Asia-Pacific Network for Global Change Research

Integrating carbon management into development strategies of cities – establishing a network of case studies of urbanisation in the Asia-Pacific

Final report for APN project 2004-07-CMY-Lasco

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Final Report submitted to APN

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Overview of project work and outcomes

Non-technical summary

The way urbanization unfolds will have a profound implication for future growth in energy use and emissions, and consequently, global environmental change. Cities offer many potential environmental protection benefits, arising from efficiencies in transport, energy used in cooling and heating, as well as opportunities to sequester additional carbon on land release from use by denser human settlements. On the other hand, cities have often been centres of wasteful consumption and serious air pollution problems. This project drew on past and on-going research efforts on emissions and urban management in Asia to establish a new set of coordinated case studies of New Delhi, Jakarta, Manila, Ho Chi Minh City and Chiang Mai. This group now collaborates under the label **U-TURN** or the *Urban Transformation and Urbanization Research Network*. A protocol for urban carbon management research was developed, explored and revised through applications in these five cities with their different constraints of data, prior research and political systems. Overall, the project achieved its three main initial objectives: to establish a network, develop a protocol, and provide guidance to a longer-term research programme. In addition, it hinted at several key new areas where research in urban areas could contribute to better understanding of, and actions in response to, global environment change. [1]

Objectives

The main objectives of the project were:

1. Establish a long-term research network of 4-6 integrated regional case studies from around the Asia-Pacific region, centred around cities with different urbanization and economic development histories;

2. Agree on common protocols and datasets that will allow comparability of results across these and other similar collections of case studies;

3. To synthesise the state of the knowledge about integrating carbon management into the development strategies of cities in a way will help guide a longer-term research programme.

Amount received for each year supported and number of years supported

Supported for 2 years: 2002- 33,000 USD; 2003 – 27,000 USD.

Participating Countries

Case study work was undertaken in five countries (Thailand, Vietnam, Indonesia, Philippines, and India). In addition one researcher from Singapore completed the core group of collaborators.

Work undertaken

The first step was to develop a shared protocol that jointly considers both social processes of urbanization and governance as well as emission inventories. This was developed through an initial planning meeting of collaborators in Manila and then revised as a result of a web conference and initial efforts in applying it to the case studies.

[1] This report was prepared by Dr. Louis Lebel and Drinya Totrakool from the Unit of Social and Environmental Research, Faculty of Social Sciences, Chiang Mai University,Thailand on behalf of the collaborating organizations in U-TURN.

The protocol then helped guide secondary and primary data collection and analysis to the urbanizing regions around cities in 5 countries: New Delhi (India), Chiang Mai (Thailand), Ho Chi Minh City (Vietnam), Jakarta (Indonesia) and Manila (Philippines). These studies were then written up as individual working papers. First drafts of these were discussed in a web conference and final drafts in a synthesis workshop in Chiang Mai in January 2005.

Results

The results of this activity are both scientific in terms of method development and findings, and capacity building in terms of creating and supporting a regional network.

Methodologically the group identified several challenges to aggregating statistics for urbanizing regions in developing countries that constrain the quality of emission inventories over time. It also explored but did not resolve some of the accounting and attribution issues associated with deemed emissions.

In terms of basic findings the diversity in contributions of different sectors is itself noteworthy, suggesting urban forms and functions do matter.

An important output of this activity was the creation of a network (U-TURN) of collaborating institutions. This network, for example, successfully competed for 2 small grants in an air quality and emissions program in Taiwan.

Relevance to APN scientific research framework and objectives

This activity further establishes cities and urbanizing regions as a key foci for research on global environmental change, confirming and extending the significance already demonstrated by earlier APN funded work on mega-cities.

Self evaluation

The activity was successful in raising awareness about urbanization's role in the global carbon cycle, and in the sense of proof-of-concept in developing a more integrative protocol. To go much further into urban planning and practice, however, would require substantially greater human resources and funds both for inventory work, sectorial and more integrative policy analyses, and creating forums to deliberate regional and municipal development strategies.

Potential for further work

The potential for a radical, or transformative, role for urban transformation and urbanization in helping moderate carbon emissions remains. This study suggests a more rigorous and well-funded inter-regional comparative effort would be plausible and likely to yield valuable insights. It also suggests that much more such work needs to be done in intermediate size cities and newly urbanizing regions, and not just the mega-cities of the world, from which comparatively much more is already known.

Publications

Public web page (U-TURN)

www.sea-user.org/carbon_management.php

Web Community Site (U-TURN)

www.sea-user.org/communities.php

Web Conference Site

www.sea-user.org/e-conference.php

Working Papers

www.sea-user.org/publications.php

Contreras, A., G.-l. Ooi, and L. Lebel. 2005. Integrating carbon management into urban development in Asia: a preliminary synthesis. USER Working Paper WP-2005-06. Unit for Social and Environmental Research, Chiang Mai University, Chiang Mai.

Lebel, L. (in prep.). Urbanization and the Carbon Cycle. Invited Editorial. Global Environmental Change.

Lebel, L., J. Manuta, P. Garden, D. Totrakool, and D. Huasai. 2004. A carbon's eye view of urbanization in Chiang Mai: improving local air quality and global climate protection. USER Working Paper WP-2004-09. Unit for Social and Environmental Research, Chiang Mai University, Chiang Mai.

Lasco, R., F. Pulhin, and R. Banaticla. 2005. Integrating carbon management in the development of Metro Manila-Laguna Lake basin, Philippines. USER Working Paper WP-2005-02. Unit for Social and Environmental Research, Chiang Mai University, Chiang Mai.

Mitra, A.P., Charma, C, Pundir R. (*in review*). Emission of pollutants from transport sector in Indian Mega-cities: case studies of Delhi and Kolkata. (*Submitted to Atmospheric Environment*).

