Ambiente* passed in March 1997 rescued the coordinating role of the 1960 IRP, fostering taller buildings and the recycling of old neighborhoods. During 2004, in a highly controversial and contradictory decision, using decree #3,518 of 1980, the government authorized the land-use changes (from agriculture to urban development) of important portions of land located on the northern vicinity of the city. This means that the city expansion will continue through low density neighborhoods. This has important implications for the carbon balance. On the one hand, as stated above, commuting time increases and therefore the utilization of different means of transportation augments. As we shall show below, private cars are favored among the *Santiaguinos*. On the other, land used for agriculture and therefore a potential carbon sink is now used for suburban, low density housing. Change in use, and the correlated carbonizing activities associated to construction contribute to a new balance in the area.

1.4 Socio-economic and demographical dynamics

Chile's population increased from 3,230,000 inhabitants in 1907 to 15 millions in 2002, at an annual average rate of 1.8% between 1982 and 2002. Out of 13 million which inhabited Chile in 1992, more than 49% lived in the largest five cities of the country (Table IV.1), and Santiago concentrated 36% of the population while only 13% populated the other four. In 2002 Santiago's population increases its share (38%) of Chile's total.

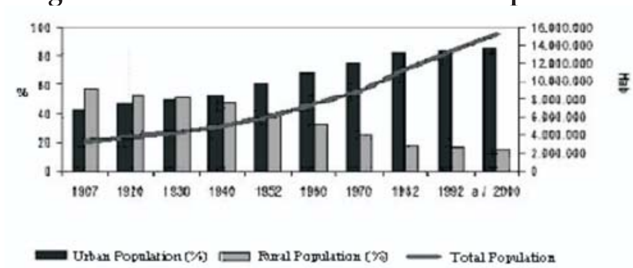
At the beginning of the 20th Century, most of the population lived in the countryside (58% in 1907) but it swiftly migrated to the cities. By 1940 more than 50% and by 2000 86% of the population was urban (Figure IV.1), increasing the pressure on the soil and the resources

Table IV.1: Population in Main Chilean Cities (1992)

City	Population
Greater Santiago [1]	4.756.663
Greater Valparaíso [2]	762.918
Greater Concepción [3]	619.929
Greater La Serena [4]	243.582
Antofagasta	228.408

[1] Includes Province of Santiago and municipalities of San Bernardo and Puente Alto.
[2] Includes Valparaíso, Viña del Mar, Quilpue and Villa Alemana
[3] Includes Concepción, Talcahuano and Penco.
[4] Includes La Serena and Coquimbo
Source: Martínez (2002).

Figure IV.1: Rate of Urban and Rural Population



Source: Statistics National Institute (INE): (1907 1992 Census).

Chile's economy has grown steadily, even if the rates during 1980-2000 have been variable (Table IV.2). The main contributors to the GDP in 1990 were the manufacturing industry with 2.3 billion dollars, commerce with 2 billions, and financial services with 1.6 billions.

In relation to the contribution of different administrative regions, the Metropolitan Region is the most relevant, since it contributes to the national GDP with financial services and commerce. The manufacturing industry of this region is also a main contributor to the GDP (Figure IV.2). This shows that the Region where the capital city is located concentrates the bulk of the economic activity. In fact, the Metropolitan Region generated 38% of the GDP in 2000, while the regions of Biobío and Valparaíso and contribute with just 7.2 and 7% of the GDP respectively.

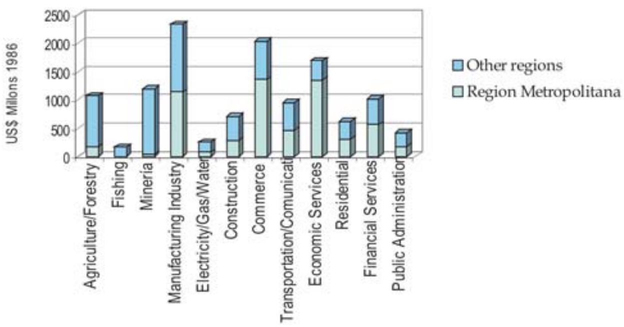
The industries that are located off the Metropolitan Region are mining, located mainly in the Andean fringes of the Atacama Desert in northern Chile, and fisheries, located in the southern regions of 'Biobío' and 'Los Lagos.'

Table IV.2: National GDP

	1980	1990	2000
National GPD (Thousand US$, constant prices 1986)	11.545	18.154	34.386
% Growth	--	57,1	89, 6

Source: Central Bank (2002).

Figure IV.2: Contribution to GDP by economic sector, 1990



Source: Central Bank (1998).

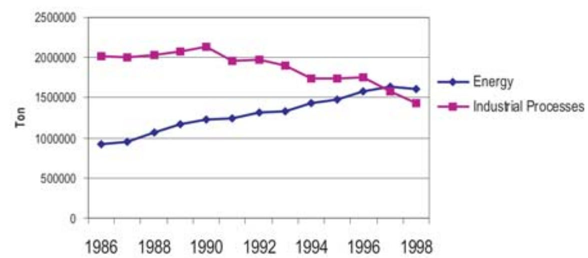
1.5 GHG emissions in Chile

Data on emissions at national level were obtained from the "Inventario de emisiones de GEI: energía, procesos industriales y usos de solvente en Chile 1986- 1998" (PRIEN 2000). The IPCC's methodology was used to create this inventory, so that results could be comparable to those obtained in other countries.

For the analysis that follows, Chile's emissions have been split in the "energy" and the "industrial and solvent use" sectors (Figure IV.3). "Energy" includes, following the IPCC guidelines, the energy industry, manufacturing and construction, transportation, commerce, residential, and agriculture, logging, and fishing sectors. All their emissions are a result of combustion. The "industrial and solvent use" sector includes all emissions of industrial processes not generated by combustion, such as the cement industry, iron, and the paper mill industry (PRIEN 2000).

Industrial activities not related to combustion are the main source of contaminants such as SO_2, CO, NOx and COVNM. The processes associated to these emissions are those transforming inputs physical and chemically, such as the cement, iron, steel, copper, and cellulose industries. There is, however, a constant decrease in the emissions of these sectors starting 1990 due to technological change in the industry. These reductions are a response to the public pressure, and even if they were not thought to have carbon implications, they have certainly impacted positively the carbon balance. In 1996 emissions totaled 2,011,020 tons while they were 1,437,750 tons in 1998, 28% less (PRIEN 2000).

Figure IV.3: Greenhouse gases emissions by energy sector and industrial processes



Source: PRIEN (2000)

SO_2 is the major contaminant in this sector, since it represents 99% of its emissions. SO_2 is liberated during the processing of copper, the main mineral that Chile produces. Emissions rose until 1990 at an annual rate of 1.4%. Since then, more stringent regulations reduced emissions significantly.

Emissions from the "energy" sector increased 79% between 1986 and 1997. Just a 4.6% of this amount corresponds to fugitive sources. Fugitive sources correspond to coal mining, oil wells, natural gas, and copper refinement (PRIEN 2000). There is one exception to the low participation of fugitive sources in emissions. That is the case of CH_4 because coal mining contributed with 62% of CH_4 emissions during 1986-1998.

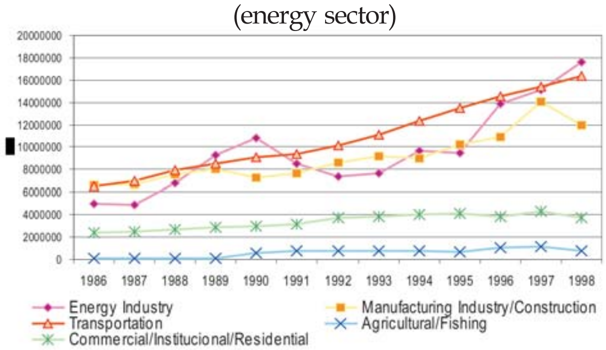
Of the total number of gases included in the inventory, those of CO are the largest. The main sources are the commerce and residential sectors. In relation to other gases, CH_4 and COVNM show low annual growth rates (Figure IV.6), as opposed to NOx, NH_2 and SO_2 that show significant growth over the years (8,9%, 17,7% y 8.7%, respectively). SO_2 emissions from the "energy" sector have increased 156% between 1986 and 1998 (8.7% per annum). The energy industry, manufacturing and construction are the most important emitters.

CO_2 emissions in Chile are generated by both the "energy" and the "industrial processes and solvents use" sectors. PRIEN treated separately emissions from combustion of biomass from the rest of combustion processes.

Figure IV.4: Energy sector´s Non-CO_2 Greenhouse Gases Emissions

Source: PRIEN (2000).

Figure IV.5 : CO_2 Emissions by combustion (energy sector)



Source: PRIEN (2000).

