Are we missing the point? Particularities of urbanization, sustainability and carbon emissions in Latin American cities

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ABSTRACT The discourse on how to reduce greenhouse gas emissions in cities is dominated by ecological modernization theory, which focuses primarily on technological approaches supported by market mechanisms to curb carbon emissions. This discourse has contributed to a research and management agenda. Yet this is based primarily on perceptions and precedents drawn from high-income nations. This paper draws on empirical evidence from Latin American cities for a critical discussion of the usefulness and limitations of this approach when applied to cities in low- and middle-income nations. The paper suggests that for such cities, ecological modernization is an inappropriate framework for addressing global (and local) environmental problems.

KEYWORDS eco-cities / ecological cities / ecological modernization / GHG emissions / urbanization

I. INTRODUCTION

It is accepted that cities are both drivers of change in the carbon cycle and key players in the search for strategies that may contribute to reducing our societies' dependence on carbon-based fuels and making them more sustainable. Two approaches have dealt with the question of how to achieve those transformations: ecological modernization and attempts to define a sustainable urban setting. The goal of this paper is two-fold: first, to describe briefly both approaches; and second, to present some of the reasons why, notwithstanding their overall utility, ecological modernization and the notions of eco-city and ecological cities may be of doubtful applicability to Latin American urban centres (and also urban centres in Asia and Africa).

The paper begins with a short characterization of ecological modernization and the notions of "eco-cities" and "ecological cities" (Section II). Then it presents three sets of interrelated reasons why these approaches are not applicable to Latin American cities. The first refers to urbanization, which belongs to one of the global trends altering the carbon cycle and other biogeochemical processes. Yet urbanization has followed specific development pathways in Latin America (and other Southern areas), with diverse consequences for net regional and global carbon balances (Section III). Second, Latin American cities are not big emitters compared to cities in high-income nations; rather than climate change, the health implications of air quality are the main concern for local authorities.

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Curbing carbon emissions may be only "localized", when it can be linked to pressing issues (e.g. air quality) already on the local agenda (Section IV). Finally, the specific socioeconomic and institutional conditions of Latin America strongly constrain the feasibility of the governance model implied in both ecological modernization and the notions of "eco-cities" and "ecological cities" (Sections V and VI). The paper closes with some remarks and recommendations with regard to tools and data gathering.

II. DO CONVENTIONAL APPROACHES APPLY TO LATIN AMERICAN CITIES?

Cities are key drivers of change in the carbon cycle. Urbanization has become a major global process with profound local, regional and global impacts on the way in which energy and land are used.[1] At the same time, cities are centres of diverse kinds of innovations (including technological innovation) that may contribute to de-carbonizing our societies and making them more sustainable. Only through the transformation of infrastructure, especially transport, and the use of power in cities' buildings, and through changes in the behaviour and in the production and consumption patterns of their residents will it be possible to improve the global environment.[2]

The question is then how to achieve this transformation? How do we move our cities from their current and unsustainable development path? Two dominant approaches have dealt with these questions: ecological modernization and attempts to define a sustainable urban setting. In contrast to the attractive though vague concept of sustainable development, some scholars argue that ecological modernization is a more rigorous and less radical approach to dealing at national and regional scales with such environmental problems as greenhouse gas emissions.[3] To achieve this goal, a structural change – or shift – to less carbon-intensive societies should occur at the macroeconomic level, through the use of new and less carbon-intensive technologies whose use is induced by market mechanisms. The state should play a minimum role in the switch to ecological modernization, namely ensuring that institutions are restructured on ecological principles and away from a purely economic rationale. Three projects are at the heart of this switchover:

- restructuring production and consumption to minimize their environmental impacts, by cutting waste streams and integrating wastes back into production. This entails both deploying new technologies and decoupling economic development from the relevant energy inputs, energy use and greenhouse gas emissions;[4]
- assigning economic value to nature and ecological services and introducing a structural tax reform; and
- integrating environmental policy goals into other policy domains.

Urban research has developed such terms as "eco-city" and "ecological city" to describe urban areas interested in reducing their carbon emissions and other pressures on the natural environment.[5] The term "ecological city" refers to such processes as the recycling and re-using of raw materials and the promotion of alternative transportation systems (e.g. public transport, cycling) aimed at ensuring that a city performs its fundamental functions in an ecologically sensitive way without jeopardizing the chances of future generations to take care of their own needs. The notion of the

1. Steffen, W, A Sanderson, P D Tyson, J Jäger, P A Matson, B Moore III, F Oldfield, K Richardson, H-J Schellnhuber, B L Turner II and R J Wasson (2004), *Global Change and the Earth System*, IGBP, Royal Swedish Academy of Sciences, Stockholm; also Pataki, D E, R J Alig, A S Fung, N E Golubiewski, C A Kennedy, E G McPherson, D J Nowak, R V Pouyat and P Romero Lankao (2006), "Urban ecosystems and the North American carbon cycle", *Global Change Biology* Vol 12, pages 1–11.

2. Hunt, J (2004), "How can cities mitigate and adapt to climate change?, *Building, Research and Information* Vol 32, No 1, page 55.

3. Gibbs, D (2000), "Ecological modernization, regional economic development and regional development agencies", *Geoforum* Vol 31, pages 9–19.

4. See, for instance, Von Weizäcker, A B Lovins and L H Lovins (1997), *Factor Four. Doubling Wealth, Halving Resource Wealth*, Earthscan, London.

5. Myllylä, S and K Kuvaja (2005), "Societal premises for sustainable development in large southern cities", *Global Environmental Change* Vol 15, pages 224–237.

"ecological city" is embedded in the belief that environmental problems can be solved through technological and industrial innovations.[6] It is related in this respect to the discourse on ecological modernization.

The term "eco-city" refers to cities in which ecological principles generate an urban harmony between the environment and societal structures, culture and the economy.[7] Scholars perceive theories on eco-cities as a critique of Western culture.[8] They seem to represent alternatives for the recovery of liveable cities through ecology, a sense of community and multiculturalism.[9]

In its supporters' view, ecological modernization offers the only approach to managing the ecological crisis, through more industrialization i.e. modernization.[10] This view has been crucial in pushing a research and management agenda for high-income countries and even for some low- and middle-income countries.[11] As an economy develops, sectors such as agriculture and fisheries change to manufacturing industries and further transform into service industries. Industrialization, combined with science and technological progress, leads to a series of processes (e.g. rural migration to urban areas, improvements in city residents' living conditions) that fuel urbanization.[12]

Nevertheless, ecological modernization has been criticized because it overstresses the industrial and technological aspects and overlooks the social and political context in which the ecological switchover has to take place. By suggesting that institutions can be reformed on ecological lines, proponents of ecological modernization fail to consider the real constraints to restructuring such institutions.[13] The emphasis on technological solutions runs the risk of "*…turning the 'ecological city' into a 'commercial eco-city', where daily ecological solutions are based on inhabitants' ability to purchase products derived from ecological innovations*."[14] The notion of eco-city pays more attention to the social and institutional dimensions of sustainability. Yet it reflects the values of post-modern societies and may, hence, mirror issues related to urban development in Europe and North America. The rest of this paper is devoted to presenting three sets of reasons why these concepts do not necessarily help explain the nexus between urban development and carbon emissions in Latin American cities.

