Paradoxical cities: Lower carbon emissions might not lead to low carbon cities

1. INTRODUCTION

Figure 1. Urban Built-up Areas +500,000 inhab. Argentina

This paper explores and identifies consumption and CO2 emissions patterns produced by built-up urban areas of more than 500,000 inhabitants in Argentina. The behaviour and performance of different people who plan, manage and use transport will also be analysed.

Part of the identified behaviours is related to socio-spatial organisation decisions that determine land occupation modalities (closed urban areas or shanty towns) and urbanistic modalities (built-space density, topography and landscape). Other behaviours are related with urban management models and the means of transport used by state or private managers that define the relationship between the urban functioning and the associated mobility.

Argentina has a population of 40,000,000 inhabitants and 2,700,000 km^2 of land surface. An 85% of the population lives in cities and a 42% of that total (16,186,535 inhabitants) is concentrated in the five analysed cities with more than 500,000 inhabitants: Metropolitan Area of Buenos Aires (MABA), Metropolitan Area of Córdoba (MAC), Rosario (MAR) and La Plata (MALP). (Figure 1)

2. METHODOLOGICAL APPROACH

The quantitative variable study was based on secondary information for the five cities with more than 500,000 inhabitants: origin-destiny surveys in the Metropolitan Areas of La Plata, Rosario, Córdoba and Mendoza, and a TRANUS model in the Metropolitan Area of Buenos Aires.

Emission calculation was made by estimating the means of transport routes and the vehicle type through the TransCAD model. With the estimated routes, the emissions were determined following the established indicators by LEAP software (2005).

The quantitative variable analysis was done from self-obtained information gathered from experience of carrying out some studies and from information obtained from qualified informants in each of the cities. Accepted projects and concrete actions were compared as well.

For the qualitative information analysis, the estimated indicators are presented for the four cities. For the difference between the Metropolitan Area of Buenos Aires and the other four cities, only some figures are presented as a contextual reference. For the comparison between quantitative and qualitative information, only the Metropolitan Areas of La Plata, Rosario and Córdoba are presented.

3. URBAN MOBILITY PATTERNS

The five analysed cities are characterised by concentrating a high percentage of the GDP and the population (42% of the country). As regards population and the trips generated by the population, a significant breach between the Metropolitan Area of Buenos Aires (MABA) with 12,000,000 inhabitants is verified. This represents a 73.8% and the rest of the urban areas show the following numbers: Córdoba (1,340,107 inhabitants), Rosario (1,171,995 inhabitants), Mendoza (1,024,420 inhabitants) and La Plata (705,909 inhabitants). (Table 1) This same difference is verified in the productive and commercial activity volume. Therefore, only the information about the Metropolitan Area of Buenos Aires is taken as a reference.

Built-up Area	Population	Trips/ inhab	%	Urban Km2	Daily trips
MABA	11,944,104	2.1	73.8	2,353	25,327,928
MRA	1,171,995	0.9	7.2	189	1,014,732
MCA	1,340,107	1.2	8.3	235	1,634,087
MMA	1,024,420	1.3	6.3	147	1,330,584
MLPA	705,909	1.5	4.4	116	1,028,715
Total	**16,186,535**				**30,336,046**

Table 1: Population, trips and urban surface.
Source: Author's elaboration based on secondary information.

It can be observed that the highest trip number is produced in the Metropolitan Area of Buenos Aires. In the rest of the cities, the indicators show similar values except for the Metropolitan Area of Rosario. This difference shows higher inhabitant concentration with unsatisfied basic needs than the rest of the cities in relation to the total population.

Total daily trip generation shown in table 1 suffered, in all cases, modifications related to modal partition between 1980 and 1990. These changes, resulting from structural financial transformations, modified the population mobility modality due to the combined action of two phenomena. First, employment deregulation and the increase of service activities; second, motor vehicle stock growth promoted by the motor industry through easily accessible loans. At the same time, the government implemented contradictory policies as it was necessary to develop mitigation measures: transport service deregulation, railway system destruction (leaving more than 600 towns neglected) and land use regulations which gave way to 'closed urbanizations': a type of urban expansion produced in all peripheric areas of large cities, nowadays, with more than 600,000 inhabitants. The combination of state financial and political transformations led to the increase of car use for transport. This increase was favoured by the lack of modernization of public transport, which is inadequate for current transport demands. The increase of taxi and private car service use (i.e. door-to-door services) is associated with motor vehicle stock growth. Therefore, the number of agencies providing this service multiplied.