Mitra, A. P., and C. Sharma. 2005. Integrating carbon management into the development strategies of cities: Delhi case study. USER Working Paper WP-2005-03. Unit for Social and Environmental Research, Chiang Mai University, Chiang Mai.

Sari, A., and N. Salim. 2005. Carbon and the city: carbon pathways and decarbonization opportunities in greater Jakarta, Indonesia. USER Working Paper WP-2005-04. Unit for Social and Environmental Research, Chiang Mai University, Chiang Mai.

Tri, N. H., P. T. A. Chau, N. K. Thanh, P. Duc, P. T. N. Diep, and N. T. B. Ha. 2005. Integrating carbon management into the development strategies of cities: Ho Chi Minh City and surrounds. USER Working Paper WP-2005-05. Unit for Social and Environmental Research, Chiang Mai University, Chiang Mai.

Acknowledgments

We thank the START International Secretariat for managing a portion of the APN grant. We also thank the SARCS Secretariat in Taiwan for follow-up grant for a comparative urban air-quality study that closely compliments the activities began with the APN and START support.

Technical Report

Preface

This report summarizes and documents the findings of a U-TURN (Urban Transformation and Urbanization Research Network) pilot project in Asia. The main body of the report synthesis the findings of a set of working papers included in the full as appendices. This activity drafted and then made a preliminary test of a protocol for carrying out a comparative analysis of how urbanization interacts with the global carbon cycle. The protocol was unusual in the attention it gave to understanding social processes, both as sources of leverage for decoupling social development and emissions growth and for exploring issues of social justice that emerge with various interventions. The first iteration of the protocol was applied to the urbanizing regions around the cities of New Delhi (India), Ho Chi Minh City (Vietnam), Jakarta (Indonesia), Manila (Philippines) and Chiang Mai (Thailand). The findings confirm that the urbanization process should be central to efforts at integrating carbon management into regional development strategies. They also, however, highlight the need for more experimental and radical interventions through fostering new urban forms and functions that will have impacts go well beyond current tinkering with efficiencies and emissions.

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Integrating carbon management into the development strategies of cities and urbanizing regions in Asia

Main body of report prepared by Louis Lebel, Antonio Contreras and Ooi Giok-ling

With additional inputs from: Rodel Lasco, A.P. Mitra, Agus Sari, Nguyen Hoang Tri

1.0 Introduction

The way urbanization and urban transformations unfolds over the next few decades in Asia will have profound implications for sustainability cast broadly and for energy related emissions more narrowly.

Urbanization, an important component of economic development, has come relatively late and fast for many of the countries of Asia. Urbanization results from intrinsic population growth, migration adding population to existing urban areas, and human settlements reaching a certain threshold size or density after which they are formally recognized as urban by their national governments. No universal definition of "urban" exists, in part, because urban boundaries are always subject to local definitions and negotiations (Lebel 2004a). Typically urban has connotations of higher population density and availability of services and infrastructure and livelihoods in commerce, industry and service sectors.

The goal of this paper is to explore how carbon management—*a carbon's eye view of development*—can be integrated into development strategies of cities and urbanizing regions (Global Carbon Project 2003). The human alteration of the global carbon cycle is of concern because of its impacts on the climate system (Field & Raupach 2004). A carbon perspective may be similar to an energy and materials one, but not always, especially if renewable energy sources are pursued and major efforts are undertaken to secure carbon stocks or sequester additional carbon through space that urbanization "frees up". Indeed this is exactly why it may be valuable to think in terms of carbon management (Global Carbon Project 2003).

In taking such a perspective, however, we do so with full acknowledgement that the evolution of urban form and functions on the time scale of decades is inherently uncertain, and thus development strategies, must have a large learning and adaptive component. We also acknowledge that carbon is unlikely to ever be the dominant concern of a City Mayor but rather that adopting a carbon perspective is complimentary to more conventional ways of thinking about history and the future of regional development.

In particular, we propose that newly urbanizing regions provide profound opportunities for re-organizing human activities and social organization in ways that could help decouple growth in emissions from improvements in quality of life. Mass transit systems and multi-function town service centres can be planned and built ahead of time thus helping shape urban form rather than being an afterthought. Architecture and green spaces can be preserved for passive climate control. The principle challenge here is ensuring enough flexibility that boom-bust cycles of global economies don't impact too strongly on services and city competitiveness.

Although more challenging, we also believe there are significant opportunities within more established cities to transform along less carbon-intensive pathways as their functions, size and form shift away from manufacturing and primary industries into service roles. Declining city centres may be re-vitalized by claiming back road surface for pedestrians and bicycle, and commercial building re-fitted as inner city apartments. At the same time issues of industrial relocation, deemed and embedded emissions need to be explored to assess the real carbon consequences of changes in urban function.

But are the opportunities that urbanization and urban renewal create being captured in Asia? Has carbon management begun to be incorporated into the development strategies of cities and urbanizing regions? If not, why hasn't social mobilization occurred?