III. URBANIZATION TRENDS AND CITIES' EMISSIONS TRAJECTORIES

Urbanization belongs to a set of worldwide mega-phenomena that are profoundly altering human-environment relations and consequently affecting the Earth system in complex and accelerating ways.[15] Still, urbanization follows different development pathways with diverse consequences for net regional and global carbon balances. It is complicated to understand what influences urban change at the national level, as the scale and nature of urbanization and its underlying causes differ significantly from nation to nation and even within countries. It could be said though, that the most important direct cause of urbanization as a global phenomenon is the movement of populations from rural to urban areas. And the main underlying driver is the concentration of new investment and economic opportunities in particular urban areas together with the lack of opportunities in people's home farms and villages.

> "A nation's urban system (the network of urban centres and their interconnection) is best understood as the 'geography' of its non-agricultural

6. See reference 3.

7. Newman, P and J Kenworthy (1999), *Sustainability and Cities. Overcoming the Automobile Dependence*, Island Press, Washington.

8. See reference 5.

9. See reference 5; also Kenworthy, J (2006), "The eco-city: ten key transport and planning dimensions for sustainable city development", *Environment & Urbanization* Vol 18, No 1, April, pages 67–85.

10. See reference 3.

11. For developed countries, see reference 4; also Jänicke, M and H Weidner (1997), *National Environmental Policies: A Comparative Study of Capacity Building*, Springer, Berlin. For developing nations, see Jung, T Y, E La Rovere, H Gaj, P R Shukla, D Zhou et al. (2000), "Structural changes in developing countries and their implication for energy-related CO_2 emissions", *Technological Forecasting and Social Change* Vol 63, pages 111–136; also Shen, L, S Cheng, A J Gunson and H Wan (2005), "Urbanization, sustainability and the utilization of energy and mineral resources in China", *Cities* Vol 22, No 4, pages 287–302.

12. See reference 3.

13. See reference 3.

14. See reference 5, page 227.

15. See reference 1.

economy and government system. It is also in effect a map of where profit-seeking enterprises have concentrated and of where people working outside of agriculture make a living."[16]

To date, the world has undergone two urban transitions with implications for the carbon cycle and other biogeochemical cycles. The first was led by Europe and the United States in the late nineteenth and first half of the twentieth centuries. It was mainly and internally driven by industrialization, the use and exploitation of energy and natural resources, together with national scientific, technological and institutional innovations. A series of processes related to that wave of urbanization: migration to urban areas; growth of industrial and mining activities; abundant natural resources, largely from Africa, Asia and Latin America; active populations moving first from primary to secondary activities and then to the tertiary sector; agricultural modernization; improvements in the quality of life of urban residents; and migration to the "New World" (the Americas, Australia) as a livelihood strategy for the poor in industrialized countries.[17]

Latin American nations also experienced urban growth, but of a different nature. Until the beginning of the twentieth century, urbanization was mainly driven by such external processes as export-oriented demands, foreign investment and credits, the international division of labour, and economic demands and political interventions from industrialized countries.[18] São Paolo, for example, had a population of 65,000 in 1890. Widespread coffee cultivation for the international market brought sudden prosperity and transformed São Paolo into a lively economic region that attracted a massive influx of migrants from Europe.[19] Although there were major cities in Latin America at this time, their scale was dwarfed by cities in high-income nations. In 1900, Rio de Janeiro had 967,000 inhabitants, Buenos Aires 813,000 and Mexico City 415,000. But London had 6.5 million dwellers in 1900, New York 4.2 million and Berlin 2.7 million.[20] A not yet fully researched question is whether both energy requirements and carbon emissions in Latin American urban areas were as small, relatively, as their populations.

From the 1930s until the 1970s, in part in response to the recession in Europe and North America, import substitution policies, such as support to infant industries and high trade barriers, were important in many Latin American nations in underpinning urbanization (and rural–urban migration). Of comparable significance was the lack of prospects in the rural areas. A key characteristic of urbanization in Latin America was the high level of urban primacy, with a large percentage of a given nation's urban population living in a single city.

The current urban transition differs from that in the early twentieth century in other respects. First, the scale of change is unprecedented. The world's urban population increased more than ten-fold during the twentieth century. The proportion of the world's population living in urban areas has gone from less than 15 per cent in 1900 to almost 50 per cent today. The fastest-growing cities are concentrated mainly in the world's largest economies, a fact that supports the idea of a strong link between economic growth and urbanization.[21] As the population becomes more urban, the way cities develop and are managed in terms of greenhouse gas emissions and associated pollution becomes a central point of intervention for addressing climate change. But the peculiarities of such urbanization pathways still need to be further understood. This paper is one attempt in that direction.

16. Satterthwaite, D (2005), "The scale of urban change worldwide 1950–2000 and its underpinnings", IIED, London, page 14.

17. Gruebel, A (1994), "Industrialization as a historical phenomenon", in R Socolow, C Andrews, F Berkhout and V Thomas (editors), *Industrial Ecology and Global Change*, Cambridge University Press, pages 43–68; also Galeano, E (1978), *Las Venas Abiertas de América Latina,* Siglo XXI, Mexico, 470 pages; and Ponting, K (1991), *A Green History of the World. The Environment and the Collapse of Great Civilizations*, Penguin.

18. See reference 11, Shen et al. (2005).

19. Cohen, B (2004), "Urban growth in developing countries: a review of current trends and a caution regarding existing forecasts", *World Development* Vol 32, No 1, pages 23–51.

20. Data for Latin American cities are taken from Chandler, Tertius (1987), *Four Thousand Years of Urban Growth: An Historical Census*, Edwin Mellen Press, Lampeter, UK, 656 pages. Data for cities in high-income nations are taken from Berry, B J L (1990), "Urbanization", in J F Kates, B L Turner II, W C Clark, R W Richards, J T Mathews and W B Meyer (editors), *The Earth as Transformed by Human Action: Global and Regional Changes in the Biosphere over the Past 300 Years*, Cambridge University Press with Clark University.