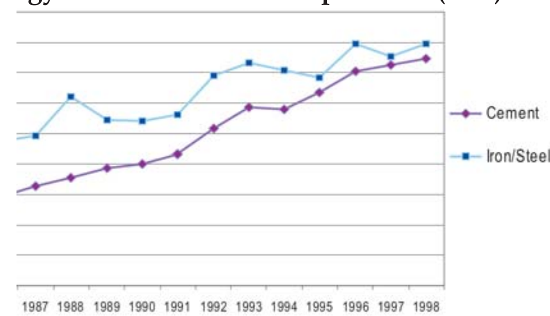
Transportation is the main emitter, and its emissions grew at an annual rate of 7.9% during the 1986-98 period. In 1986 this sector emissions totaled 6,537,000 tons and in 1998 they had increased to 16,324,000. It is important to keep in mind that "transportation" includes air, train, maritime and road transportation.

Another important sector corresponds to the energy industry: from 1986 to 1990 there is a persistent increase of emissions, peaking in 10 million tons in the latter year, mainly due to an important drought that affected most of the country. The drought increased the thermoelectric generation. In 1998, CO_2 emissions peaked again (17 million tons).

The manufacturing and construction industries contribute with important amounts of emissions: during 1986-98 the average contribution was 23%, and the annual contributions increases at an annual rate of 5.6% (Figure IV.5).

Another source of CO_2 emissions included in the "energy" sector corresponds to biomass consumption. These emissions are generated by the combustion of firewood and other components derived from wood processing. These emissions totaled 16,831,000 tons in 1998, similar to the contribution of the transportation sector.
Finally, the emissions of the "industrial sector and solvent use" sector have been considered (Figure IV.6). The largest contributions correspond to the cement, iron, and steel industries, while copper refinement, pulp mills and solvents industries do not contribute to CO_2 emissions (PRIEN 2000).

Figure IV.6: CO_2 Greenhouse gases emissions by energy sector and industrial processes(Ton)



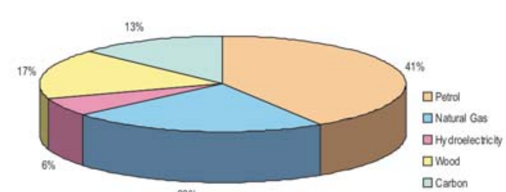
Source: PRIEN (2000).

1.6 Primary energy consumption

At the national level, energy consumption has increased constantly during the 1986-98 period from 269 thousand to 657 thousand TeraJoules, which represents an 18% annual increase (PRIEN 2000).

From the total energy consumed in the country in 2002, oil and natural gas conformed a 64% of consumption. Transportation along Chile is primarily based on oil. Only since recently natural gas became an important source of energy, mainly because the Metropolitan Region was declared a "saturated by contamination area" in 1996. Since then, firms located within the basin have been requested to substitute their energy source by natural gas imported from Argentina (Figure IV.7).

Figure IV.7: Fuel type consumption, 2000



Source: PRIEN (2000).

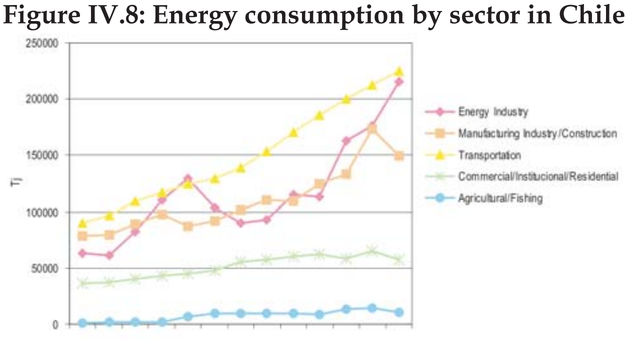
As stated above, transportation represents a major energy consumer (Figure IV.8). The increase in Terajoules (Tj) shown is a response to the increase in the vehicle fleet and increased demand for freight transportation, which in turn reflects the economic growth experienced by the country.

One of Chile's main sources of energy, electricity, is generated by means of two sources: hydropower and thermoelectric. The latter depends primarily on coal and natural gas, and the plants generate electricity through steam and gas (thus called combined cycle). Those plants are in use since 1999.

Hydropower plants have lower production costs in Chile, but due to the country's geography and climatic regimes, they are located in southern Chile. This location implies higher transmission costs. On the other hand, thermal plants have been located near the major consumption centers, i.e., the central area of the country. These plants can use other sources of energy than natural gas and coal, such as oil, and firewood.

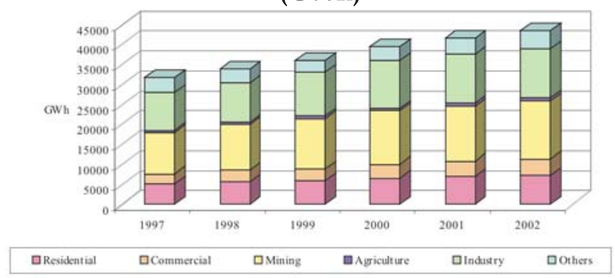
Mining and industry are the sectors showing the highest consumption of electricity and natural gas (Figure IV.9). Their consumption has increased in 5.8% during the 1997-2002 period. Mining occurs off the city limits, but industry is primarily located in Greater Santiago. Therefore, this sector's demand increases track demand for processed goods in the international market. Exports of processed goods are expected to increase in the future. Therefore, demand for electricity will continue to increase. Therefore, carbon emissions from this sector might show an important increase.

Figure IV.8: Energy consumption by sector in Chile



Source: PRIEN (2000).

Figure IV.9: Electric energy consumption by sector (GWh)



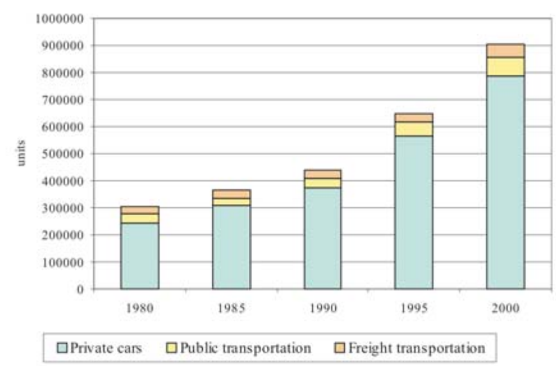
Source: INE (2003).

Other sectors such as agriculture, commerce and housing increased their energy consumption at rates of 7.3, 10, and 7.1% respectively during 1997-02. Higher consumption can be explained by population increase, which grew at 6.6% during the period.

1.7 Transportation

In 1998 the vehicle fleet reached 2 million units, of which 1.68 millions were private automobiles. Vehicles for passenger and freight transportation represent just 17% of the fleet (Figure IV.10). The current index is 113 automobiles by 1,000 inhabitants.

Figure IV.10: Total National Fleet by type



Source: INE (1980-2000).

2. The city of Santiago

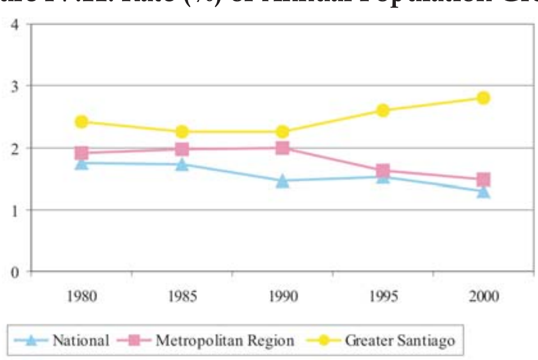
The Metropolitan Region contains the capital city of Chile, Santiago. The "Greater Santiago" comprises 32 municipalities in the Province of Santiago and the municipalities of Puente Alto and San Bernardo. The two latter belong to other provinces but the conurbation process has incorporated them as part of the city. Santiago is defined as a city according to the National Institute for Statistics, which states that a city is an urban entity with a population larger than 5,000.

2.1 Demographic and economic dynamics

In 1980, the Metropolitan Region had a population of 4.2 millions and in 2000 it surpassed 6 millions. Hence, population increased at an annual rate of 1.8%. During the same period, Greater Santiago's population varied from 3,697,700 to 5,794,400, at a higher annual rate (2.5%).

Greater Santiago contains the largest concentration of the population, since it corresponds to approximately 38% of the national total. The next populated regions are Biobío and Valparaíso with 13 and 10% respectively. Figure IV.11 shows the annual growth rates, and compares those of the country, the Metropolitan Region, and Greater Santiago. The latter has the higher rate, while the country the lowest.

Figure IV.11: Rate (%) of Annual Population Growth



Source: INE (2002).

Changes in laws and regulations affecting land-use within and beyond the city limits have resulted in the horizontal expansion of the city, rather than vertically. In 1980, the city covered 413 km^2 and 725 km^2 in 2000. Within 20 years, the city increased its radial size by 57%. This process has been characterized by an intra-urban migratory process that has resulted in the abandonment of traditional neighborhoods inhabited by wealthier families, like downtown, and the development of new poles away from the center, each time more remote.