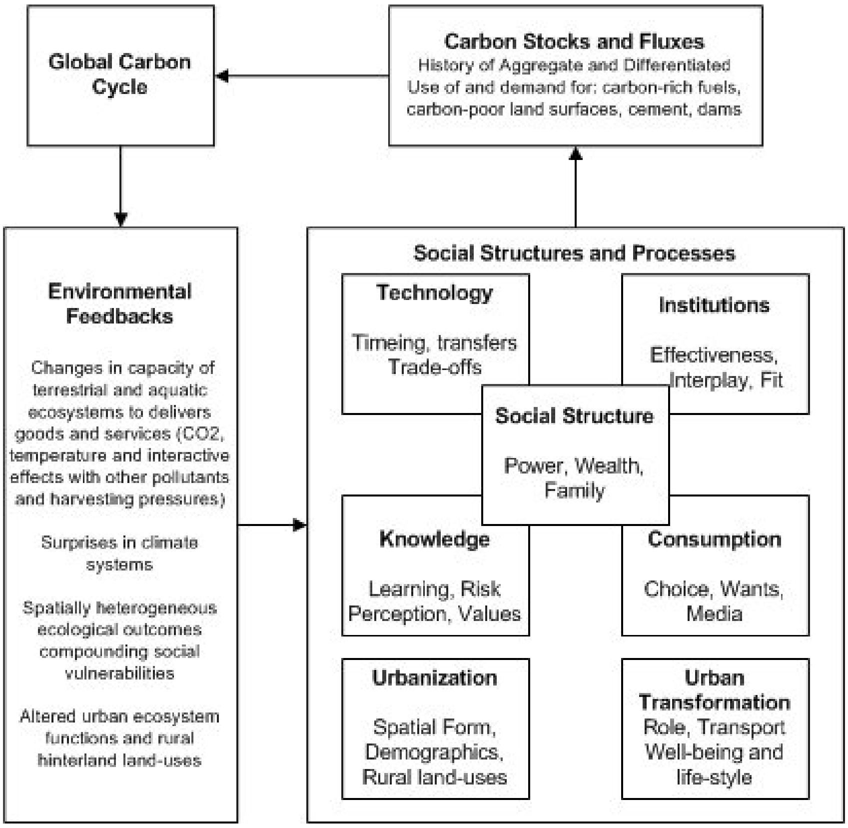
Overall, carbon management policies seem incidental to overall thrust of development planning and more spontaneous elements of economic growth. Climate change mitigation policies in Asia, as elsewhere in the world, largely remain sector-based. A look at the National Action Plans of countries in the region confirms this. Urbanization itself has rarely been considered a lever, above and beyond more immediate concerns with transport sector or energy production. Clean air initiatives on the other hand have often had the air-shed of a city or municipality as their focus. The high density of activities in cities means that relatively modest increments in individual emissions can in their aggregate easily exceed thresholds of local air-sheds to assimilate and disperse pollutants.

Are there win-win options? In other words, could measures to maintain or improve air quality in urban areas also be carried out in ways that would help reduce greenhouse gas emissions?

Most energy and related emissions inventory research to date has focused, understandably, on the regions' mega-cities. These studies have revealed surprising amount of variation among cities in absolute and relative patterns of, and rates of change in, energy use and emissions (Dhakal 2004; Marcotullio 2003; Molina & Molina 2004). These studies have also improved our understanding of assumptions in making inventories, especially with respect to deemed and embedded emissions, and the large role of energy and transport sectors. A few have also begun exploring taxes, incentives and other policy instruments to encourage alternative technologies, energy sources, and land management practices (Betsil 2001; Dhakal 2004). These important endeavors in their own right but are limited by incomplete considerations of urban function, forms and norms in shaping carbon-intensive lifestyles (Lebel 2004b).

To do this requires placing a strong emphasis on integrating understanding of behavioral, cultural and institutional issues with the conventional emphasis on inventorying and modeling greenhouse gases and atmospheric pollutants. A more socially and politically nuanced understanding of underlying causes and constraints on responses will provide greater policy relevance to biophysical and technologically oriented research on emissions and the carbon cycle (Figure 1.1).

Figure 1.1: A conceptual framework for how social development processes may influence the carbon cycle - modified after (Lebel 2004b).



Looking ahead the contributions to emissions growth of vastly more numerous intermediate and smaller sized cities globally will only grow in importance. It is not clear that the challenges these pose for environmental management and policy are identical to those of mega-cities. It is also uncertain if the lessons from countries that industrialized earlier will apply equally to those changing later (Marcotullio 2003). Access to cheap fossil fuels and alternative energy sources, and the nature of world trade, to name just two key contextual factors, vary greatly over time.

The cumulative and per-capita impact of cities in developing countries of Asia on the global environment has been small relative to cities in industrialized and post-industrial economies with their high energy use, work place and household consumption patterns. Nevertheless, as their economies grow so their potential impacts increase (Lebel et al. 2001). Guiding transfers of, and investments in, cleaner and more efficient technologies will be critical (Forsyth 1999).

Moreover, there are insights to gain from a better understanding of urbanization in developing countries for transforming urban lifestyles in the "*over-developed*" nations. The newly industrializing economies of Asia, for example, may be achieving levels of well-being at much lower per-capita CO_2 levels than their counterparts as a result of social institutions that foster higher density activities, better sharing of space, trust or which moderate wasteful consumption (e.g. Carpenter et al. 2004; Dhakal 2004).

Finding pathways of transformation for cities and urbanizing regions that are less carbon-intensive would be highly desirable on both public health as well as global climate protection grounds. Transformations in the high consumption cities will require reductions in per- capita materials and energy use. In the developing world the desirable de-coupling would be a reduction in the rate of growth of emissions without a corresponding decrease in rates of gain in social development. Greenhouse gas emission reduction programs that significantly constrain such development for the poor would be unjust. Options that provide clear benefits such as improved air quality where people live and work or lower cost mobility and shorter commutes, on the other hand, would be desirable.

The primary analyses and most illustrations in this paper are drawn from a comparative study (Contreras et al. 2005) of how urbanization has unfolded in the regions around the cities of New Delhi (Mitra & Sharma 2005), Jakarta (Sari & Salim 2005), Manila (Lasco et al. 2005), Ho Chi Minh City (Tri et al. 2005) and Chiang Mai (Lebel et al. 2004b). This project was intended to be a pilot study of a research protocol for a broader international effort initiative of the Global Carbon Project (2003).