21. See reference 16. The author mentions two caveats. First, by 2000 the world was less urbanized and less dominated by large cities than had been expected. Second, it can be misleading to use existing statistics to set up urban trends and comparisons. Rather than being established according to universally agreed criteria, city boundaries are set based on local and national criteria and these can be different from nation to nation. For instance, India's rural population lives in villages with between 500 and 5,000 people

Second, unlike urbanization at the beginning of the twentieth century, which was mostly confined to nations with the highest levels of per capita income, rapid urban change is mainly concentrated in middle- and low-income countries.[22] Here is where a huge structural problem arises. Notwithstanding fast economic growth, the economies of these cities have been unable to absorb more than a fraction of the growing labour force. As a result, unemployment and underemployment (poverty) persist as a structural problem. Even when donors supply capital for infrastructure, the poor – a majority – lack the resources to pay taxes and cover the costs of the operation and maintenance of urban infrastructure. In this context, city authorities' efforts to deal with any environmental issue are constantly constrained by lack of capital, resources and planning.[23]

Third, the nature and amount of urban growth is currently more reliant on the global economy than ever before. Latin American cities have been relatively less successful than their new industrializing Asian counterparts (the so-called Newly Industrializing Countries) at taking advantage of economic opportunities.[24] Nevertheless, globalization has drastically reduced the need for spatial proximity and has reshaped the organization, management and production of firms and industry.[25] In large urban areas, enterprises have changed their localization patterns to corridors of different economic importance, situated both within the cities and in outside localities. New plants in the São Paolo region of Brazil have located as far as 200 kilometres from the central core. The bulk of foreign investment and the most dynamic commercial and service activities of Mexico City concentrate in the corridors of Santa Fé–Polanco (to the west) and Periferico-San Angel (to the south); industrial activities locate to the north. Industries locate to the north and north/central zones of Buenos Aires, and services activities have moved to such renovated areas as Puerto Madero, near Río de La Plata.[26]

Another key component of this more decentralized pattern of urbanization is the existence of more competent and effective cities. Investments tend to localize in smaller cities that offer functional linkages with regional markets (e.g. Mexican cities close to the US-Mexico border) and/or secondary cities that have helped to generate economies and urban systems less dominated by large cities in the USA, China, Brazil, India, Mexico, the Russian Federation and South Korea.[27]

The different localization patterns of enterprises have also been driven by cities' negative externalities (e.g. congestion costs) and by government incentives to relocate. Processes such as severe economic recession and programmes of structural adjustment are also important (see Section VI below), as are changes in spatial demographic dynamics and rapidly growing private vehicle ownership and usage.

With regard to demographic dynamics, urban population growth rates for the whole region have been decreasing since 1970 (Table 1). The population growth rates of all Latin American megacities registered dramatic declines during the 1980s and 1990s. Core areas have been losing population while the population in suburban areas has increased, contributing to urban sprawl. For instance, between 1990 and 2000, Mexico City's core area, or central city, saw a drop in its population as it registered an annual average growth rate of –2.1 per cent, while the population of the suburbanized zones increased by 2.8 per cent a year.[28] The population of Greater Buenos Aires continued to grow between 1991 and 2001, however the population of the core area (the city of Buenos Aires)

that are classified as rural. If they were classified as urban, as they would be in some other countries, then India would be predominantly urban. Some countries lack recent (and in some cases even 10 to 20-year old) census data. But their circumstances have changed so much that the projections based on an old census may not be accurate.

22. As shown by Satterthwaite, rather than just being confined to low- and middle-income nations, rapid urban growth has taken place in cities of North America, for example, Las Vegas, Phoenix-Mesa and Orlando. See reference 16, page 13.

23. Lee, K N (2006), "Urban sustainability and the limits of classical environmentalism", *Environment & Urbanization* Vol 18, No 1, April, pages 9–22.

24. Thirteen of those nations accounted for 80 per cent of all manufacturing output of the developing world during the 1980s. See reference 17, Gruebel (1994), page 35.

25. The automobile industry for example, which is one of the most important industrial sectors in Mexico, has subsidiary offices in Mexico City's most dynamic economic corridors as well as production facilities, such as Volkswagen, in Puebla, one of Mexico City's satellites, manufacturing mainly for the US and Canada. See Hiernaux, D and M T Carmona (2003), "Dinámicas metropolitanas y reestructuración de la región centro de México: ¿hacia la metrópoli?", in D Villareal, D Mignot and D Hiernaux, *Dinámicas metropolitanas y estructuración territorial*, UAM/Porrua, México, 309 pages.

26. Ciccolella, Pablo (1999), "Globalización y dualización en la Región Metropolitana de Buenos Aires. Grandes inversiones y restructuración socioterritorial en los años noventa", *EURE* Vol 25, No 76, pages 5–27; also Romero Lankao P, H Lopez, A Rosas, G Gunther and Z Correa, (2005), "Can cities reduce global warming? Urban development

hardly changed between 1960 and 1991 and then declined between 1991 and 2001. Several of the municipalities immediately adjacent to the core area also had declining populations between 1991 and 2001.[29]

As in US and Australian urban areas, after the Second World War in Latin America "*…the automobile, supplemented by the bus, progressively became the transportation technology that shaped the city*."[30] Recent motorization trends cast a worrying shadow over the projected course of carbon emissions. Releases from motorized vehicles are the fastest growing source of carbon. While private vehicle use is reaching unparalleled heights, public transit is decreasing at a comparatively steady rate (Table 2).

Changes in the localization patterns of population and economic activities, as well as increased private automobile use, lie behind a transition in the urban form of the largest cities from a city-based to a region-based pattern. For instance, in the last two decades, Buenos Aires, Santiago and Mexico City have experienced a polycentric urban expansion of first- and second-order urban localities sprawling along major highways and functionally linked to the main city.[31] The polycentric pathway of urbanization is associated with carbon-relevant consequences, especially when it is not accompanied by public transportation policies. As illustrated by

and carbon cycle in Latin America", IAI, UAM-X, IHDP, GCP, Mexico.

27. See reference 16.

28. See reference 26, Romero Lankao et al. (2005), page 24; also INEGI (2000), XII *Censo General de Población y Vivienda 2000. Resultados Preliminares,* Talleres Graficos de la Nacion, Mexico; and SEMARNAT (National Ministry of Environment), DDF (Federal District Government), SMA (Ministry of Environment of the Federal District) and GEM (Government of the State of Mexico) (2003), "Programa para mejorar la calidad del aire de la zona metropolitana del Valle de México 2002–2010", Comisión Ambiental Metropolitana, México DF.