Within this context, the massive and non-massive transport relation was inverted. (Table 2) This is verified as from the 1980s decade. Although the 2001 Argentinean financial crisis marked the beginning of an incipient recovery of transport in massive modes, its effects do not stop the mobility growth curve in non-massive transport.

Built-up Area	Mode	1991	%	2003	%
MA Córdoba	Massive	733,961	38	694,765	34
	Non-massive	575,162	29	836,685	41
MA La Plata	Massive	616,657	61	382,109	48
	Non-massive	297,775	29	539,105	34
MA Rosario	MassiveMassive	778,416	49	417,525	24

	Non-massive	105,857	33	597,207	34
MA Mendoza	Massive	411,129	52	519,057	31
	Non-massive	260,497	33	688,966	42

Table 2: Evolution of **Modal Partition**. Source: Author's compilation based on secondary information from various sources.

The greatest transference from massive transport to non-massive transport is verified in La Plata, where the percentage varies from 61% to 48%. In the rest of the cities, although they are minor, the differences go from 52% to 31% in Mendoza and from 49% to 24% in Rosario. In the case of Córdoba, there exists a more equal distribution between massive and non-massive modes even though the modal transference pattern in non-massive modes is repeated: from 29% to 41%. Therefore, there is a clear increase in emissions coming from car use rise and public transport inadequacy. This modal partition is completed with the increase of motorcycle and bicycle trips for which there are no traffic regulations or requirements for driving. Hence, there are no controls to ensure that traffic regulations are followed. This increases traffic accidents, road network congestions and emissions as well.

Table 3 shows the indicators of CO2 tons per inhabitant produced in each of the built-up areas.

The Metropolitan Area of Buenos Aires produces the highest level of pollution: 1.2 tons of

Built-up areas	**population**	**%**	**CO2 Emissions in annual tons**						**CO2/ Inhabitants/**
			total	**%**	**massive**	**%**	**Non-massive**	**%**	
MABA	11,944,104	73.79	14,783,863	92.41	3,131,644	21.18	11,652,219	78.82	1.2378
MARosario	1171995	7.24	257.649	1.61	81,581	31.66	176,068	68.34	0.2198
MACórdoba	1340107	8.28	362,657	2.27	117,572	32.42	245,085	67.58	0.2706
MAMendoza	1024420	6.33	329,186	2.06	111,584	33.90	217,603	66.10	0.3213
MA La Plata	705909	4.36	264,951	1.66	94,379	35.62	170,573	64.38	0.3753
Total			**15,998,307**		**3,536,759**		**12,461,548**		

Table 3: CO2/inhabitant Passenger transport system, largest urban areas. 2003
Source: Author's compilation based on secondary information.

CO2 per inhabitant. The rest of the cities produces emissions in decreasing order: Rosario (1,171,995 inhabitants) = 0.22 Tn of CO2/inhabitant/year; Metropolitan Area of Córdoba: 0.27 Tn of CO2/inhabitant/year; Metropolitan Area of Mendoza: 0.32 of CO2/inhabitant/year and the Metropolitan Area of La Plata: 0.38 CO2/inhabitant/year. The distribution of CO2 emissions produced by passenger transport is not directly related to the number of inhabitants. Rosario is an example of this asymmetry. It has one of the highest numbers of inhabitants among the considered built-up areas and it produces the lowest emissions per inhabitant. This can be explained because the city has the highest number of inhabitants below the poverty line. The highest absolute values of CO2 annual emissions are presented in Greater La Plata (after the MABA) which has one of the lowest numbers of inhabitants among the analysed cities (705,909 inhabitants).

The differences between Mendoza and Córdoba can be attributed to two main situations: due to the localization of the inhabitants -which is more dispersed in the Mendoza-, to manage public transport system effectively is more difficult. The other reason is that different income levels place Mendoza inhabitants in a better position for using intensively private cars.