The primary objectives of this APN project were to: establish a research network, develop a research protocol, and provide guidance for a longer term research program. The main body of this technical report, however, is not organized around descriptions of each of these activities, but rather a synthesis of some of the main outcomes of these iterations with applying the protocol in the case study cities. That is, it is focused on the science rather than process.

In the main body of the report we address three over-arching questions:

1. What are the consequences of different material and energy pathways and social processes of urbanization and urban transformation for carbon stocks and fluxes?
2. What are opportunities and prospects of decoupling growth in carbon emissions from social development through explicitly incorporating carbon management into the development strategies of cities and urbanizing regions?
3. What are the main social justice considerations that need to be taken into account in de-carbonization efforts?

This paper is organized as follows. First the different pathways through which carbon stocks, fluxes and regional balances are altered are described and estimated. Second, we review the various urban transitions that have changed the size of these pathways. Third we review past efforts at carbon management and their governance and justice implications. Fourth we synthesize what we have learnt about opportunities and their prospects in terms of development strategies for cities and urbanizing regions. The paper ends with a brief conclusion.

2.0 Methods

2.1 Case Study Selection and Definition

In defining the boundaries of our case studies we chose to go beyond conventional municipal boundaries so that our prospective and policy analyses could consider surrounding areas that are not yet, but will soon be, urbanized. The surrounds are also potential locations for new and relocated industries as well as for food production and conservation with their own implications for carbon stocks and emissions. Pragmatic considerations of data availability meant that study areas usually fit administrative boundaries a level above the municipality (Table 2.1).

Table 2.1: Basic geographical characteristics of the case studies.

Case Study	Definition of urbanizing region adopted in the case studies	Total Area in km^2 (urban area)	Population (millions in 2000)
Manila	Metro Manila + Laguna Lake Basin	4500 (620)	9.9
New Delhi	National Capital Region Territory	1500 (750)	12.0
Chiang Mai	Chiang Mai + Lamphun provincial capital districts and 8 nearest districts	2900 (180)	0.9
Jakarta	JABOTABEK- Jakarta, Bogor, Tangerang, Bekasia, Depok	4000 (1730)	20.9
Ho Chi Minh	Ho Chi Minh City	3000 (1000)	5.2

Development of the research protocol

The five case studies drew primarily on secondary data sources, including documents, interviews, and expert group meetings. Our methods fall into three major groups, inventories, urbanization process and governance studies.

First, we characterized changes in carbon stocks and fluxes for at least 1980, 1990 and 2000 using standard methods for inventory of energy-related emissions and removals by sectors (industry, commercial, transport, agriculture, land-use and household). Much of the effort was expended in disaggregating statistics to fit the urbanizing regions selected and making assumptions about uncertainties in activity datasets. For this study carbon stocks and fluxes include carbon dioxide (CO_2), methane (CH_4) and black carbon. CO_2 and CH_4 are two of the most important greenhouse gases. Black carbon, on the other hand, is one of the classes of aerosols that impact radiative balances, and therefore influence climate. It refers to the various carbonaceous end products (chars, charcoals and soots) of the incomplete combustion of fossil fuel and biomass. Aside from climatic influences, black carbon is a major health concern.

Second, we explored the spatial, economic, cultural and demographic development of the urbanizing region, through quantitative statistics and qualitative studies of process of urbanization and its role in regional development. These analyses were guided by a protocol of shared research questions focusing on understanding drivers of energy and land-use changes that would have carbon consequences. Not all case studies were able to delve equally into each individual question, nor would it have been appropriate too, but the full set provided a comparable basis for our analyses.

Third, we explored urban and regional systems of governance, including recent air quality and greenhouse gas initiatives, to assess the prospects for further incorporating carbon management into regional and city development strategies. This dealt with both issues of creating a constituency around carbon emissions as well as knowledge and capacity issues. We also addressed implications of alternative courses of action for social justice.

3.0 Results & Discussion

3.1 Carbon pathways

Energy use

The most profound trend across all five city regions has been the tremendous growth in energy use over the past two decades from what were relatively modest per capita levels. Consumption of petrol and diesel in Delhi , for example, multiplied around 4-fourfold between 1980 and 2000.

Electricity consumption has also grown extremely fast in several of the cities. For Delhi coal consumption in thermal power plants within the city has decreased and been replaced by natural gas or electricity purchased from national grid and consequently indirect emissions have risen.

Renewable energy sources are currently a minor component of the budgets of each city.

Land use

The extent of roads and building surfaces in all five city regions has grown tremendously over the past few decades, reconfiguring aggregate and spatial organization of land uses. In the case of Chiang Mai, for example, the change in areal extent far exceeds the growth rate of resident population.

Agricultural lands giving way to urban uses, however, may not imply loss of sinks, because of the importance of paddy rice as a source of methane emissions.

Changes in urban forests and green-spaces varied widely across cities. Overall, green-spaces in Jakarta have been contracting with the massive growth in built -up areas (Rustiadi et al. 2004). In contrast in the Delhi National Capital Territory there has been a substantial net increase in forest cover in the past decade. In Ho Chi Minh approximately 4% of land cover in urban areas is trees. Improved management of the 40,000 hectares of mangroves in the Can Gio Mangrove Biosphere reserve could be an important strategy for the city to conserve biodiversity at the same time as benefiting from air pollution cleaning and climate control services this major green-space provides the city.

Green-spaces may become more important in moderating urban heat island effects in the larger cities, which can create a positive feedback loop in terms of rising demand for air-conditioning and associated energy consumption.