TABLE 1
Urban population growth rates

	1970–75 (%)	1975–80 (%)	1980–85 (%)	1985–90 (%)	1990–95 (%)	1995–2000 (%)
Latin America and the Caribbean	3.8	3.5	3.0	2.8	2.4	2.2
Central America	4.3	3.8	3.2	2.9	2.4	2.0
South America	3.7	3.5	3.1	2.7	2.4	2.2

SOURCE: United Nations (2006), *World Urbanization Prospects: the 2005 Revision*, United Nations Population Division, Department of Economic and Social Affairs, CD-ROM Edition, data in digital form (POP/DB/WUP/Rev.2005), United Nations, New York.

TABLE 2
Trends in mode share of public transport in selected cities

City	Earlier year	Public transport as % of motorized trips	Later year	Public transport as % of motorized trips
Bangkok	1970	53	1990	39
Buenos Aires	1993	49	1999	33
Kuala Lumpur	1985	34	1997	19
Mexico City	1984	80	1994	72
Moscow	1990	87	1997	83
São Paolo	1977	46	1997	33
Seoul	1970	67	1992	61
Tokyo	1970	65	1990	48
Shanghai	1986	24	1995	15
Warsaw	1987	80	1998	53

SOURCE: Wright, L and L Fulton (2005), "Climate change mitigation and transport in developing nations", *Transport Reviews* Vol 25, No 6, pages 691–717.

TABLE 3
Commuting distances and times by public transportation, Mexico City

	1987			2000		
Mode of transport	**Length of trip (km)**	**Speed (km/h)**	**Average time per trip (min)**	**Length of trip (km)**	**Speed (km/h)**	**Average time per trip (min)**
Bus	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), *OECD Territorial Reviews. Mexico City*, OECD, Paris, page 34.

Mexico City (Table 3), passengers' commuting distances and travel times have increased in recent years, and this might also be the case with freight transportation. It may also be that by augmenting their urban area and population and economic activities, cities increase their ecological footprint and their impact on satellites and areas outside their boundaries, however also providing these with energy, food and other resources.

IV. BIG EMITTERS?

The most significant increases in energy consumption and CO_2 emissions have taken place in cities and this is expected to continue.[32] Yet just as urban centres register different levels and paths of economic development, cities do not contribute to global warming at the same level. Carbon emissions per person in cities in low- and middle-income nations are very small compared with those in wealthy urban areas (Figure 1). Each citizen of Los Angeles emits an average of 15.6 tons CO_2 equivalent. These amounts are huge when compared to those in Mexico City, where each inhabitant releases four times less than in Los Angeles (3.6 tons CO_2 equivalent). If we multiply the per capita numbers by the total population, then Los Angeles and Mexico City emit 234 and 64.8 million tons per year, respectively. Curbing carbon emissions may therefore not be "the local environmental priority" for Latin American cities now, but rather, vulnerability and adaptation to the impacts of climate change.[33]

What then is the local priority? How can it be related to climate change – a global concern? Different studies have pointed to these cities' local environmental priorities such as the inadequacies in provision for water, sanitation and drainage for large sections of the regions' urban populations.[34] City authorities have already developed some responses to these questions as well. According to the local government of Mexico City, for instance, mitigating greenhouse gas emissions only makes sense if it offers win–win options and opens windows of opportunity for Latin American cities, such as access to financing (e.g. the Clean Development Mechanism).[35] Climate change may become a political priority if, as in many other cities, it is reframed as a local issue (i.e. air quality) already in the policy agenda.[36] A large number of Latin American cities have already "localized" global warming as an air quality concern in terms of its consequences on health. The Cities for Climate Protection (CCP) campaign of the International Council for Local Environmental Initiatives (ICLEI) is an example of that trend. The authorities of 23 cities and municipalities in the region are current members of this campaign.[37]

29. Pírez, Pedro (2002), "Buenos Aires: fragmentation and privatization of the metropolitan city", *Environment & Urbanization* Vol 14, No 1, April, pages 145–158. Census data for 2001 from Fundación Metropolitana (2005), *La Gran Buenos Aires; Agua y Saneamiento en la Región Metropolitana Buenos Aires*, Fundación Metropolitana, Buenos Aires, 77 pages. e

30. See reference 7.

31. See reference 26, Romero Lankao et al. (2005); also Aguilar, A G and P M Ward (2003), "Globalization, regional development and megacity expansion in Latin America: analyzing Mexico City's peri-urban hinterland", *Cities* Vol 20, No 1, pages 3–21; and De Mattos, C A (1999), "Santiago de Chile, globalización y expansión metropolitana: lo que existía sigue existiendo", *EURE* Vol 25, No 76, pages 29–56.

32. See reference 7; also Dhakal, Shobhakar (2004), *Urban Energy Use and Greenhouse Gas Emissions in Asian Megacities*, Urban Environmental Management Project Institute For Global Environmental Strategies, Kanagawa, Japan, 176 pages.

33. IPCC (2001), *Climate Change 2001. Synthesis Report*, Cambridge University Press, UK and USA.

34. Hardoy, J G, D Mitlin and D Satterthwaite (2004) *Environmental Problems in an Urbanizing World*, Earthscan, London.

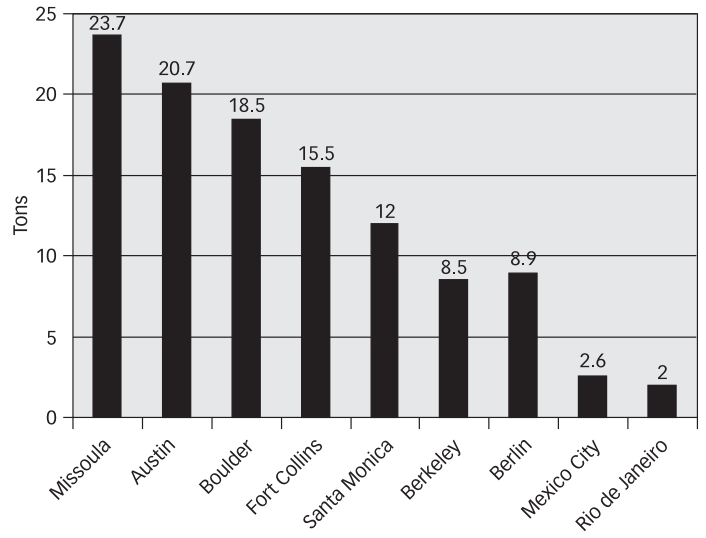

FIGURE 1
Per capita CO_2 equivalent emissions for selected cities, 1990*

* Data for Mexico City are for the year 2000.