These structural transformations added to external requests to control greenhouse gas emissions led to the execution of studies and projects to change the situation. Projects, applied measures and the results of three of the analysed urban areas will be exposed: Córdoba, Rosario and La Plata. Even though the case of the MABA is not detailed, it is possible to provide an overview of the following problems: privatization of underground services and interurban trains constitutes one of the central issues. The management of both systems does not follow the minimal regulations to carry out an efficient service in spite of the fact that the companies have received generous subsidies. This leads to car trip increase, traffic congestion in all accesses and avenues, and accidents among others. Despite international financing, it was not possible to develop a comprehensive project as the basis to implement progressive measures in order to improve the whole system. The conflicts over political interests among the government of the city of Buenos Aires, the governments of the 19 towns that comprise the Metropolitan Area of Buenos Aires and the national government do not allow the implementation of any type of initiative. This situation worsens because of the existing conflicts between the chambers of transportation of automobile companies, the railway and underground systems, and the unions that concentrate power which is difficult to overcome.

3.1. Metropolitan Area of LA PLATA (MALP)

It is formed by three towns interconnected by an adequate road network and with univocal socioeconomic relations. It has the lowest inhabitant number among the analysed cities. (Figure 2) Despite urban interaction, its urban expansion and transport system are not regulated by any planning and transportation body that groups them. The Metropolitan Area of La Plata does not escape the political and financial changes that affected the country, which provoked a decrease in public transport use because of inadequate private and State management and an increase in non-massive mode of transport use. Motor vehicle stock growth is verified between 1993 and 2000, varying from a vehicle rate of 1 automobile every 5.2 inhabitants to 1 automobile per 3.6 inhabitants.

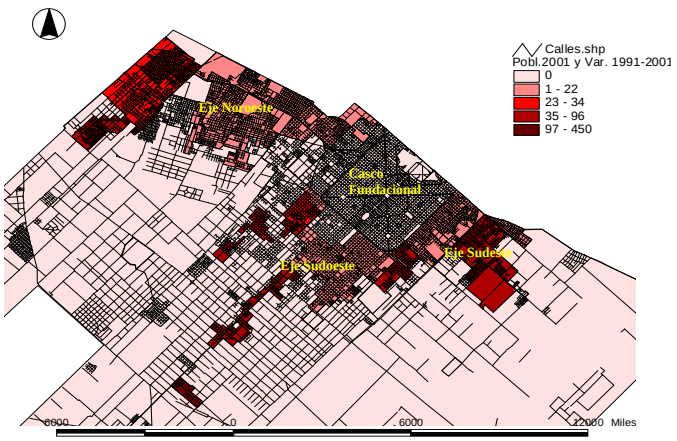

Figure 2. Metropolitan Area of La Plata

At the same time, it was possible to observe the decrease of population in central areas of the city and an increase in the periphery where land value is lower and it has high levels of accessibility either by car or public transport. This migration implies an increase in trips, especially by car. Car trip increase is not verified only with the passenger's own car, but also by the use of taxis and minicabs -a new mode that appeared by the middle of the decade. While in 1993, taxis absorbed less than 5% of total passenger trips, in 2001 measures were taken before the national financial crisis and taxis absorbed 11.3% and minicabs 7%. Competing with the taxis, minicabs offered reduced fares and became an alternative to massive public transport.

As a response to this situation, La Plata City Hall through its Department of Transportation reorganized the public transport system in 2002, in the middle of the financial crisis. Despite efforts made, it was not possible to structure a single system for the three towns. Thus, there exist two overlapping systems: one that is managed at the local level and another one that is

managed at the provincial level. Each system determines its own routes and modifications. This overlapping and the spatial organisation of the local system provoke vehicle concentration in the city centre which combined with private car growth causes congestions that reduce public transport commercial speed discouraging both its use and the movement by bicycles, which do not have their own lanes. This situation increases the production of greenhouse gas emissions. The system foresaw the optimization of fuel consumption for the apparent rationalization of the new routes and the implementation of a ticket passengers were able to use for all buses. Notwithstanding, none of these plans could be implemented due to the inefficiency of the State management and pressure from the companies.

Despite this situation, in the MALP there is no **comprehensive urban transport system planning.** Plans, projects and interventions intended to improve mobility and urban transport are not coordinated among one another. While in the Department of Transportation a restructuring of the transport was being designed (1998-2002), the Urban Planning Department was formulating a new regulation for land use (1997-2000) with no coordination with the first one. The localisation guidelines, density and occupation of this new regulation were not related to the capacity of the transport infrastructure. At the same time, a railway-automobile node was being projected, in the site where the railway station is currently functioning independently from the urban motor public transport. In this way, the institutional and political structure that is uncoordinated and fragmentary in the three conglomerates does not favour the creation of a transport plan or a structure that integrates different measures related with urban movement optimization.