The net impacts of urbanization on land-use, however are difficult to assess there may be compensatory effects elsewhere. Rural-to-urban migration around Chiang Mai, for example, is leading to a de-population zone of villages with population declines, ageing and school and other service closures. It is not yet clear whether trends of increasing forest cover observed in some areas of northern Thailand to what extent this can be attributed to demographic changes releasing agricultural land to forest rather than forest reserve and protected area policies and management practices.

Production-consumption linkages

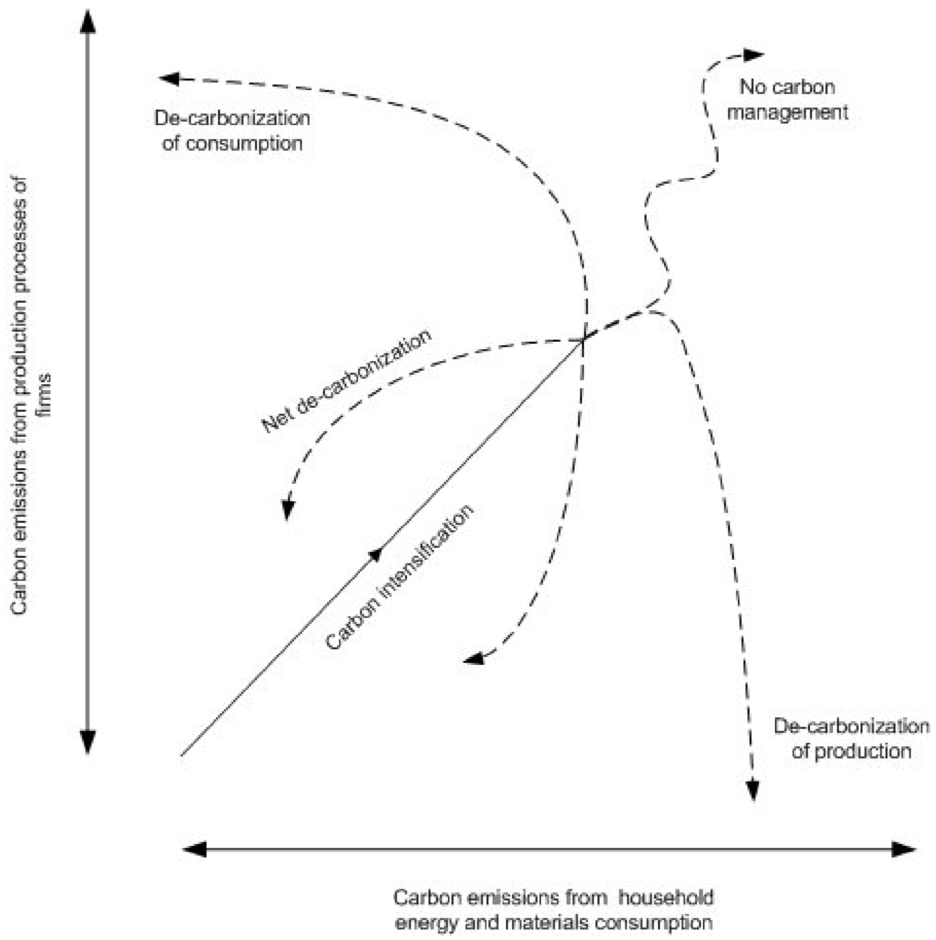
The emissions arising within the boundaries of a region may be relatively small to those that are driven externally by consumption activities which is why various “footprint” or “deemed” emission calculations can be revealing.

A good illustration of this is the deemed emission of methane from enteric fermentation by livestock. People in Delhi and Chiang Mai, for example, are now drinking much more milk than they did before. This change in lifestyle has surprisingly significant emission consequences.

Apart from the obvious indirect emissions associated with production of electricity other behaviors that are worth exploring include transport emissions associated with air travel (of residents or visitors) and the emissions associated with production of cement.

The emissions from production and consumption activities in an urbanizing region invariably increase during period of initial rapid economic growth, but with time opportunities arise for de-carbonization of both production and consumption activities (Figure 3.1). Considering both perspectives is important otherwise you can end up with clean cities with huge deemed emissions.

Figure 3.1: A production-consumption perspective on alternative carbon pathways with continuing urbanization and transformation in a region.



Regional balances

Ultimately the key issue is, other things being equal, whether or not urbanization results in higher or lower net regional emissions. By other things being equal I mean at least population (ie per capita-wise), but it may also make sense to consider adjusting in some way for income.

3.2 Urban transitions

Urbanization is a complex mixture of social processes.

Demographic

Urbanization results from intrinsic population growth, migration adding population to existing urban areas, and human settlements reaching a certain threshold size or density after which they are formally recognized as urban by their national governments (Sheng 2001). Rural to urban migration is the most obvious aspect of urbanization and invariably associated with changes in livelihood and economic activities although many households maintain important reciprocal links with agricultural roots. Apart from spatial reorganization, however, urbanization also helps bring about concurrent demographic changes with profound longer-term consequences for patterns of labor productivity, consumption and emissions, for example, by altering fertility and age structures of both source and destination populations.

From a demographic perspective the Southeast Asian region is still very dynamic. Population sizes continue to increase, albeit more slowly. Fertility and mortality rates are falling as countries go through various versions of the demographic transition, with some countries facing relatively rapid changes in age structure over the coming decades. Migration, facilitated by improved infrastructure and stimulated by new economic opportunities, is high, but varies with economic conditions, regions and ethnic backgrounds. Overall, the movements to and from urban and rural areas in Southeast Asia are linking these sub-systems much more closely than before (Rigg 1997).