SOURCES: Data for the US cities are from City of Fort Collins (2006), "City of Fort Collins' local action plan", accessible at http://www.fcgov.com/airquality/lap.php. Data for Mexico City are from SMA (2004), *Estrategia Local de Acción Climática de la Ciudad de México*, SMA, México. Data for Berlin and Rio de Janeiro are from La Rovere, E (2002), "Climate change and sustainable development strategies: a Brazilian perspective", OECD, accessible at http://www.oecd.org/dataoecd/22/13/1934683.pdf.

35. SMA (Ministry of Environment of the Federal District) (2004), *Estrategia Local de Acción Climática de la Ciudad de México*, SMA, México.

36. Betsill, M M (2001), "Mitigating climate change in US cities: opportunities and obstacles", in *Local Environment* Vol 6, No 4, pages 393–406; also Bulkeley, H and M Betsill (2003), *Cities and Climate Change. Urban Sustainability and Global Environmental Governance*, Routledge, London.

37. ICLEI is the International Council for Local Environmental Initiatives. Local governments participating in ICLEI's Cities for Climate Protection (CCP) Campaign commit to undertake and complete five performance milestones, namely: conduct an energy and emissions inventory and forecast; establish an emissions target; develop and obtain approval for the Local Action Plan; implement policies and measures; and monitor and verify results. See ICLEI (2006) at www.icle.org, 20 April 2006.

TABLE 4
Selected synergies and conflicts between local pollution control and mitigation of greenhouse gas emissions

Local action	Synergy	Conflict
Vehicle fuel efficiency standards	Reduces both local pollution and CO_2 emissions per vehicle–km	Increased CO_2 if vehicles' travel distances increase or drivers switch to vehicles with larger engines
Introducing CNG or propane for motor vehicles	Reduced NO_x and particulates, and reduced CO_2	Needs good maintenance and management to avoid increasing emissions of unburnt CNG or propane
Controlling NO_x and suspended particulates released by diesel vehicles	Significant reductions in CO_2 and air pollutants	Diesel engines emit less CO_2 than gasoline engines but are often major contributors to NO_x and particulates
Reformulated gasoline	Reductions in smog, volatile organic compounds and toxic air pollutants	It compromises fuel economy nominally by 1–2%; CO_2 emissions might increase
Landfills over incinerators	Reductions in CO_2 emissions	Increases in methane

SOURCE: Shobhakar, Dhakal (2004), "Urban energy use and greenhouse gas emissions in Asian megacities", Urban Environmental Management Project Institute For Global Environmental Strategies (IGES), Kanagawa, Japan, pages 115–117.

If global warming is not necessarily a local concern, then what is the scale of local air quality problems in Latin American cities? What are the possible synergies between actions to control local emissions and reduce greenhouse gas emissions? Is there any conflict between them? Table 4 summarizes some of the synergies and contradictions between air quality and greenhouse gas emissions control. Contrary to what could be expected, air quality can be particularly serious in Latin American cities. Just as with carbon emissions, most of the pollution comes from the combustion of fossil fuels (coal, oils and natural gas) for heating and electricity generation, for running motor vehicles, and in industrial processes. Another source of pollution is households using fuels in inefficient heaters and cookers. It is also usual to find emissions such as wind-blown dust and carbon as a result of land use changes, and these are aggravated by poor land management and many unpaved roads.[38] The concentrations and mixes of some air pollutants exceed World Health Organization standards (Table 5). They are high enough to cause illness in more susceptible individuals, and premature death among the elderly, especially those with respiratory problems.[39]

38. See reference 34.

39. Molina M and L Molina (editors) (2002), *Air Quality in the Mexico Megacity: An Integrated Assessment*, Kluwer academic publishers, the Netherlands.

Curbing carbon emissions is not a local environmental priority at present. But Latin American cities should not assume a passive attitude towards this global concern. On the contrary, they need to act. Furthermore, they can use climate change as a reason to promote sustainable patterns of urbanization. They can generate energy-efficient production utilities and make consumer goods and services available to more people without jeopardizing natural resources, ecosystems and people's livelihoods at the national and global scales.

V. ECOLOGICAL ISLETS – GLARING "EMISSIONS" INEQUALITIES

Kai N Lee points out that the prevailing model of environmental governance is relatively more applicable to wealthy cities, which already have in place both the infrastructure and well-functioning institutional settings to deliver transportation, energy and other services to "*…meet*

TABLE 5
Megacities and their air quality data

Megacity*	Population (millions) 2000*	TSP ($\mu g/m_3$) 1995**	SO_2 ($\mu g/m_3$) 1998***	NO_2 ($\mu g/m_3$) 1998***
Tokyo, Japan	26.44	49	18	68
Mexico City, Mexico	18.13	279	74	130
São Paolo, Brazil	17.76	86	43	83
Los Angeles, USA	13.14		9	74
Rio de Janeiro, Brazil	10.58	139	129	ND
WHO standards		90	50	40

* City population is the number of residents of the city as defined by national authorities and reported to the United Nations. Mostly, the city refers to urban agglomerations.
** Data are for the most recent year available between 1990 and1995. Most are for 1995.
*** Data are for the most recent year available between 1990 and1998. Most are for 1995.

SOURCE: Molina, M and L Molina (editors) (2002), *Air Quality in the Mexico Megacity: An Integrated Assessment*, Kluwer academic publishers, the Netherlands, page 5.

the needs of the present."[40] That model was constructed under specific historical conditions:

> "…robust economic growth; governmental, financial and educational institutions that enable regulation and investment to be carried out over time scales of more than a decade; and an educated electorate in a competitive political system."[41]

Latin American cities (and those in other low- and middle-income nations) are governed by different socioeconomic and institutional structures, which limit the feasibility of the governance model implicit to both ecological modernization and the eco-city. Real GDP per capita in San Francisco, for example, is 4.8 times that in Mexico City; and that in Los Angeles is 3.3 times that in Rio de Janeiro (Table 6). The local level expenditure per capita in these Latin American cities is tiny compared to that in cities in Europe and the USA.[42] The bottom 20 per cent barely get between 4.2 and 6.3 per cent of the total income in some Latin American urban areas (see Table 7). In such conditions, the binding constraint in Latin America for dealing with any component of the carbon agenda is the lack of economic resources from peoples' taxes and the lack of economic growth.

40. The relative success of the conventional model of environmental governance results from the lack of effective feedback about the regional and global impacts of consumption and investment within the cities. See reference 23.

41. See reference 23; also see reference 5.

42. For example, according to data from 1998, the per capita local level expenditure in Seattle (US$ 889) was 3.4 times higher than that in Buenos Aires (US$ 258). See United Nations Population Division (2001), *World Urbanization Prospects*, United Nations, New York.