The poor functioning of the railway system, privatized in 1991, hinders the improvement of the environmental quality. During the first four years, the new local government relatively improved the service in the northern area of the city, which was translated into an increase of trips of 203% (trips by train had lowered 75% between 1987 and 1991). Even though there were generous state subsidies, the service started to deteriorate because of the lack of a regulation policy that defined the service providers' obligations. This situation led to an 85% decrease in train trips within a period of two years.

In the MALP, there are no policies intended to promote non-polluting vehicles. Walking and bicycle transportation in the area go up to 5.15% and 2.05% respectively, which represent 57,087 and 22,724 daily trips respectively. This option that became more frequent after the 2002 crisis has no growing possibilities because there is no adequate infrastructure.

3.2. METROPOLITAN AREA OF CÓRDOBA

This city has an important financial activity as regards industry, commerce and tourism. It concentrates 8.28% of the total population in the large built-up areas in the country. It is characterised by a very dense historical centre and a periphery with an important number of closed urban areas.(Figura 3) By the end of the 1980s, a very efficient urban transport system was implemented. This increased the demand that reached 61% of the total trips. This situation was completely reverted when the new authorities assumed command of the government in 1990 leaving the system functioning on the hands of private companies. These companies, having no control from the State, did not invest either in the maintenance or in the necessary substitution of old units and, consequently, made the demand lower 26.6%. At the same time, there was an 11% reduction of travelled kilometres and the commercial speed was damaged. Because there was an unfulfilled demand, other means of transport started to appear as a competence for the established system: differential services; spread of chauffer-driven cars (unlicensed minicabs); increase of private cars and motorcycles. In this same period, the motor vehicle stock grew from 343,470 vehicles in 2001 to 361,357 vehicles in 2003. This represents an increase of 5%. Trips by private cars

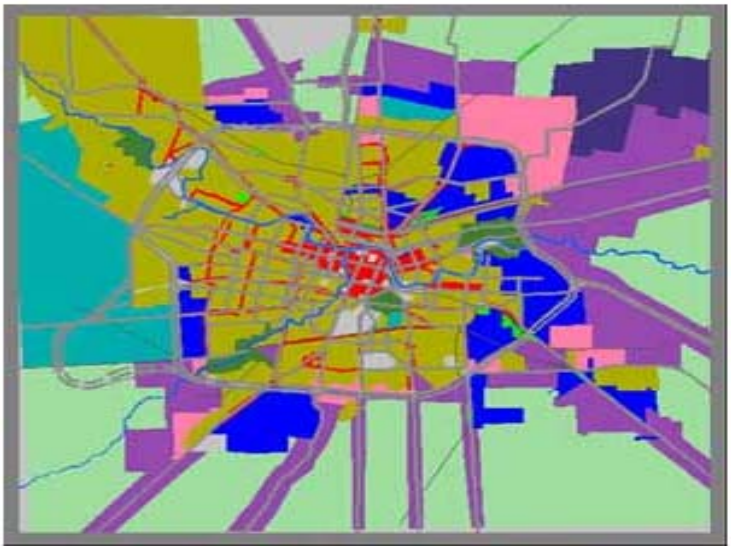

Figure 3. Metropolitan Area de Córdoba.

increased up to 41% (836,685) of the total trips made. The use of public transport -buses- decreased 34% (694,765 daily trips). The same pattern is observed for walking, which represents 9.2% of the trips made this year.

Given the transport system deterioration during 1997-2000, the new administration implemented a set of measures and projects which translated into formulating a plan to reactivate the system and, recently, into restructuring a project including the incorporation of a tram system. The main objective of the new administration was to recover the central role lost in earlier erratic policies and to instill a social culture which regarded massive means of transport as a common means of transport for a substantial part of the population.

These are some of the measures included in the 2003 City Strategic Planning objectives (Plan Estratégico de la ciudad in Spanish). The following projects are mentioned: 1. Urban Passenger Transport Plan; 2. Comprehensive Traffic Plan; 3. Improvement and optimisation of Urban and Metropolitan Main Road System. Incorporating these projects into an urban plan, assumes exceeding the traditional fragmentary approach which addresses the transport problem in our cities. Coordinated management of both transport and traffic aims at solving the area main problems and the superimposition of actions which generate higher costs.