Demographic transitions are a key aspect of urbanization process across the Asia-Pacific region, and because of the linkages through trade and investment among countries, have regional consequences for competitiveness, labour costs, and the organization of industry. For example, consider the case of Chiang Mai – Lamphun (Lebel et al. 2004a). The population of the urbanizing region has progressed overall at a steady rate just below 1% per annum for several decades despite a very sharp fertility decline. By the mid-80’s fertility had reached below replacement levels in northern region of Thailand. This has profound implications for demographic change, with sharp rise in median ages, family structures and dependencies, and combined with rural-to-urban migration and death from AIDS the prospects of significant collapse of many rural communities. These profound over-arching demographic changes help shape and bound transformations of housing stocks, patterns of land inheritance and car ownership. Urban growth in the Chiang Mai case study is not predominantly a demographic phenomenon. Over the past two decades this growth is expressed more sharply by the massive increase in infrastructure, in particular, roads, housing estates and commercial land-use, beyond the historical compact old city areas that greatly exceeds changes in residential populations. Rural-to-urban commuting, seasonal migration in construction and service sectors, and the consistently large number of tourists also shape the size of the effective consuming population of Chiang Mai.

For its part, the contribution of migration, as a demographic force, to urban growth, has declined in Manila due to urban diseconomies. For example, the percent contribution of migrants to the total population of Metro Manila appear to be declining, from 18.2% in the period 1975-1980, to 11.5% percent in 1985-1990. However, this could not be said of Delhi, where migration remains a significant factor in population dynamics. Nevertheless, change in population density is not uniform all over Delhi, where some parts are experiencing significant increases, even as these large increases are not seen in other parts.

In several of the cities internal demographic re-structuring was leading to a “bagel effect” with falling densities in the central commercial and business districts of the city as overall urban area expands. This depopulation trend was quite pronounced in central Jakarta and Delhi in the 1990s. Metro-Manila continues to grow but now at slower rates even below those of neighbouring regions. In Chiang Mai, like Manila, most new growth is outside the older inner parts of the city. The growth of suburbs in the metropolitan fringes and the adjacent provinces is foreseen as the reaction of the growing middle class to high land values, traffic congestion and overcrowding in the metropolitan core. This expansion of urban areas directly affects transport activity in the metropolis by increasing the distance traveled from the residence to the workplace, and that required for hauling goods and services.

Economic

In earlier periods of nationalist development, the policy of import-substitution led to the concentration of industries in capital cities. Policies of economic protectionism enhanced the initial urbanization phase. The liberalization of investment and globalization of trade and production systems through the operation of transnational corporations has deepened the integration of most countries in Asia with each other and the world economy (Lebel et al. 2001). Capital cities and other rising urban centers are now less attractive for primary industries due to rising land rents. Export-oriented development strategies then led to industrial estates and export processing zones being established in rural peripheries to take advantage of cheap surplus rural labor and lower land prices. Industrial dispersion, whether induced by government policy or by sheer market forces, allowed the metropolitan core to retain its commercial nature, where trading in goods and services is the core economic activity.

The evolving spatial organization of the five cities studied here illustrate this general pattern with some variations.

Manila, Jakarta and Delhi have seen the expansion of their metropolitan spaces from capital cities to become an urban sprawl with a core city that is now basically a commercial and service center, with industrial corridors radiating outwards into the periphery that has become a part of the larger urban space. Ho Chi Minh is becoming both an industry and trade center. As a former capital of South Vietnam, it has seen an industrial pathway where it served as core. Its trajectory of following the Jakarta, Manila and Delhi pathways was interrupted when the South was reintegrated into the North. At present, the policy of economic reforms, and the increasing integration of the Vietnamese economy in the global economic order, may become drivers that would eventually transform Ho Chi Minh to take a path very much like that taken by Manila and Delhi. Even Chiang Mai the smallest and relatively remote regional hub for northern Thailand has seen the emergence of industrial estate in its’ twin city Lamphun to which it is now being joined by residential and commercial corridors. Tourism, however, plays a special role for Chiang Mai not seen in the other four cities, and acts as a constraint on certain forms and patterns of industrial development.

In terms of carbon consequences, while urban growth based on the service sector may not produce carbon emissions in the same levels as when it is based on industry, this may only be true in the core metropolitan areas that are formerly the home for these industries prior to their relocation to the periphery. Such emissions are now “exported” or “relocated” to these new industrial enclaves, now popularly called as export processing zones. In fact, there is even evidence that attempts to change the location of industries in Metro Manila. Since 1973 ban was imposed on locating new factories within a 50km radius of Manila with aim of decongesting. It did not however work, but rather created an industrial ring on the urban periphery (Mercado 2002). Unlike most of the other cities, urbanization in Manila has proceeded relatively slowly and without corresponding industrial and economic growth.

Urban areas have diverged in the post-independence period because of the differences in development ideologies. In Vietnam, for example, there was actually a process of de-urbanization during the 1970s and early 1980s, due in large part to the control of the process of rural-urban migration. Today, however, Ho Chi Minh City is economically dominant producing 30% of the total industrial output of Vietnam. This has produced a tremendous surge in jobs and wealth. High levels of obsolete equipment and poor regulatory capacities, however, have also meant rapidly deteriorating air quality. A key issue is whether to relocate or transform the many small industries that make up this dynamic sector (Frijns 2001).

The sectorial structure of economic activities in urbanizing regions and the functional relationship with the wider economic and global systems of production (Douglass 2000; Douglass & Ooi Giok-Ling 2000; Marcotullio 2003) profoundly affect the amount and composition of emissions. In particular as economies of a city takes on more commercial and service functions, industrial output may fall, resulting in relatively high deemed emissions but rather modest direct ones.

Mobility

Undoubtedly one of the most interesting aspects of Asian cities in the global context of urbanization has been the high density of activities, that, at least historically made non-motorized and public transport plausible. The last decade or two has seen a growing number of counter-examples as income thresholds for the purchase of personal motorcycles and cars have been surpassed and at the same time urban form has shifted in ways that make the convenience of personal mobility highly valued. Changes in employment and the large number of jobs in manufacturing obviously impact on travel demand as well.