In Santiago this process was stimulated by the Decree of Law 3,516 mentioned above that allows the subdivision of agricultural land. This impacted the market, and initiated development of the city towards the north and west (Dascal y Villagran 1997). One problem derived from the intra-urban migration is that the population now living in the periphery maintains linkages with the urban center. Thus, the physical impacts on the environment (such as land use changes and air contamination) are compounded by processes such as increased commuting time to access to jobs and services (Ortiz y Morales 2002:173). This has also been complemented by secluded neighborhoods, according to the wealth of their neighbors. This is a reflection of another social and economic reality: in 2002, the richest decile obtained more than 42% of total income while the poorest decile only got 1,1% of it (Table IV.3).

Table IV.3: Income Distribution

Decil	1990	1992	1994	1996	1998	2000
I	1,4	1,5	1,3	1,3	1,2	1,1
II	2,7	2,8	2,7	2,6	2,5	2,6
III	3,6	3,7	3,5	3,5	3,5	3,7
IV	4,5	4,6	4,6	4,5	4,5	4,5
V	5,4	5,6	5,5	5,4	5,3	5,7
VI	6,9	6,6	6,4	6,3	6,4	6,5
VII	7,8	8,1	8,1	8,2	8,3	7,9
VIII	10,3	10,4	10,6	11,1	11,0	10,5
IX	15,2	14,8	15,4	15,5	16,0	15,2
X	42,2	41,9	41,9	41,6	41,3	42,3

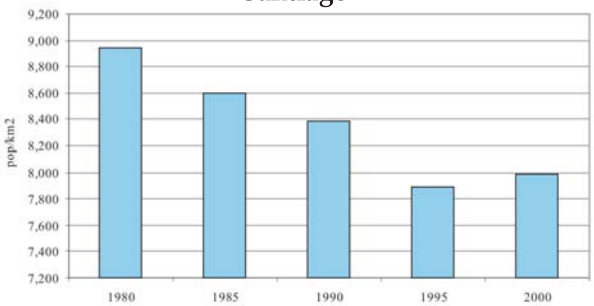
Source: Socio-economic Survey (CASEN) (1990-2000).

This is a particularly relevant fact because Santiago suffers from a strong spatial segregation: the higher income groups inhabit 6 municipalites, while the rest of the population is distributed among 20. Quality of infrastructure and services varies, depending on wealth of neighborhoods/neighbors (Rodríguez y Winchester 2001).

The population density in the city has decreased because the population growth rate is lower than that at which the city expands (Figure IV.12). During the period 1980-2000 the density decreased from 8,939 to 7,984 residents/km^2.

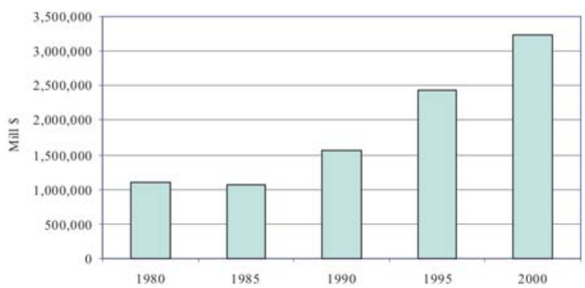
The concentration of the population as well as the economic activity results in an increased Gross Product for Greater Santiago (Figure IV.13). During 1980-00 it varied from 34 to 38% as a proportion of the Gross National Product. During this period the city's contribution to the economy grew from US$ 1.1 billion to 3.2 billion. The local GDP per capita shows the same trend (Figure IV.14).

Figure IV.12: Population Density in Greather Santiago



Source: INE (2002); Ducci (2002).

Figure IV.13: Absolute GDP Values (US$ 1986 prices) in Greater Santiago



Source: Banco Central (2001); Banco Central (2002); CIEPLAN (1993).

Figure IV.14: Greater Santiago per capita GDP (US$ 1986 prices)

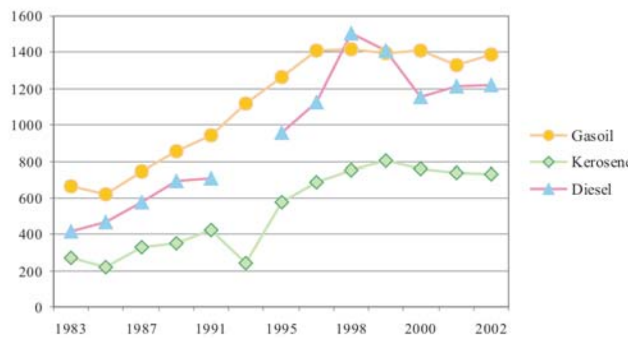
Source: Banco Central (2001); Banco Central (2002); CIEPLAN (1993).

2.2 Energy consumption

As shown above, Chile's main source of energy is oil, and it is within the city where it is primarily consumed, same as with other sources of energy. For all sources, consumption in the city has increased, and it is likely that this trend will persist in the near future, due to the increased industrial activity and quantities of vehicles (Figure IV.15).

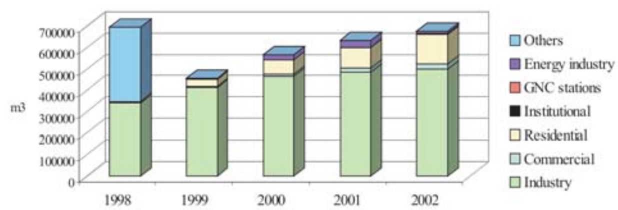
In addition, consumption of natural gas has increased rapidly after the first gasoducts initiated the flow from Argentina (Figure IV.16). The economic sector using natural gas is the industry located in Greater Santiago, followed by housing. Oil gas is mainly used in homes. Greater consumption is explained by the increased population and cars.

Figure IV.15: Energy Consumption (m^3)



Source: Oil National Company .

Figure IV.16: Natural Gas Consumption by sectors



Source: Oil National Company.

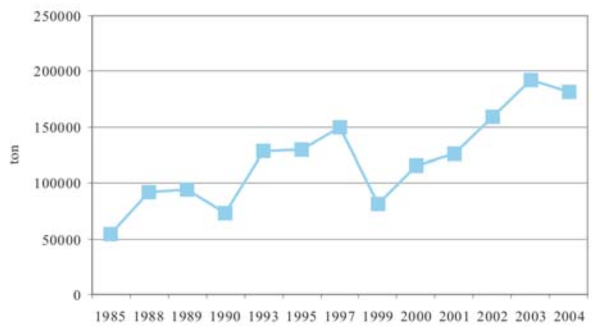
2.3 Building materials

Utilization of inputs for construction, such as iron, has increased because of the high rates of construction within the city. Construction has been one of the most dynamic sectors in the entire economy, due to higher incomes, and population increase. This process has taken place primarily in the suburbs of the city. But at the same time, this sector is highly sensitive to the up and downs of the economy, as shown by Figures IV.17, IV.18 and IV.19. These figures show the variations of different materials used in construction: premixed concrete, rebar, and cement.

Figure IV.17: Premixed concrete (m3)

Source: Chilean Chamber of Construction (2004).

Figure IV.18: Rebar (ton)



Source: Chilean Chamber of Construction (2004).

Figure IV.19: Cement (ton)

Source: Chilean Chamber of Construction (2004).

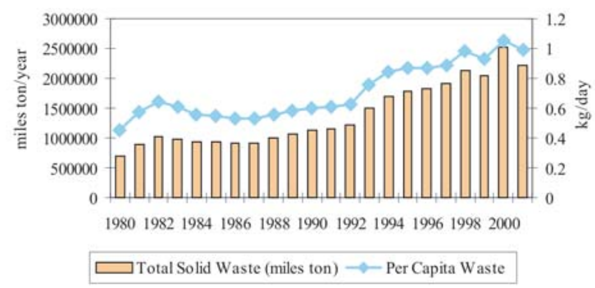
2.4 Solid waste

The processes that take place within the city generate large amounts of waste, in different stages such as liquid, solid, and gases. Gases generally correspond to greenhouse gases, and will be analyzed in the following section. Solid waste produced by the city population has jumped from half a kilo per capita on a daily basis to one kilo, during the 1980-00 period (Figure IV.20).

Total amount of residues has increased from 700 million tons in 1980 to 2,500 million tons in 2000, due to increases in population and affluence. Several studies show that the pattern of consumption of the wealthier segments of Santiago has changed over the last decades due to affluence. Thus, an important component of the waste that ends up in landfills corresponds to inorganic materials such as paper and cardboard, most of which comes from packaging.

In Santiago there are only few certified landfills. Therefore, in many of them, liquids percolate to reach the aquifer, and gases are liberated to the atmosphere. Methane--one of the main gases generated by waste decomposition--is released from landfills without control. Thus, methane emissions increase if quantities of waste per capita per day rise. This is what currently happens in Santiago, where there are no statistics that depict this situation.