The Public Transport Reactivating System Plan which is part of the strategic planning uses the system's structure as basis for the project, incorporating new units with Euro 4 and 5 engines to the bus fleet and expanding the routes. Similarly, measures were implemented to facilitate fare payment- tokens, cards and special fares for both school students and low classes. These measures contributed significantly to public transport promotion.
In some cases, bus routing was restructured since it overlapped with trolley routing (a transportation system introduced in 1989), this also avoid extending two new trolley tracks. Yet, there still was a significant decrease in passenger number. It is important to mention that the trolley system was favoured by users because it was clean, quick and frequent.
By adopting these measures, non-massive transportation decreased during 2004-2006, being the percentage lower than in the other cities.

These measures also included constructing new exclusive lanes, extending avenues and boulevards, widening pavements, forestation, improving central bed flowers and bus stops, and providing more green spaces to favour pedestrians. Provincial and local governments implemented other policies and measures intended to reduce the environmental impact produced by the transport sector. The following can be mentioned: Changing motor vehicle stock to CNG (Compressed Natural Gas), vehicle control and authorization Regime, and Mandatory Technical Testing, these two enforced in the province.
Nowadays, there exists a project to recover the tram system, a non-polluting transport, which will both revalue the city's cultural heritage and its historical identity.

3.3. METROPOLITAN AREA OF ROSARIO

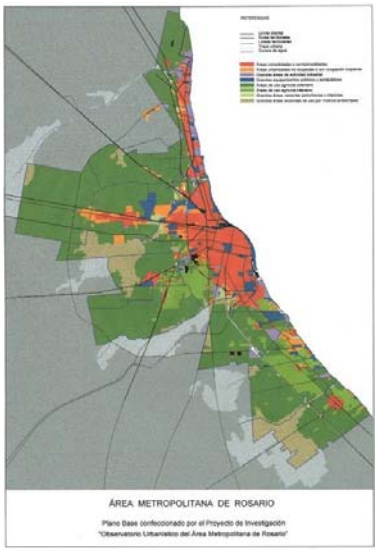

Figure 4. Metropolitan Area of Rosario

The Metropolitan Area of Rosario (Figure 4) has a population similar to that of Córdoba and Mendoza cities and it has an urban transportation system which evolved like the systems in the rest of the cities. There was a significant vehicle rise and a massive transport trip loss, even though there was a considerable decrease in the total amount of daily trips. In 1993, 63% of the population made a daily trip but in 2000, the percentage was only 42%. Population growth with unsatisfied basic needs justifies this situation. However, during 1990 and 2004 while massive transport mobility decreased from 49% to 24% in the number of trips made, car trips rose from 33 % to 34 % which translated into a 12.7 % increase. The current public transport network provokes traffic congestion in the city centre and it lacks spatial coverage for population distribution. The road system does not adjust to current traffic requirements and, in turn, it does not allow easy traffic flow and mode separation. (Figure 5)

The reasons for the decrease in public transport trips can be attributed to motor vehicle growth, deterioration of the service, an increase in time trips due to congestion and the massive use of taxis and door-to-door services for high income sectors. For lower income population, there was an increase in bicycle and motorcycle trips. These different modes of transportation for unsuitable roads caused traffic congestion and car accidents.

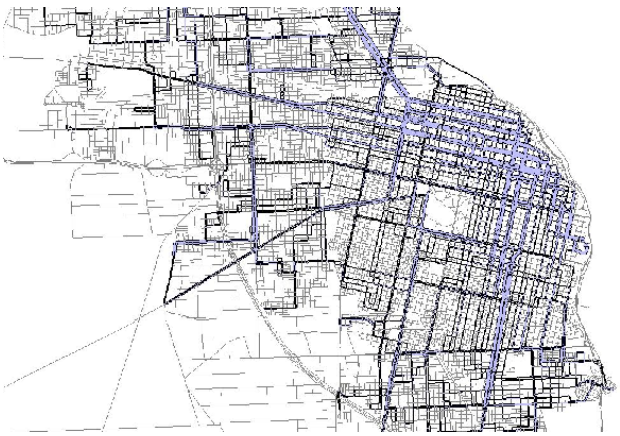

Figure 5. Urban Public Transport System of Rosario

Rosario developed government and institutional policies which fostered the creation of a consolidated planned structure, with clear aims for restructuring the transport system and integrating it into land use. A Transport Operating Body was created in connection with the city master plan. This body proposed the restructuring of nine main lines with nineteen intermodal terminals for communicating several neighbourhoods. A tram service was implemented along one of the most travelled corridors with thirty-two million annual trips intended for 2012. This proposal aims at restricting car trips and parking in said corridor, which -in turn- leads to an increase in business and a reduction of pollution, noises and congestion. However, this body did not integrate Rosario Metropolitan Areas, which meant that local authorities did not participate in the project. The master plan promoted individual projects which did not take into consideration the body's projects.