The outcome has been very rapid growth in vehicle ownership, during the past two decades in all five cities, often from relatively low baseline. Vehicle registrations between 1991 and 2001 in Delhi increase at compound growth rate of 6.7% that is, almost doubling in a decade. At the same time the share of fleet has been moving strongly away from two-wheelers to passenger cars and jeeps.

Again and again city authorities have struggled to anticipate and build roads at the rates of growth in vehicles in cities (Ooi and Kwok 1997). Congestion and high densities on key routes are frequent. Average travel speed in Manial was 10km/hr similar to Bangkok. Per capita road surface in most Asian cities is well behind Europe and US cities. In the mid-90s Jakarta had about 0.5 meters per person and Bangkok 0.6, about a quarter of typical cities in Europe and US (Sari & Susantono 1999). While this may helps explain congestion with rising vehicle ownership it should not necessarily be viewed as evil, but perhaps, even an opportunity for following an alternative trajectory.

Sprawling urban growth, in which large areas of land are hard to access for either residential or agricultural use, makes personal vehicles essential. These patterns have been in part shaped by the political economy of land markets and road construction projects (Ooi 2000). This is most apparent in the largest urbanizing regions like Jabotabek and Metro Manila where major highways connecting what were separate cities become the focus of new ribbon development. For example, approximately 30% of people working in Jakarta actually live in the surrounds or "Bodetabek". Between 1985 and 1993 the number of commuters increased four-fold. Without corrective measures the number of car-based trips is expected to rise to 56% in 2010 (Sari & Susantono 1999). In 2003 32% of register vehicles in the Philippines were from Manila. Predictions are that proportion of trips in private vehicles would rise from the 21% in 1995 to as much as 34% in 2015.

The help of international agencies like World Bank has been secured for the improvement of urban transport infrastructure particularly in Metro-Manila. A major initiative is to shift the mode of transport for urban commuters to rail as well as public transport. This is also the plan for the surrounding area of Metro-Manila up to 100 kilometers outside the metropolitan region.

Delhi, too, appears to have been incrementally working towards carbon emissions reduction particularly through the transport sector. There has been a shift to CNG as well as unleaded petroleum through legislation and promotion by the public sector. Such shifts have involved both public sector and private business vehicles. A Mass Rapid Transport System is being designed and developed for Delhi to try and replace dependence on roads for daily work-related trips.

In the smallest city studied, Chiang Mai, troublesome aspects of rising personal vehicle dependency were arising, like congestion, declining air quality around intersections, and very low use of non-motorized transport modes. These are ominous sign for other small and intermediate-sized cities where high density living is unlikely to develop spontaneously.

The over-arching lesson that can be drawn is that *public mobility systems should help shape rather than just follow urban form*. This has different meanings in different city contexts, but in all it includes creating secure nodes and corridors for non-motorized transport with good links to public transport infrastructure (Whitelegg & Williams 2000). Reducing or moderating growth in auto-dependency with public commuter rail system, restrictions on parking and by not over-building road surface areas also matters. Forward planning can proactively shape form of new urban areas with pre-laid commuter rail and road-based public transport system and re-new old ones by adding stations with integrated service facilities. In the latter case the model must be to decentralize but maintain standard of key services (e.g. schools, health, market areas) and make access convenient locally by non-motorized or via public transport system. Finally, there are huge opportunities to make much better use of information technologies to reduce inefficiency in transport logistics and enable flexible reduced-commuting employment.

Lifestyle

Income is likely to be strongly associated with direct and deemed emissions. Our interest here is to what extent differences at particular income levels associated with lifestyle are present and whether policies around carbon management could foster less carbon-intensive lifestyles.

The central issue in urbanization is whether as a process it actually contributes to reductions in energy and material use. There are many reasons to expect that a household getting wealthier but remaining in a rural setting will use more resources than one which has moved or been transformed into an urban one because of greater access to public transport, shorter commuting distances to regularly used services, and smaller more compact settlements and thus social relations. On the other hand, the shift to an urban context also transforms lifestyles and patterns of consumption. Invariably wealth and disposable incomes also changes, and not always upwards either. There is surprisingly little direct data about such transitions in developing country contexts. This clearly should be a focus of future research.

In Chiang Mai and Ho Chi Minh City urbanization is "incomplete". Many households, the landscape and social organization straddle urban-rural linkages that defy attempts at simplistic boundary setting in space or classification of households or people. A portfolio-style of logic is needed to understand changes in livelihoods and perhaps, also lifestyles as even these may shift seasonally and vary among individuals in the same household.

Changes in architectural fashions is another important issue often driving up, when it could be helping reduce, energy consumption. This is reflected both in the substitution of wood construction materials with concrete, and the shift to closed rather than open structures, which require air-conditioning. Poor design is an obvious feature of many new suburban developments around the case study cities.

Mobility, convenience and comfort are key lifestyle attribute. Urbanization is defined by its participants through lifestyles. Contrary to the consumer sovereignty myth, however, much of the growth in consumption of firms, households and government agencies is not just about meeting needs, but through advertising, creating new needs. Unfortunately many of these have carbon implications whether through relatively direct energy consumption in the use of products and services, or more indirectly, in the energy used in their production.