Figure IV.20: Solid waste in landfills (Greater Santiago)



Source: CONAMA (2000).

3. Emissions in Santiago Metropolitan Region

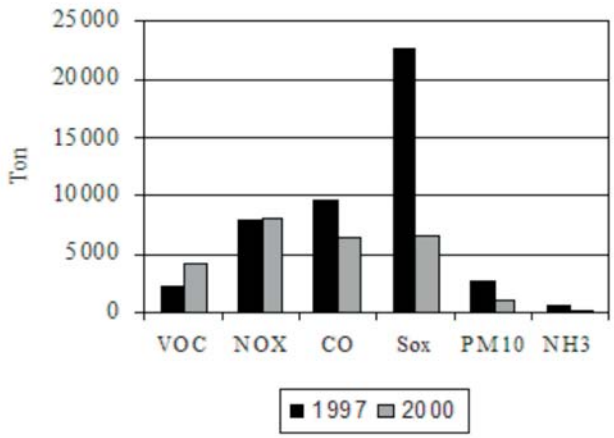
3.1 Air-quality relevant pollutants

Data on emissions in the Metropolitan Region were obtained from the "Improvement of the Emission Inventory of the Metropolitan Region" published in 1997 and 2000 by CONAMA. The inventory considers three sources of pollutants: stationary, mobile in route, and fugitive dust (PM_{10}). The latter was not included in the inventory. Gases inventoried correspond to PM_{10}, CO, NOx, VOC, SOx and NH_3.

Among the stationary sources there are two sub-groups: point and areal. The point sources (Figure IV.21) are related to combustion, industrial processes (chemicals, wood, pulp, metals, among others) and *evaporitas* (cleansing of containers, production of gas derived from oil, etc.). Main gases emitted by this source correspond to SOx, NOx and CO, and in lesser quantities to VOC, PM_{10} y Nh_3.

In 1997 SOx was the most emitted contaminant (Figure IV.22), especially from electric generation, industrial furnaces, and house heating. However, in 2000 there is a 30% reduction due to more stringent environmental regulations derived from the 1997 policy framework.

Figure IV.21: Non-CO_2 Greenhouse Gases Emissions by Point Sources



Source: CONAMA (1997); (2000).

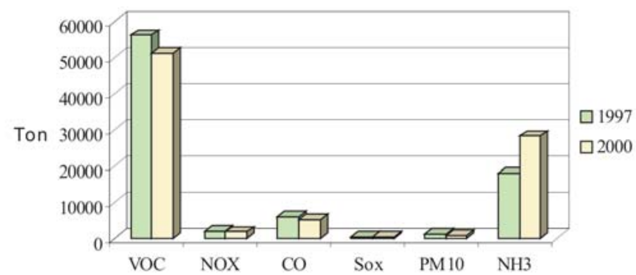
The same does not apply to VOC and NOx emissions, which increased in about 7% and 1% respectively. These are the only two gases with increased emissions within the two evaluations. Figure IV.22 shows that VOCs are the pollutants with higher emissions in 1997 but somehow they decreased in 2000 in 5,000 tons.

Mobile sources of pollutants correspond to buses, trucks, automobiles, and motorcycles (Figure IV.23). These mainly emit CO (186,437 tons in 1997 and 191,934 tons in 2000), and NOx (41,178 in 1997 and 47,222 in 2000). Private cars are the main source of contamination, since they contribute with more than 70% of the CO.

This figures should allow the public authorities to reorient some of their policies, since most of them target emissions from public transportation, and as of 2005, new highways are been built in Santiago that will result in an enhanced use of private means of transportation.

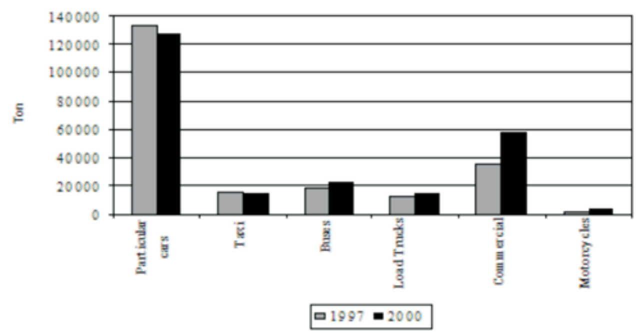
Emissions of PM_{10} generated by construction and demolishing, and agricultural lands preparation were also inventoried (Figure IV.24). These sources emit around 4,000 tons, the main being floating dust in the city.

Figure IV.22: Non-CO2 Greenhouse Gases Emissions by Area sources



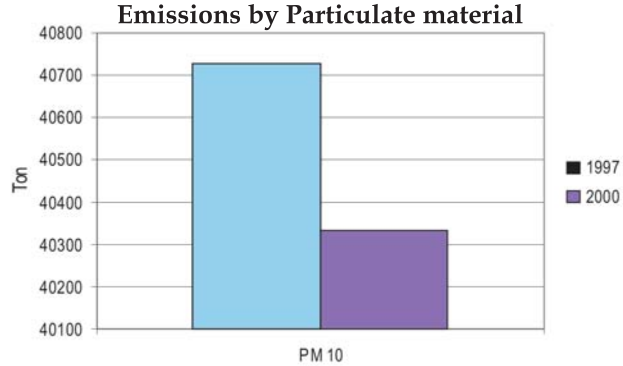
Source: CONAMA (1997 and 2000).

Figure IV.23: Non-CO_2 Greenhouse Gases Emissions by Fugitive sources



Source: CONAMA (1997 and 2000).

Figure IV.24: Non-CO_2 Greenhouse Gases Emissions by Particulate material



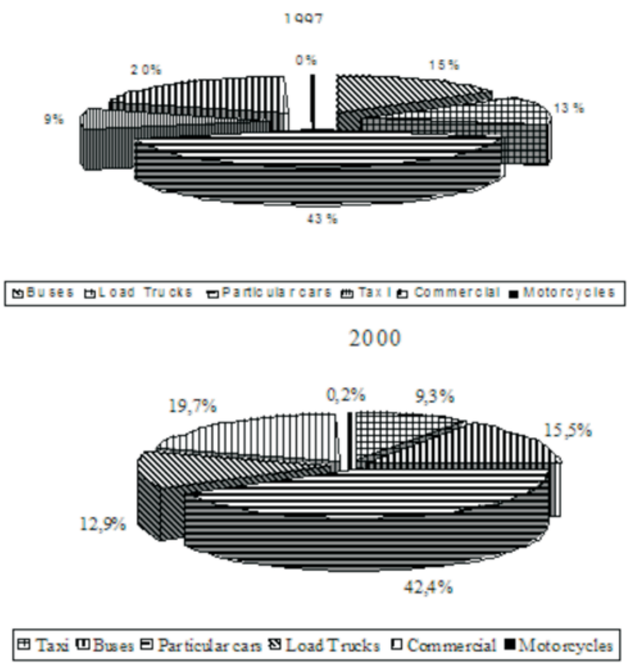
Source: CONAMA (1997 and 2000).

3.2 CO_2 emissions

In order to measure CO_2 emissions to the atmosphere the inventory records for 1997 and 2000 were considered, as well as those from the

Directorate of Scientific and Technological Research of the Catholic University of Chile (DICTUC) from 2002. According to the inventory, in both 1997 and 2000 the only sources of CO_2 were the mobile ones, i.e., buses, trucks, cars, and motorcycles. Figures are similar for both years, with a slight decrease in 2000 mainly due to the renovation of the car fleet in Santiago and quality improvement of gasoline. Commercial mobiles, such as buses emit 25% of CO_2, while trucks and cabs emit 20% (Figure IV.25).

Figure IV.25: CO_2 Emissions by transport, 1997 and 2000



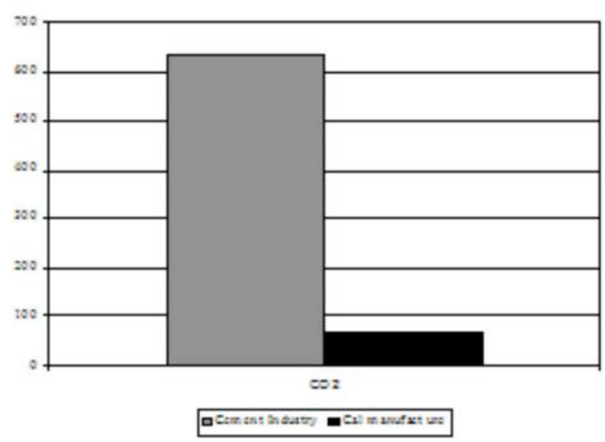
Source: CONAMA (1997 and 2000).

Transportation is the most important carbon emitter in the city. Within this category, private cars are the largest contributors. Pollution in the city relates to demography, economics, and urban growth. For example, population increase and affluence have resulted in increased demand for cars. Increased commuting time due to the disorganized expansion of the city and an inefficient public transportation system will result, in turn, in higher amounts of CO_2 emitted.