This proposal, however, does not contemplate a medium-term general restructuring plan and a conflict of interests within the body, provincial and national organisms prevents the project from being implemented, which makes it difficult to choose the best alternative. Even if this system fails to be integrated into an overall restructuring system, it could manage to

reduce 30% of greenhouse gas emissions.

The proposal includes the construction of 250km bicycle lanes, yet only 30km were built. However, even if GDP increased in the last five years and the total number of bicycle trips rose up to 19%, the 2003 project could not be implemented. Conflict of interests, a deficient administration and priority to other investments due to financial and political pressures still prevent these projects from being materialized even in cities with consolidated planning systems.

4. COMPARATIVE ANALYSIS

Quantitative data analysis suggests that the four cities, with equal population number, have similar mobility and modal participation. The rise in car trips and the decrease in public transport use are also similar. Fewer trips per inhabitant in MAR are linked to a high percentage of population not meeting basic needs. For this reason, Rosario city has the lowest quantity of CO2 tons/inhab. Fewer motorised trips are replaced by bicycle trips (14.5% over total trips) and walking (27%). These figures are higher than the ones in the other analysed cities (5% and 11%).

In table 4, indicators for trips/inhab. and car trips/inhab. are compared.

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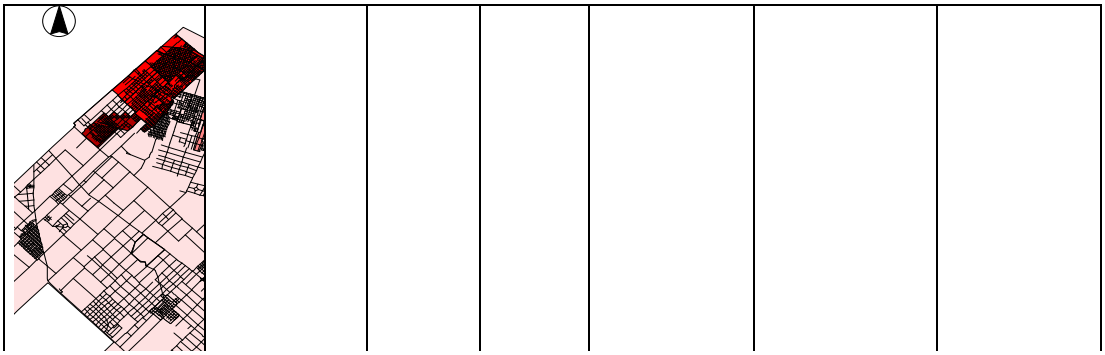

Car/inhab. indicador is not associated to medium income per inhabitant. Within similar medium income, a significant difference in car/inhab number can be noted. While in La Plata and Córdoba the medium income varies 4.4%, car number per inhabitant is 36% higher. The Metropolitan Area of La Plata has a higher number of car/inhab. (after MABA) and more car trips per inhabitant.

Table 5 shows the number of travelled kilometres per inhabitant in massive and non-massive means of transport. MABA shows the highest number of travelled kilometres per inhabitant. If the relation between the urban surface to be covered by a transportation service and total number of travelled km. per day and passenger are compared, Greater Córdoba offers better spatial efficiency since each trip covers an average of 3.03 km. for an urban surface twice as big as Greater La Plata, where the average of travelled km. per day/trip is higher (3.82). Rosario shows a lower number of trips/person/day which might be associated to fewer trips, and not with travelled distances which are similar to those of La Plata.

Built-up Area	km/inhab/ year	km/inhab /day	Non-massive/ Inhab.	Non-massive/ Km/inhab
MABA	5361,47	14,69	439,9	4921,5
MAR	889,82	2,44	51,9	837,8
MAC	1106,53	3,03	65,4	1041,
MALP	1394,61	3,82	100,4	1294,

Table 5. Travelled distances by massive and non-massive means of transport. Source: Author's Compilation.