TABLE 6
Ranking of OECD metropolitan regions based on real GDP per capita, 2000

Metropolitan region	Real GDP per capita
San Francisco, USA	64,836
Seattle, USA	50,241
Denver, USA	44,113
Los Angeles, USA	40,031
Rheinland, Germany	31,227
Region Berlin, Germany	21,432
Gyeonggi, Korea	16,365
Mexico City (MAMC) Mexico	13,470
Rio de Janeiro, Brazil	12,087
Santiago, Chile	8,043
Bogota, Colombia	7,120
Curitiba, Brazil	1,091

SOURCE: OECD (2004), *OECD Territorial Reviews. Mexico City*, OECD, Paris, page 37.

TABLE 7
Accumulated income share percentiles in Buenos Aires, Santiago and Mexican urban areas

Population share	Buenos Aires (1998)	Mexican cities (1998)	Santiago (1996–1997)
Bottom 20%	4.2	4.2	6.3
Middle 40%	22.4	19.3	23.6
Middle-high 30% (middle-high 20% for Santiago)	36.8	33.5	19.6
Top 10% (top 20% for Santiago)	36.6	42.9	50.4

SOURCE: Ciccolella, Pablo (1999), "Globalización y dualización en la Región Metropolitana de Buenos Aires. Grandes inversiones y restructuración socioterritorial en los años noventa", *EURE* Vol 25, No 76, pages 5–27; also De Mattos, C A (1999), "Santiago de Chile, globalización y expansión metropolitana: lo que existía sigue existiendo" *EURE* Vol 25, No 76, pages 29–56; and World Bank (2004), *Poverty in Mexico: An Assessment of Conditions, Trends and Government Strategy*, World Bank, Washington DC.

Social inequalities have another carbon-relevant dimension. They crystallize in the emergence of enclaves or "islets" of wealth as a counter-development to the growing informal areas and congested urban neighbourhoods.[43] Inhabitants of enclaves have more financial resources than the majority of the population to invest in goods, environmental services and, hence, in their general well-being. Mexico City offers some examples of this. Private cars are highly concentrated in the wealthy sectors. Only 35 per cent of households located in the city have a private car[44] and, as noted in the next paragraph, private modes of transportation only satisfy the commuting needs of a minority.

On the other hand, the wealthy in "ecological islets" burden the city's environment by, for instance, emitting relatively more CO_2 equivalent than poor sectors. The wealthy produce relatively more solid wastes (a source of methane) and arrange for solid waste disposal outside their residences without contributing to the deployment of such facilities. This can be illustrated by looking at the transportation sector of Mexico City, which accounts for the highest share (34.7 per cent) of CO_2 equivalent emissions.[45] Private cars contribute 16.1 per cent of the city's daily trip segments but account for 40.8 per cent of CO_2 equivalent emissions, while public transport accounts for 82 per cent of those trip segments and emits 25.9 per cent of CO_2 equivalent emissions (Table 8).

A similar trend exists in the mode share of urban transportation in São Paolo, Santiago and Bogotá. Private vehicles cover 31 per cent, 16 per cent and 12 per cent of the daily trips, respectively.[46] It was not possible to get data on emissions from private cars for these cities. But if conditions are similar to those in Mexico City, then wealthy sectors are likely to emit far more CO_2 equivalent per person than poor sectors.

The co-existence of islets of wealth and areas of "slums" or informal settlements has two implications that constrain the feasibility of relying on technological alternatives and the purchasing power of inhabitants to manage carbon emissions. First, low-income groups do not have the purchasing power to buy the ecological solutions aimed at generating more efficient production systems and commodities. Second, Latin American

43. See reference 5; also see reference 23.

44. The percentage is higher (38.8 per cent) at federal district level and lower (31 per cent) within conurbated municipalities. The proportion of households with a private car in high-income delegations/municipalities such as Benito Juarez and Cuautitlán Izcalli is much higher (60.6 per cent and 43.7 per cent, respectively) than in poorer delegations/municipalities such as Chalco (17.3 per cent). See INEGI et al. (2005), *Estadísticas del Medio Ambiente del Distrito Federal y Zona Metropolitana 2002*, Eds. Secretaria Medio Ambiente, INEGI and Gobierno del Distrito Federal, Mexico.

45. See reference 35.

46. Wright, L and L Fulton (2005), "Climate change mitigation and transport in developing nations", *Transport Reviews* Vol 25, No 6, page 697.

TABLE 8
Fleet and CO_2 equivalent emissions by different transportation modes in MCMA, 2000

Mode	Total fleet	%	Ton CO_2 equivalent	%	Trip segment (%)
Private	2,556,378	72.7	8,513,771	40.8	18
Public*	322,018	9.2	5,413,172	25.9	82
Freight**	562,994	16.0	6,799,455	32.6	–
Unspecific***	72,704	2.1	133,893	0.6	–
Total	**3,514,094**	**100.0**	**20,860,291**	**100.0**	**100**

* "Public" refers to transportation that is open to the public irrespective of who operates it, i.e. a private or a public agency. It includes: buses (3.2% of CO_2 equivalent emissions), trolleybuses and metro, operated by the government; and taxis (10.5% – third emitter), combis (2.6%) and microbuses or *colectivos* (6.3%), operated by private agents.
** Freight comprises pickups (7.9%), vehicles < 3 tonnes (14.9% – second emitter), semi-trailers (6.8%), vehicles > 3 tonnes (3.4%) and heavy-duty LPG trucks (0.4%).
*** Motorbikes used for several purposes.

SOURCE: Molina, M and L Molina (editors) (2002), *Air Quality in the Mexico Megacity: An Integrated Assessment*, Kluwer academic publishers, the Netherlands, page 111; also SMA (Ministry of Environment of the Federal District) (2004), *Estrategia Local de Acción Climática de la Ciudad de México*, Annex 7, SMA, Mexico.

urban areas lack a citywide eco-social morality, defined as a principle or practice of adjusting values of ways of life according to more sustainable principles of development.[47] Rather than identifying with the general well-being of these cities, and also constructing solidarity with the poor, in many aspects (e.g. lifestyles) dwellers of enclaves may feel and may be closer to the inhabitants of cities in high-income nations.