The central government is currently designing the *Plan Transantiago*, which is aimed to organizing a better public transportation system, and providing drivers with improved highways. These two principles may result in less commuting time and in incentives for citizens to use public transportation that will combine surface (buses) and underground (metro) means. Thus, carbon emissions might decrease. However, this plan should be complemented with other policies aimed at reversing the inter- and intra-urban migration trend and at promoting economic activity in other regions, a way to help de-saturate the Metropolitan Region.

In relation to the stationary sources within the Metropolitan Region, the cement industry is the major emitter (Figure IV.26), which contributed with 550 thousand tons of CO_2 in 2002, approximately 9% of total CO_2 emissions.

Figure IV.26: CO_2 Emissions by specific point sources



Source: DICTUC (2002).

3.3 Air quality management

Santiago's air quality is regulated by a series of standards depicted in Table IV.4. Requirements for Ozone and SO_2 have been increased through the years, in correspondence with the reformulation of the decontamination plan for the Metropolitan Region. The standards include lead since 2002.

Table IV.4: Air Quality Standards

	1978	1992	1998	2000	2001	2002
Ozone (ppbv/8hrs.)	160 (ug/m3N/1hr.)				61	61
NO_2 (ppbv/1hr.)	213	213	213	213	213	213
CO (ppbv/8hrs.)	9	9	9	9	9	9
SO_2 (ppbv/24hrs.)	140	140	140	140	96	96
PM_{10} (ug/m^3N/24hrs.)	150	150	150	150	150	150
Plomo (ug/m^3N/year.)				0,5	0,5	0,5

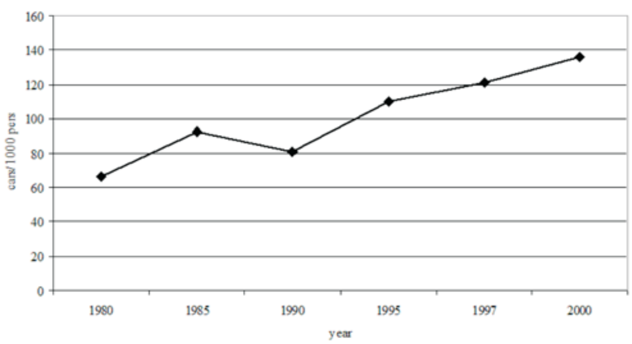
Source: Ministry of Health (1978); CONAMA (2000).

3.4 Transportation

The amount of vehicles in Greater Santiago increased from 300 thousand in 1980 to near 1 million in 2000. During these years, 80 and 85% respectively, corresponded to private cars.

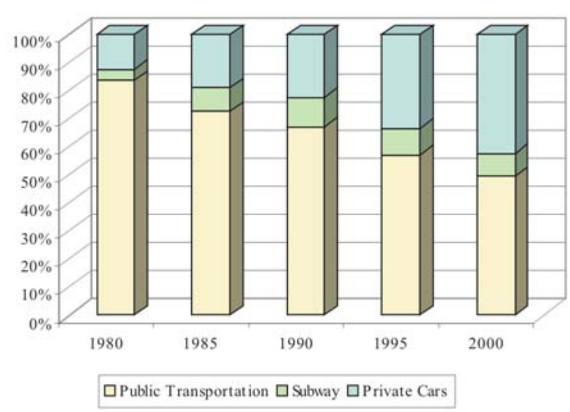
Private cars have increased their participation in the daily trips that occur within the city. For example, in 2000 they represented 45% of the 15 million daily trips. In contrast, public transportation conformed 90% of the daily trips in 1980 (Figure IV.28), and only 55% in 2000. Thus, over time the inhabitants prefer to use private cars as the main means of transportation within the city.

Figure IV.27: Passenger Cars per 1000 persons



Source: SECTRA (2002).

Figure IV.28: Mode share vehicle trips in the city



Source: SECTRA (1979, 1992 and 2002).

4. Institutional aspects

4.1. Transportation and emissions

The Metropolitan Region was declared Saturated Zone through a Presidential Decree in 1996 for four atmospheric pollutants: Suspended particles, breathable particles (PM_{10}), CO, and ozone. It was also declared Latent Zone for NO_2. Since then, the CONAMA initiated the elaboration of the Prevention and Atmospheric Decontamination Plan for Greater Santiago (PPDA). This plan was the key instrument to environmental management in the area, since it provided a set of strategies, and action plans oriented to recover the city's air quality. However, this plan has been criticized because of its vagueness, which has resulted in the difficulty to measure its success.

As it is, the PPDA does not specify standards to which it is aiming at. It contains 136 strategies, of which 104 correspond to permanent reduction of emissions measures. These correspond to “command and control” strategies, and are aimed at controlling emissions of activities such as transportation, industry, and agriculture. 26 other measures have to do with pre-emergency or emergency events, where air quality exceeds the daily standard, and 9 measures for indirect reduction of emissions, such as education.

As a result of these measures, Greater Santiago experienced a reduction between 1999 and 2002 of environmental alerts (from 27 to 21), pre-emergencies (from 14 to 5), and emergencies (from 1 to 0).

The plan was readjusted in 2000 and 2005, improving the emission baseline for 1997, and recalculation of emissions for 2000. New standards for reductions were put in place. The following are an example of specific measures that were reformulated in 2000:

Transportation

- Increase requirements for new and old vehicles
- Restrict circulation of large trucks beyond the ring Americo Vespucio
- Avoid increases in number of taxis
- Introduce city diesel, which contains 300 pmm of sulphur, instead of 1,000.
- Forbid utilization of leaded gasoline

- Create incentives to utilization to natural gas in public transportation buses
- Eliminate surface parking
- Create exclusive lanes for public transportation

Fix sources

- Increase compensations to new sources
- Control emissions of the construction sector

Suspended Dust

- Increase urban reforestation
- Increase construction of parks and green areas
- Pave and wash streets

Improve monitoring network

- Increase number of stations from 5 to 8
- Monitor PM_{10} in real time

Critical Episodes

- Improve models for environmental forecasts
- Increase restrictions to non-catalytic private vehicles
- Add catalytic vehicles to daily restrictions to circulation
- Specify routes for exclusive use for public transportation during critical episodes
- Increase from 20 to 30% the reduction of emissions from

The State and the private emitters will pay for the fix sources during pre-emergencies

There are also some measures considered as **"major"**:

- Renovation of the public transportation fleet, an trucks
- Improve quality of gasoline and diesel
- Increase requirements for new city carsdirect costs of the plan. Indirect costs and benefits such as consumer and producer surplus, changes in market structures and productivity, changes in employment levels have not yet been calculated.

However, some estimations show that the industry, commerce and construction sectors spent around 17 million dollars in 1997 and 7 millions in 1999 to comply with the requirements of the plan.

Additionally, changes in gasoline and diesel quality represented a cost of approximately 14 millions between 2001 and 2003.

One of the key projects to improve quality of life in Greater Santiago corresponds to the enlargement of the metro. The required investment to complete two new lines during 2003-06 is 1,2 billion dollars. At the same time, the Transantiago Plan, based on the improvement of the surface public transportation system will require an investment of around 905 million dollars. This amount will be covered primarily (92%) by private agents. The State will participate with 260 million dollars that will be invested in infrastructure improvement.

4.2 Land use

Land use and development in Greater Santiago are regulated by the Intermunicipal Regulatory Plan originally designed in 1960. However, due to successive changes and market forces, the ways in which the city developed are quite different to the spirit of the plan. Additionally, a wide variety of political orientations applied to the plan since 1979 have made this instrument difficult to apply and manage (MINVU 1994).

Thus, the plan is reformulated in 1994 with the intention to increase coherence to the development of the city, and improving urban land-use. This version of the plan indicates which areas are riskier for human settlements, because of the vulnerability of the areas to flooding or other events. It also specifies zones of ecologic interest and areas that need to be preserved. At the same time, it specifies the areas that can be developed or that should be kept as industrial neighborhoods.

5. Final considerations

According to the data presented here, there is strong evidence to support the notion of a strong and permanent trend to population concentration in just one city in Chile. This city is the capital of the country, which concentrates the bulk of economic activity. This has enormous consequences for the quality of life of the citizens as well as for the environment.

The national GDP and the per capita income have increased over the years, in spite of several international economic crises. The city is where much of the industry in Chile is located, characterizing this urban space with commercial transactions. This has its counterpart in carbon emissions.

Economic development has provided opportunities for the city inhabitants to access local and foreign goods, which in turn has attracted immigrants from other cities throughout the country. Hence, the city has experienced a completely disorganized growth and development.

During colonial times the city was conformed by a set of well designed streets that have expanded constantly to reach 725 km2 in 2000, in an "oil spill" fashion.