Table 6 shows the quantity of CO2 tons/inhab. The differences between La Plata and Mendoza metropolitan areas (0.38 CO2/inhab and 0.32 CO2/inhab, respectively) and Córdoba and Rosario (0.27 CO2/inhab and 0.22 CO2/inhab, respectively) can be noted. The lowest quantity of emissions per inhabitant is not directly related to area density but to a better transport system management. In Córdoba, simple measures were adopted: Modernizing public transport stock with public subsidy and promoting non-motorised transport modes (bicycle lane construction) which help decreasing emissions. These measures, however, are not integrated into State policies but are just implemented by some politicians who can easily be replaced when authorities change or when members of the same or opposing parties decide to replace them. Most of the emissions in La Plata Metropolitan Area are due to: lack of a comprehensive transport plan, power mechanisms, management control, lack of a single Transport Organism which regulates transport, and political and personal interests among jurisdictions. These factors lead to a disarticulated and inefficient system with overlapping routes and inadequate concentration in some city areas.

Built-up Area	Population	%	trips/ inhab.	Medium Income '99 U$s/month	Vehicle stock (2003)	cars/inhab.
MABA	11,944,104	73.79	2.1	941.48	3,554,793	1.51
MAR	1,171,995	7.24	0.87	459.23	167,564	0.51
MAC	1,340,107	8.28	1.2	520.54	201,675	0.65
MAM	1,024,420	6.33	1.3	501.03	144,125	0.78
MALP	705,909	4.36	1.5	543.74	94,913	0.89

Table 4: Income and Transport. Source: Author´s compilation based on secondary information and Population and Economic Census (INDEC)

Lack of criteria to define urban expansion was found in the four studied cities.
Strategies for urban expansion are one of the most central factors for creating more routes. The proliferation of "closed urbanization" scattered in nearby low density rural areas disarticulated with urban areas become a barrier for implementing real and definitive mitigation measures. From the point of view of the authorities' behaviour, lower emission indicators are closely related to policies enforced by ruling organisms. In this sense, Rosario and Córdoba took coherent actions and managed to reduce considerably travelled kilometers and to achieve a more effective organisation of companies. La Plata, on the other hand, lacks an integrated policy and this translates into higher emission indicators.

5. CONCLUSIONS

Transport was not only a key issue considered at local level (in the three analysed cities) but also at national level. Management transport policies both at national and local levels include criteria discussed in most international forums. However, applying these measures can be difficult because: 1. Political and financial sectors promote car purchases while the main objective to decrease emissions is incrementing the use of non-motorized vehicles. In spite of the international financial crisis and an apparent fall of purchases in 2008, car sales

continue to be high; these purchases are encouraged by installment payment suitable for most of the population.
2. From the perspective of the local government, applying these measures is difficult since: a) personal, political and financial interests restrict its materialization since, it is impossible to reach interjurisdiction or intersector agreements due to pressure from private companies or unions associated with the local government, b) financial criteria to carry out a project whose internal rate of return might take fifteen or twenty years, c) deficient management administration and, d) failing to integrate university knowledge with the government's experience.

From the previous analysis, we can conclude that technical conditions to achieve low carbon emissions exist. These analyses show that there are technical conditions to lower carbon emissions in cities. · *To achieve this, according to IPCC one needs to "change consumption patterns, which could be more important than enforcing climate change mitigation measures". Both society and the State should work together to change consumption patterns. Society, by taking into account the need to improve drastically its driving behaviours, changing fundamentally its travelling habits.* It has been noted that improving driving behaviour might prevent even 30% of emissions with very low investment.

The State should, firstly train technicians in environmental issues. Secondly, to have influence on government officers so that their personal interests do not interfere with what is best for the society as a whole. Thirdly, to implement urban planning which controls urban expansion, articulates transport with land use, includes infrastructure encouraging the use of non-motor means of transport, and improves current transport system, even if achieving this change is a complex task. There exist both the expertise and the technology needed for this change, yet lack of will and awareness prevents the change from happening. In the light of this analysis, one fundamental question arises: If citizenship participation is a key issue in sustainable development, how is it possible to make these energy-intensive consumers assume their own responsibility and act upon the decisions politicians make?

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