47. See reference 5, page 227.

However, the benefits and privileges of the wealthy in "ecological islets" are paradoxical. With some exceptions (including Curitiba, see

TABLE 9
Population, urbanized area and density in Mexico City and Santiago de Chile (1980–2000)

	Population ('000s)		Surface (ha)		Density (persons/ha)	
Year	Mexico	Santiago	Mexico	Santiago	Mexico	Santiago
1980	12,333	3,698	105,660	36,658	117	101
1990	15,047	4,611	121,320	44,116	124	105
2000	18,210	5,794	145,000	61,396	125	94

SOURCE: for Mexico City, see INEGI (2000), *XII Censo General de Población y Vivienda 2000. Resultados Preliminares*, México Talleres Graficos de la Nacion; also SEMARNAT (National Ministry of Environment), DDF (Federal District Government), SMA (Ministry of Environment of the Federal District) and GEM (Government of the State of Mexico) (2003), "Programa para mejorar la calidad del aire de la zona metropolitana del Valle de México 2002–2010", Comisión Ambiental Metropolitana, México DF. For Santiago, see Instituto Nacional de Estadistica (INE) 2002, *Censo de Población y Vivienda 2002*, Santiago de Chile.

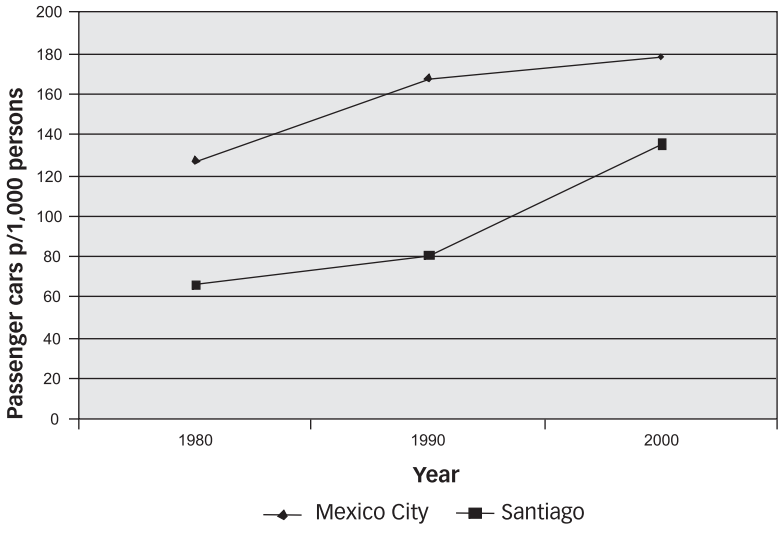

FIGURE 2
Passenger cars per 1,000 persons

SOURCE: For Mexico City: GDF (1999), *Anuario de Transporte y Vialidad de la Ciudad de México 1998–1999*, GDF, México; also GDF (2001), *Anuario de Transporte y Vialidad de la Ciudad de México 2000*, GDF, México. For Santiago: INE (2002), *Censo de Población y Vivienda 2002*, INE, Santiago.

Section VI below), Latin American cities have experienced uncontrolled sprawl and motorization in recent years (Figure 2 and Table 9) and they are increasingly caught in an automobile-dominated traffic system. The urbanized areas of Mexico City and Santiago, for instance, increased by 37.2 per cent and 67.5 per cent, respectively, during 1980–2000, while their densities decreased during the same period (Table 9).

These densities, however, are higher than in Singapore (80 persons/hectare) and, in the case of Mexico City, higher than in Tokyo (100 persons/hectare).[48] Yet high densities alone do not seem to have significant effects on travel distances and modal splits, as some scholars expect. Curitiba in Brazil and Bogotá in Colombia show how policies can influence the patterns of transportation. Authorities in these cities designed high-quality and relatively cheap bus systems[49] and a package of complementary supporting actions. These include car restriction measures and infrastructure for non-motorized transport (e.g. exclusive right of way lines for buses, cycle ways and pedestrian upgrades). Bogotá and Curitiba illustrate that public policies require a "high degree of political will", quality and ambition.[50] But managing carbon is not only a matter of political will. Other institutional aspects come into play, some of which will be reviewed in the next section.

48. See reference 7, Figure 3.2, page 101.

49. Bus Rapid Transit systems (BRT) are currently "*…being delivered in the range of US$ 1–15 million/kilometre, depending upon the capacity requirements and complexity of the project. By contrast, elevated rail systems and underground metro systems can cost from US$ 50 million to more than US$ 200 million/kilometre*." See reference 46, page 698.

50. See reference 46; also see reference 7.

VI. INSTITUTIONAL CHALLENGES TO SUSTAINABLE URBANIZATION IN LATIN AMERICAN CITIES

It is often suggested that cities in Latin America (and in Asia and Africa) need to introduce institutional reforms to imitate the modernization process of cities in high-income nations, as soon as they can avail themselves of the economic resources to do so - a process described as "global convergence".[51] Modernization in high-income nation cities is predicated on technological innovations (e.g. less carbon-intensive production facilities and transport systems) induced by market mechanisms. This presupposes societal structures developed during a phase of nation building, such as a strong civil society, democratic regimes and a state with the fiscal and institutional capacity to implement public policies. But each urban region has its own socioeconomic characteristics and institutional features that are sometimes not transferable, even within the same (high-income) country.[52]

51. See reference 5, page 227.

Latin American countries do not necessarily fit within such a scheme, at least not within the area of reducing carbon emissions. Rather than dealing with the impacts of industrialization (i.e. curbing carbon emissions per se), the most pressing issues for Latin American urban areas are to manage the local implications of air pollution on health and to cope with the impacts of climate change.[53] They face the challenge of deploying different patterns of industrialization. Their main concern may not lie in pursuing economic growth and technological change per se but, rather, in accessing technology (e.g. through the Clean Development Mechanism), strengthening socioeconomic equity (see Section III above) and introducing "good governance structures".[54]

52. See reference 23; also see reference 5.

53. See reference 33.

54. See reference 5, page 229.

Access to technology is not only a matter of moving know-how from high-income nations. For technology transfer to be successful, an "*…enabling environment must be created by a strong state*"[55] and a less restrictive trade context. Yet that is precisely what Latin American cities

55. Eakin, H and M C Lemos (2006), "Adaptation and the state: Latin America and the challenge of capacity building under globalization", *Global Environmental Change* Vol 16, No 1, page 11.

currently lack. Global actions to protect intellectual property and patents (e.g. Trade-related Aspects of Intellectual Property Right of the World Trade Organization's 1994 General Agreement on Tariffs and Trade) may constrain the in-house utilization of mitigation technologies.[56]

Furthermore, Latin American cities lack many aspects of the enabling environment. For example, a cross-country comparison of productivity and competitiveness of OECD metropolitan regions shows that Mexico City's real GDP per capita, a robust indicator of productivity, is 63rd out of the 66 metropolitan areas listed. Such low levels are linked to low levels of human capital and research and innovation and technology, and to a lack of a competitive economy. This creates a situation where enterprises have fewer incentives to introduce less carbon-intensive technologies.[57]