This unplanned expansion, controlled primarily by market interests, has neglected the legislation. Laws and regulations were altered through time to satisfy the requirements of speculators and developers. This meant, for example, that the environmental dimension has never been considered.

Another characteristic of city dynamics is the migratory flow that attracted peasants in the past, and continues to attract urbanites from other locations in the country. At the same time, wealthy segments have continuously moved from downtown towards the Andes Mountains to the East, thus provoking the abandonment of neighborhoods that have suffered long-term deterioration and expanding the city limits to remote locations. Governments have attempted to control this process, but they have certainly failed.

Development of municipalities that were traditionally poor has been hit by a sudden wave of wealthy immigrants. Such is the case of "Huechuraba", a municipality based on agriculture until recently that is one of the most demanded neighborhoods by affluent families willing to escape from the congestion of the city.

This in turn results in a city characterized by a spatial and social segregation. Thus, the city has a few wealthy municipalities (located toward its north-east side), and many middle and low income municipalities (located toward the south-west), where land is less valuable, industries have flourished, together with noise and contamination. Use of fuel has increased steadily. Gasoline and diesel are the most widely used. During the last years natural gas imported from Argentina has replaced some of the former. Nonetheless, insecure supply from Argentina makes this replacement not sustainable in the future. However, use of natural gas has improved air quality within the Metropolitan Region, which was declared as "saturated" for several contaminants.

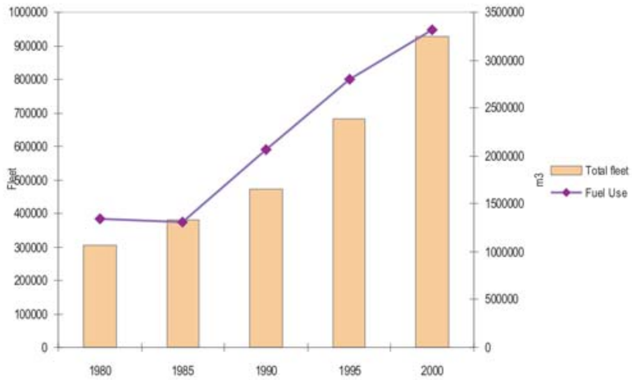
Excessive contamination of air, soil, and water called for the development of a decontamination plan since 1996. One of the purposes of the plan is to decrease emissions from stationary and mobile sources. The plan includes measures such as private vehicle utilization restriction, which in turn has promoted the renovation of the car fleet. Old vehicles (private and public transportation) were taken away from the Metropolitan Region.

Other measures included in the plan are related to air quality monitoring. Thus, companies have been forced to change their technology or pay high fines. This has been complemented with the design of an emission tradable permits system in the basin.

According to the available inventories, the most salient emitted greenhouse gas in Greater Santiago is CO_2. The main source of these emissions is transportation, especially private vehicles. Hence, to understand the reasons why air contamination in Santiago has increased, we need to keep in mind that the private vehicle fleet has changed, from 66 cars per 1,000 inhabitants in 1980 to 135 in 2000. Considering that gas emissions due to fuel consumption are directly related to the amount of cars, if the latter increases, the former will do so (Figure IV.29). This issue has direct implications for carbon emissions.

New urban and transportation programs as Transantiago and enlargement of the Metro network should improve quality of public transportation. Hopefully this huge investment will pay off with time, especially considering that currently 45% of daily trips in the city are done in private vehicles.

Figure IV.29: Relation Total Fleet Fuel



New urban and transportation programs as Transantiago and enlargement of the Metro network should improve quality of public transportation. Hopefully this huge investment will pay off with time, especially considering that currently 45% of daily trips in the city are done in private vehicles.

V. Research findings, the way forward

Patricia Romero Lankao

This Project focused on the interactions between both local and global socioeconomic and institutional processes and GHG emissions in four Latin American cities: Mexico, Mendoza, Buenos Aires, and Santiago. It intended to explore:

1. the linkages between specific pathways of development and cities' trajectories of GHG emissions

2. how diverse drivers operating at different scales produce trajectories of GHG emissions

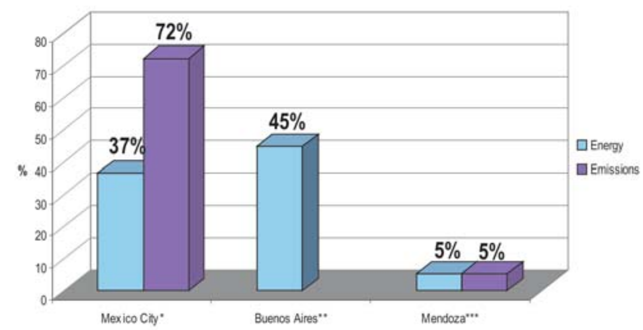
3. the patterns of causation between GHG emissions by diverse activities and their underlying drivers

Project's findings and lessons mainly refer to the first two issues, and only secondarily to the third. We will present here a short comparison of cities' trajectories of GHG emissions. We will describe some findings regarding the linkages between urban development pathways and carbon emissions. We will reflect on the importance of scale, i.e. how GHG emissions trajectories and their drivers change in concordance with the level at which they are analyzed.

1. Emissions trajectories

It was not always possible to get data on the trajectories of energy consumption and GHG emissions at the city level. Existing information allowed though for some findings. Consumption of most fossil fuels increased during last years in the cities, so did GHG emissions (Figure V.1). The increase in emissions can be due to cities' economic growth, but also to a more precise and encompassing inventory of emissions.

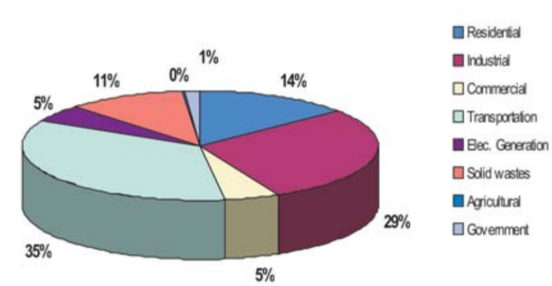
Figure V.1: Growth in energy consumption and CO_2 emissions[1]



[1]Percentages of growth in energy consumption for the three cities refer to the period 1990-2000, so do CO_2 emissions for Mendoza. Emissions for Mexico City relate to 1996-2000. There was no data on the growth of CO_2 emissions for Buenos Aires.
Source: *SEMARNAT (2003), **SEA (2005) and ***PRIEN (2002)

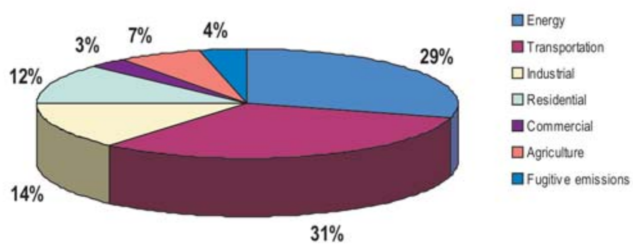
Although cities' differ moderately in the mix of activities releasing GHG, transportation stands out as main emitter. In the case of Mexico City for instance transport is followed by industrial and residential sectors (Figure V.2), while in Mendoza second and third emitters are energy production and the residential sector (Figure V.3). Emissions from fossil fuels rank high in all cities, while land use changes within the cities are not so relevant. A different accounting would result if we considered cities ecological footprint in other areas, e.g. the amount of carbon needed to feed cities requirements of food.

Figure V.2: CO_2 emissions by different sectors in Mexico City



Source:GDF (2004)

Figure V.3: CO_2 emissions by different sectors in



2. Urban development and carbon emissions

As it happens around the world, Mexico, Argentina, Chile and other Latin American countries have become more and more urban. They experienced decreased rates of urbanization in last ten years, although their urbanization rates continue to be higher than in high-income countries. Urban population has grown around 4.2 and 2.7% per annum during 1950-1975 and 1975-2000 respectively in Latin America, compared with about 1.8 and 0.9% during respective periods in high income countries (Montgomery et al 2004: 83). As the growing Latin American population becomes more urban, the importance of the way cities develop and are managed for GHG emissions and associated pollution happen to be a central point of intervention for addressing climate change.

Which have been the patterns of urban growth of the cities and what have been their carbon implications? It was possible to find for Mexico City both theoretical discussions (e.g. Aguilar and Ward 2002, Cohen 2004) and empirical data on its transition during the 1980s from a city-based to a region-based pattern of urban development. That was not the case of the teams working on Buenos Aires and Santiago. Neither they could discus literature on the issue, nor did they explicitly look for information on pathways of urban development, because they were constrained by the short duration of this project, and could only present some data which will be used in this section to draw some conclusions.

The city-based model of urban development dominated during the import substitution industrialization (ISI) period (1940-1970) in Latin American cities. In Mexico City for example, the city-based model was defined by high rates of economic growth, as well as by city's big captive market and attraction of migrant labour also expulsed by increasingly hard conditions in rural areas. The city as the "metropolis" of Mexico experienced a contiguous and apparently uncontrolled urban growth outwards made of two components. The core area continued to be densely populated by working class people. While suburban areas grew up through both legal middle-income developments and irregular self-build settlements.

The current region-based pattern of urban development is characterized by a polycentric urban expansion of first and second-order urban localities sprawling along major highways and functionally linked to the main city (see section II.7.1 of this report for Mexico City). Mattos (1999: 1) registers for Santiago a similar pattern, i.e. "the emergence of a city with regional coverage, surburbanized and polycentric, with imprecise boundaries, (like) and archipelago type configuration". This pathway of urban development is driven by demographic, economic and institutional dynamics operating at diverse scales.

As a middle-size city, Mendoza has undergone a lightly different urbanization process characterized by three components: functional centralization of industrial, administrative and commercial activities; accelerated growth of urban population stimulated by city's economic dynamics and the crisis of the rural sector, and non-planned urban growth (see section III.2.1 of this report).

At least three drivers of the transition to a region-based pattern of urban development (economic and demographic dynamics and institutional settings) experienced a set of changes during last two decades

[1]In Argentina for instance population grew 2% per year during 1980-1991 and 1.2% per year during 1991-2001 (see Table III.6, section III.1.1).
[2]There is though literature. See for Mexico CityAguilar and Ward (2002: 2), Ciccolella (1999) for Buenos Aires and Mattos (1999) for Santiago.

in the four cities with implications for cities patterns of urbanizations and by this for their GHG emissions trajectories.

Economic activities transited from an import substitution-industrialization (ISI) model, to liberalized and deregulated markets, open economies and the retrenchment of the State in its role as active promoter of economic growth. This transition resulted in diverse transformations for the three large-cities. Industry lost its role as leading activity of the local economies, while financing and commerce became the most dynamic sectors. Foreign investment increased its presence within the most dynamic enterprises of the three largest cities. There were changes in the localization patterns of the enterprises, related to a process of economic fragmentation. As mentioned in the report the bulk of foreign investment and most dynamic commercial activities of Mexico City tend to be situated in the corridor Santa Fé Polanco, while in Buenos Aires those activities tend to locate in its north and north/central zones respectively (Ciccolella 1999).

A consequence of the retrenchment of the state in its role as developer and regulator has been that rather than by public planning, urban growth has been driven primarily by market forces. The case of Santiago shows how laws and regulations aimed at controlling urban sprawl have been altered or not fulfilled through time sometimes to satisfy the requirements of speculators and developers. It was also shown for Mexico City that actions aimed at containing land occupation by the poor have not targeted the real mechanisms of land allocation and urban growth. Housing has increasingly taken place through informal self-help practices outside legal regulations, as high costs of legal land and low levels of income make these the only way for most dwellers to get access to land.

Population growth decreased at diverse rhythms in general but especially within the core areas of the cities. Contrary has been the case in peripheral areas where growth-rates have differently increased contributing to urban sprawl. Buenos Aires for example lowered -0.68%its inhabitants in 1980-2001. Population growth decreased at rates of 2.1% yearly in the core area of Mexico City, while it augmented 2.8% in the suburbanized municipalities of the State of Mexico.

As a result of the current pathway of urban development the three large cities have experienced a polycentric pattern of urban sprawl, and diminished density as well. Population density in Mexico City went from 129 persons per hectare in 1970 to 125 persons per hectare in 2000. Similarly in Santiago density decreased from 8,880 persons per km^2 in 1980 to 8000 persons per km^2 in 2000. Urban sprawl has resulted in three carbon relevant consequences for the large cities:

a) Passengers tend to travel longer distances to move from the locations of residence to their education, employment and recreation facilities;

b) Freight transport tends to move products to longer distances;

c) The city increases hence its ecological footprint on its satellites and surely on areas outside its boundaries serving their carbon related needs (e.g. energy and food).

3. Scale and GHG emissions drivers

Scale was relevant for the purposes of this research. GHG emissions trajectories and their drivers change in concordance with the level at which they are analyzed. As of the mix of activities emitting carbon, it was mentioned before that transportation is the main emitter at city level, not necessarily at national scale. Transport and energy are main emitters followed by industry and the residential sector in Argentina (see Figure III.2). We have in Mexico four main sources of GHG emissions: other internal combustion processes (31.9%), the forest sector (24%), transportation (14.6%), and industrial activities (6.3%, SEMARNAT 2001: 39). We found that at least for Mexico, emissions patterns illustrate on the one hand the economic structure of the country, more dominated by services especially by the informal sector than by

[3] While population in Great Buenos Aires for instance grew about 1% during 1991-2001, it increased 1.5% per year in Great Mendoza.

manufacturing. But on the other hand, notwithstanding agriculture's contribution to the GDP is insignificant, land use changes are a key source of GHG emissions.

The team explored how GHG emissions drivers operate at global, national and local scales to produce cities' trajectories of carbon emissions. There are commonalities all around the cities included in this report. GHG emission trajectories are driven by four processes operating at global scale, namely some components of the current globalization era, the state reform, urbanization already discussed above, and motorization.

At least two components of the current era of globalization, liberalization and regionalization of markets, exert an influence in the patterns of localization of population, productive activities and public investments, and by this in GHG emissions by cities and regions around them. Driven by markets opportunities opened by the North American Free Trade Agreement (NAFTA), corporations for instance have relocated their establishments within the central region of Mexico. Subsidiaries are set in city's most dynamic corridors; high tech enterprises move to localities in or around the satellites; activities demanding cheap labor move to suburban localities functioning as dormitories. All this contributes to urban sprawl, to longer commuting and freight transportation distances and by this to increased GHG emissions.

Similar is happening in the city of Mendoza. Argentina and Brazil are exporting increasing amounts of Mercosur production to the Asian markets through a main road along the Andes nearby Mendoza. In the last 5-8 years much of the public budget of the province was used to improve and increase the length of highways and paved road from Mendoza to the Pacific Harbors. The creation of infrastructure involved in this effort together with transportation activities contributes to GHG emissions as well.

One component of the state reform is also present in all the cities and in other Latin American urban areas: reduced state participation in the management of public transportation, which is related to deregulation and liberalization. Privatization of state firms and decreased public expenditures in Mexico City for example were aimed at eliminating inefficient and insolvent enterprises, thereby reducing public expenditure. Those transformations became one of the drivers of the shift in mode share from Metro and buses to minibuses and low capacity modes. This shift, which included a slight reduction in the use of private autos, resulted in increasing GHG emissions by the transportation sector. Similarly has happened in Santiago and Mendoza were the government has reduced his intervention. After making about 12% of the 15 million daily trips in 1980, private cars represented 45% of the 15 million daily trips in 2000 in Santiago. In contrast, public transportation conformed 90% of the daily trips in 1980, and only 55% in 2000. The share of public buses in Mendoza diminished from 50.5% in 1986 to 34.8% in 2000.

Motorization is taking place in the four cities and in other urban areas (Kennworthy and Laube 1996). The total fleet for instance augmented 2.3 times in Santiago during 1980-2000, 1.5 times in Mexico City in 1986-2000, and 0.7 times in Mendoza in 1993-2000. Most automobiles are private cars (85%, 73% and 68.8% respectively), but this is not reflected in their share of daily trips (45%, 19.9% and 25% respectively).

4. Discussing the IPAT identity

There is one tool frequently used in the literature to explore the forces driving GHG emissions: the IPAT or Kaya identity, according to which carbon emissions are the product of the level of population combined with affluence (e.g., measured by income per capita) and the level of technology (e.g., measured by emissions per unit of income). The Kaya identity has the advantage of being simple and allowing for “some standardization in the comparison” and analysis of diverse emissions-trajectories (Nakicenovic 2004). Clearly, it is a very very general way of looking at emissions; for example, it assumes that each variable enters linearly and independently, which is surely not the case, and it omits other factors as emissions drivers that are left as residual of the equation if looking at past emissions evolution (IPCC 2000, Nakicenovic 2004).

Some insights from this research can be used to discuss the pertinence of the IPAT identity. We did not apply the tool fully and explicitly, but we kept it in mind, what helped us identify proximate but not ultimate drivers. Examples of former in our cities were demographic dynamics and GDP, which increased as GHG emissions did, but latter have been also driven by technological innovations. As of technology, we found that indicators such as emissions per unit of product are very useful. Decreased emission rates in Argentina for instance relate to more efficient thermal generation of electricity, while in Mexico they are linked to improvements in the quality of fossil fuels. But these indicators are not enough to understand the complexity of the technological dimension. Two factors appear for instance as technological constrains for a carbon relevant restructuring of Mexico City's economy: a) low levels of human capital and research, of innovation and technology, and b) lack of competition of the economy creating an environment in which enterprises have reduced incentives to introduce new technologies and working methods.