Another particularity lies within features of Latin America's politics and policies. With some exceptions (e.g. Curitiba and Porto Alegre in Brazil, and Ilo in Peru[58]), the performance of the state, especially at local level, is limited not only by a lack of institutional and financial capacity. Local authorities frequently do not enjoy widespread legitimacy and there is a lack of public pressure from a strong civil society to undertake actions. In a context of high and increasing inequalities (see Section III above), managing carbon issues brings its own problems of dealing with scarcity, leading to patronage, corruption and rent seeking.[59] For example, dispute resolution and law enforcement in Mexico City are generally based on administrative mechanisms and negotiations between participants, i.e. authorities and their targets (drivers, dwellers). Both the local authorities and those sectors interested in getting a concession, in being registered or in occupying land, constantly negotiate, contest and change land use, transport and environmental regulations. This opens possibilities for corruption and for a weak or inappropriate enforcement of carbon-relevant measures. A culture of impunity is widespread among policy makers and their targets, as regulations work more as "recommendations", which nobody obeys.

Finally, there is the issue of government's capacity to deal with mitigation, which has been further constrained by such profound institutional changes as downsizing and retrenchment of the state, liberalization and deregulation.[60] For example, as a result of deregulation, urban growth in Santiago, Buenos Aires and Mexico City has been driven primarily by market forces rather than by public planning. Land use planning is altered or simply not undertaken, often to satisfy the requirements of speculators and developers. Actions aimed at containing land occupation by the poor do not target the real mechanisms of land allocation and urban growth. Housing is increasingly accessed through informal self-help practices outside legal regulations, as the high costs of legal land and the low levels of income make this the only way for the poor to access land and housing.[61]

Such responsibilities as the public provision of transport services (e.g. Ruta-100 buses[62]) and the regulation of concessions in Mexico City have practically been abandoned, or have been transferred or "decentralized" to the private sector and local authorities. However, this did not mean that the government abandoned its long-standing commitment to road building. Authorities have built highways and the controversial elevated highways – the *segundos pisos*.[63] But the state practically "abandoned" city transport systems, in that public transportation was deregulated, the state rolled back from its interventionist role and authorities privatized public enterprises such as the Ruta-100 bus system.[64]

56. Schaefer, R K (2003), *Understanding Globalizatio*n, Rowman and Littlefeld, New York.

57. OECD (2004), *OECD Territorial Reviews. Mexico City*, OECD, Paris, page 39.

58. López Follegatti, Jose Luis (1999), "Ilo: a city in transformation", *Environment & Urbanization* Vol 11, No 2, October, pages 181–202; also Menegat, Rualdo (2002), "Participatory democracy and sustainable development: integrated urban environmental management in Porto Alegre, Brazil", *Environment & Urbanization* Vol 14, No 2, October, pages 181–206.

59. Pezzoli, K (2000), *Human Settlements and Planning for Ecological Sustainability. The Case of Mexico City*, MIT Press, Cambridge, Mass.

60. Harris, R L (2000), "The effects of globalization and neoliberalism in Latin America at the beginning of the millennium", *Journal of Developing Societies* Vol 16, pages 139–162.

61. See reference 26, Romero Lankao et al. (2005).

62. Ruta-100 buses were provided by the local government from 1982 to deal with the collapse of the originally privately owned and operated bus companies. Ruta-100, which covered long-distance routes, was declared bankrupt in 1995 and, since its demise, the government has undertaken various unsuccessful actions to implement new bus service concessions with the private sector.

63. See reference 26, Romero Lankao et al. (2005), page 66.

64. Islas Rivera, V (2000), *Llegando Tarde al Compromiso: La Crisis del Transporte en la Ciudad de México*, El Colegio de México, Mexico.

Privatization of Ruta-100 and deregulation together with decreased public expenditure has contributed to three processes with implications for carbon emissions:

- a growth in car ownership and use (Figure 2);
- a vacuum in the provision of high-capacity public transport modes (local authorities have been unsuccessful both in attracting private enterprises and in reorganizing an integrated system of public buses);
- a shift in mode share from the Metro and buses to minibuses (*peseros* or *colectivos*) among other low-capacity modes; and
- the paradox noted earlier, whereby most vehicle trips are not made by private car although these contribute the highest share of CO_2 equivalent emissions.

These transformations, together with the institutional reforms noted above, have resulted in longer and slower travel distances for passengers and also recurrent congestion (Table 3). They show, for instance, that rather than more private transport, which does not serve the necessities of a higher proportion of users and contributes most to greenhouse gas emissions, cities in low-, middle- and high-income nations need a better public transportation system. They also require government strategies aimed at making these systems more attractive, not only to the poor but also to the high-income and middle-income social sectors.

VII. CONCLUDING REMARKS

Urbanization is one of the mega-global trends with profound implications for the carbon cycle, and through it, for climate change. In its current phase, urbanization shares some commonalities around the world, such as increased motorization and decreased use of public transportation. Yet as this paper has sought to demonstrate, cities follow different pathways of urbanization, with diverse implications for both the carbon cycle and the climate system. The paper has also sought to show why the process of ecological urbanization, which is widely considered to be a key to reducing carbon emissions in high-income nations, has limited applicability in Latin American cities.

Cities are key drivers of carbon emissions, but with very different relative contributions to such emissions. In general, Latin American cities have much lower levels of energy consumption and of carbon emissions per capita than cities in high-income nations. Curbing carbon emissions may therefore not be a local priority. Nevertheless, reducing these is a key issue for all cities in terms of its feedbacks to climate change, cities' vulnerability/adaptation to climate change, and synergies between carbon emissions and local air quality. The challenge is to further develop the understanding of both these linkages and of the relationships between different urbanization pathways and cities' emissions trajectories.

Equity is another carbon-relevant issue necessitating further enquiry. The wealthy in Latin American cities tend to have much higher carbon emissions per person and are also relatively more able to invest in their general well-being (for instance, in dealing with the health impacts of air pollution). The poor contribute much less to carbon emissions and are also much less able to contribute to the costs of more ecological solutions. Their poverty, unemployment and underemployment constrain any government efforts to deal with carbon emissions.

Finally, urban governance systems in Latin America seem ill-suited to the model of governance needed to implement ecological modernization. Rather, they need to deploy different patterns of industrialization. Their main concern may lie not in pursuing economic growth and technological change but, rather, in getting access to technology, reducing the daunting disparities between the wealthy and the poor, and developing "good governance structures".

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