Examples of ultimate drivers found in our cities and operating at diverse scales (global, national and local), but not included in the identity are liberalized and deregulated markets exerting a strong influence in urban growth, some components of current globalization era, urbanization, motorization and state reform. The automobile industry for instance has re-located enterprises and reorganized production and labor within the central region of Mexico to serve the “big market” (North America). This industry exerts a strong influence on carbon-relevant decisions such as governmental regulations on emissions levels, and catalytic converters of cars. The result has been that Mexico has standards lying more than two years behind the federal regulations of the United States.

When applying a Kaya-like approach to the residential level, it is assumed by some scholars that when population grows and standards of living improve so do the consumption of fossil fuels and GHG emissions. We explored whether this statement holds true for Mexico City and constructed some indicators. We found that there was a slight decrease in population during 1990-2000. City's consumption of energy increased 36.6 percent during the same period, while per capita consumption remained constant. Poverty and social exclusion continue though as a daunting problem. It can be suggested hence that high levels of social segregation in the MCMA, which are related to a differentiated contribution to both energy consumption and GHG emissions, should be included in the analysis of the relationship among population growth, increased standards of living, and higher GHG emissions. There is a direct indicator of this. Private cars are highly concentrated among wealthy sectors of Mexico City; 50% from the trips go to and come from 16% and 23% of the city respectively, but only cover 18 percent of the 29.5 trip segments.

Not only social segregation but also institutional settings appear as relevant drivers of GHG emissions trajectories in the cities. In Mendoza and Buenos Aires the *Plan Canje* (governmental subsidy to automobile companies for each old car accepted as payment for a new car) together with a good dollar-peso exchange rate induced Argentineans to buy new cars. As a matter of fact the *Plan Canje* aimed at supporting the automotive industry, but it also contributed to the renovation of the automotive fleet, by this, to reduced levels of Nitrogen Oxide and other pollutants.

Even a city like Mexico has shown diverse management problems, although more efforts have been undertaken to deal with carbon related issues than in the other cities. As in all cities air pollution has been the main public concern for Mexico City. But differently to the other cities in Mexico City more dimensions (e.g. energy, transport, urban growth) and scales (local, global) have been recently included in the public discourse about carbon related issues.

Public concern though is not enough to warranty effective management. If looking for the issues receiving not only discursive attention, but also financing then the broadening of carbon-related management in Mexico City becomes more apparent than real. Only two issues, technology and transportation, received most of the financing of environmental programs launched during last 15 years.

Environmental policies, transportation and city planning in Mexico City are constrained by the organizational structure of city government, i.e. by its institutional capacity. States and the Federal District, for instance, had different legal and fiscal systems contributing to undermine city's capacity to deal at Metropolitan scale with any issue. The institutional structure is made of diverse agencies with competing and overlapping responsibility for urban planning, environment and transportation. Those agencies tend to focus on and react to specific issues, and can not address the array of causes driving them. They lack appropriated harmonization of their programs and responsibilities, as well as financial provisions for them to work together and as in the case of the environmental authorities to work at all.

5. Can Cities Reduce Global Warming? The way forward

This report supports the statement that cities are key players in the field of GHG emissions. As population in Latin America and around the world becomes more urban in the coming decades, and economic activities tend to locate in cities, the importance of the way cities develop and are managed for GHG emissions and associated pollution will become a fundamental point of intervention for addressing climate change.

Notwithstanding cities' role in GHG emissions, it is hard for cities and their actors (managers, producers, consumers) to reduce their GHG emissions, because of at least three reasons:

A) Key drivers of emissions trajectories operate at national and even global scales. We found in our cities deregulated and liberalized markets and the retrenchment of the state as examples of such drivers.

B) Relevant actors in the carbon arena such as transnational corporations have national and international decision making power. It is hence difficult almost impossible for local authorities to issue regulations without corporations' conformity. Furthermore as could be seen in Mexico City, local authorities are confronted to their own limitations (e.g. lack of coordination, insufficient financial resources) regarding institutional capacity.

C) The cities we dealt with and several urban areas in the world do not have institutions explicitly prepared to deal with GHG emissions, but rather than (for example) with air quality issues which for instance do not include carbon dioxide. As it has been shown by other scholars, local actors only participate in climate related programs and networks, if they "are able to capitalize on both the material and non material resources offered by the network" (Bulkeley and Betsill 2003: 187).

It will be therefore necessary to undertake future studies focusing on carbon related strategies and their interplay with environmental policies more focused on pollution control. One example is the viability of promoting win-win strategies that aim at reducing GHG emissions and improving air quality, the latter a more established and well recognized problem by citizens and managers (unlike GHG-climate change).

There are other research paths opened to the team while undertaking this report. We found that:

A) Relevant information (e.g. cities ecological footprint) can be offered by modeling past emission trajectories of the cities, not only with traditional emissions inventories, but also with accounting tools such as metabolism approach.

[4]Material flow accounting or analysis (MFA) conceives human settlements as urban metabolisms, in which material inputs are transformed into useful energy, physical structure and waste, and it is based on accounts in physical units (usually tons) quantifying the inputs and outputs of those processes. The subjects of the accounting are chemically defined substances (e.g. carbon dioxide) on the one hand and natural or technical compounds or 'bulk' materials (e.g. coal, wood, food) on the other (OECD 2000).). "Urban metabolism" is a crucial measure of cities' ecological-footprints.

B) A stronger and more solid modeling of GHG emissions patterns can be achieved, building in part on the IPAT identity, but adding other key drivers such as institutional settings.

c) A more careful assessing of existing management strategies is fundamental and as argued has to include actions which explicitly or implicitly have an impact on GHG emissions.

d) All this efforts require to be complemented by a comprehensive understanding of the complex interactions among causes and drivers responsible for changes in GHG emissions (synthesis of a, b and to identify management options (points of intervention) and their associated policies and institutional requirements, in order to design less carbon-intensive development pathways.

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DPV: Dirección Provincial de Vialidad, Gobierno de Mendoza www.vialidad.mendoza.gov.ar/

Ministerio de Ambiente y Obras Públicas, Gobierno de Mendoza: www.ambiente.mendoza.gov.ar/

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ACRONYMUS

Mexico

DDF	Departamento del Distrito Federal
SEMARNAT	Secretaría de Medio Ambiente y Recursos Naturales
COMETRAVI	Comisión Metropolitana de Transporte y Vialidad
GDF	Gobierno del Distrito Federal
JICA	Japan International Cooperation Agency
INEGI	Instituto Nacional de Estadística Geografía e Informática de México
SMA	Secretaria del Medio Ambiente (Federal District)
ENSO	El Niño Southern Oscilation
GNP	Gross National Product.
OECD	Organization for Economic Co-operation and Development
NAFTA	North American Free Trade Agreement
LDUDF	Ley de Desarrollo Urbano del Distrito Federal
LGAH	Ley General de Asentamientos Humanos
CCCC	Commission for the Conurbation of the Center of México
COVITUR	Commission for Highways and Urban Transportation.
LGEEPA	Ley General del Equilibrio Ecológico y la Protección al Ambiente
NOMS	Normas Oficiales Mexicanas
PCMCA	Coordinated Program to Improve Air Quality in the Valley of Mexico
EGCA	Global Study of Air Quality in Mexico City
MTBE	Methyl Tertiary Butyl Ether
LPG	Liquefied Petroleum Gas
CNG	Compressed Natural Gas
SEDUE	Secretary of Urban Development and Ecology
PICCA	Programa Integral Contra la Contaminación Atmosférica.
DGRUPE	Dirección General de Reordenamiento Urbano y Protección Ecológica
CAM	Metropolitan Environmental Commission
PRUPE	Program for the Urban Restructuring and Ecological Protection of the Federal District
ZEDECS	Especial Zones of Controlled Growth.
PROFEPA	Procuraduría Federal de Protección al Ambiente
SEDESOL	Secretaría de Desarrollo Social
SCT	Secretary of Communications and Transport
PRD	Partido de la Revolución Democrática

Argentina

FIEL	Fundación de Investigaciones Económicas Latinoamericanas
INDEC	Argentina National Statistic
IPCC	Intergobernmental Panel on Climate Change
DEIE	Direction for Statistics of the Mendoza Province
CFI	Consejo Federal de Inversiones
SEA	National Secretary of Energy

Chile

IRP	Intermunicipal Regulatory Plan
CONAMA	National Commission for the Environment
PRIEN	Programa de Investigaciones en Energía
INE	Statistics National Institute
CIEPLAN	Coorporación de Investigaciones Económicas Para Latinoamericana
SECTRA	Ministry of Transportation
PPDA	Prevention and Atmospheric Decontamination Plan for Great Santiago
MINVU	Ministerio de Vivienda y Urbanismo
MINSAL	Ministry of Health
MIDEPLAN	Ministerio de Planificación y Cooperación
CORFO	Corporación de Fomento de la Producción