3.3 Governance

Mobilization

The case-studies strongly suggest that the national governments of the countries in which the cities – Metro-Manila, Jakarta, Delhi, Chiang Mai and Ho Chi Minh City – are located, have since the 1990s, set up either the institutional resources or the frameworks for effort to reduce carbon emissions. Institutional support for carbon emissions reduction appears to be strong in the Philippines. Legislation has been introduced in support of clean air initiatives. Several public sector agencies have been specifically assigned the tasks of improving air quality, transport as well as the quality of fuels being used. Initiatives have been extended to energy consumption with the public sector taking the lead at promoting energy efficiency. Incentives have been worked out for the market sector involving schemes for technology transfers to achieve energy savings.

In Delhi the Master plans have failed to keep pace with rates of urbanization. Sometimes the Supreme Court intervention, has helped, for example, in dealing with air quality problems arising in the transport sector (Bell et al. 2004). In a very different governance context, comprehensive plans for environmental protection in Ho Chi Minh City have also lagged behind staggering rates of economic change (O'Rourke 2002). Ho Chi Minh City's effort at carbon reductions emissions appears to be concentrated on the improvement of air quality. There are also emissions standards set for vehicles but so far, motorcycles have not been included in the checks that are conducted before licenses are renewed. Several internationally funded projects appeared to be aimed at infrastructure improvement in Ho Chi Minh City for transport as well as sewerage and drainage, but emissions control do not appear central to these.

Mechanisms that build social capital, collective consciousness, and a sense of community help counter the legitimacy crisis that arises from increasingly complex institutions. These include policies that rely on the legitimate power of the state to consolidate society as well as civil society actions that influence the public policy process. The carbon management discourse is new and technocratic. It is espoused by people with backgrounds like those of the authors of this paper. It remains contained in the domain of academic experts and a few technical bureaucrats and thus has not had much influence on policy.

Air quality issues, on the other hand, have been arenas for much greater social mobilization and responses. In the Philippines, for example, civil society influenced the introduction of Clean Air Act that led to banning of incinerators, although activism may not have been well informed by scientific knowledge.

Initiatives to reduce rates of growth in greenhouse gas emissions have largely be taken by the state and half heartedly. Municipalities and other city and regional level mobilization has been modest. An important and interesting exception is the Cities for Climate Change campaign which both Manila and Chiang Mai have joined. Public awareness, understanding and mobilization, however, remains very low on most issues, although air quality and green-space related items do have some saliency.

The case can be made for cities to set down in the public domain a carbon management plan which can be shared by all sectors and interested parties. Lack of awareness was discussed in the case study on Metro-Manila. So much of the effort required for an effective carbon emissions reduction agenda is predicated on the behaviour of consumers and producers, there needs to be more public declaration of goals and more effective communications of the plans and programmes to achieve them so that they are shared as widely as possible.

It is also here that active civil society participation has to be fostered. Civil society actors can become conduits for the development of a carbon constituency, which can be used to provide not only support mechanisms for policy initiatives, but also as venues to articulate demands and pressures for city and national governments to act. This, however, is predicated on a strong information dissemination campaign that will "popularize" the carbon discourse, something that remains a challenge in all the cities studied.

Interplay

All city administrations struggle to get involved in energy policy which is most often construed at the national level. Delhi, for example, is administered by a both state and federal governments. The state level status creates some important powers, for example, that have been exercised with respect to fuel use. In Jakarta the national level issues greatly constrain measures beyond efficiency type ones.

In addition larger cities like Jakarta and Manila involve coordination challenges of multiple municipalities.

Conversely, national level initiatives have to be translated to the urban or metropolitan as well as local neighborhood scales. This appears to pose a major challenge to cities including those being studied. Such scaling down of the effort at carbon emissions reduction is clearly needed in the case of Metro-Manila since the `air shed' being discussed encompasses several jurisdictions or administrative areas including municipalities and provincial authorities. There is a major concern that the local governments might not be in a position to carry out the tasks required of them if there is no support from provincial or the national state sectors.

The issues of scaling the effort that is to be mounted to address carbon emissions reduction parallel those concerning the coordination of the work being done by different agencies. This appears to be important for Metro-Manila where several national as well as metropolitan agencies – environment, agriculture and forestry, transport and energy – have been given the tasks of addressing the different problems related to air pollution and carbon emissions.

Urban pollution can only be solved if there is greater coordination of urban transport policies and land-use development. Most cities find the integration of both these developments a major challenge. The proposal for more pedestrian-oriented land-use development or even those that are bicycle-friendly requires such close integration between land-use and transport.

The complexity of the interaction between political and economic institutions with urbanization is is articulated by capitalist modes of production within a political agenda of social integration. This is observable in all cities studied, even Ho Chi Minh, where the existing political system, while remaining socialist, has opened up spaces for capitalist enterprise. Overall, interplay among state and non-state institutions with respect to underlying factors driving emissions growth is complex and unwieldy making coordinated effective action very difficult. Particular important in the five cities we studied, but need much more thorough investigation are, for example, issues related to planning and financing of major road infrastructure projects, systems for granting licenses and setting fees of other incentives for private involvement in mass transit systems, and the duties and taxes on cars and how revenues for road maintenance. Improving accountability of initial as well as operating decisions is more central to tackling air quality and climate protection issues than is normally recognized.

Accountability

The case study of Delhi highlights the lack of assessment of the progress being made by initiatives such as, the use of unleaded petrol as well as the shift to CNG vehicles. The indicators show relatively little change in emissions trends. Indeed, in Metro-Manila, there is concern about the enforcement of legislation that has been introduced. Evidently, such enforcement has to be achieved before assessment can be done which will meaningfully establish the contributions of different initiatives that have been introduced. There should also be greater clarification about the agencies that would be responsible for monitoring the progress being made.

Justice

Social justice could imply a range of different developmental goals for cities. Social justice is not an either-or proposition, but must be seen as a state of existence where social equity is achieved through good governance characterized by transparency, accountability and participation.

In the five cities we examined measures to reduce emissions have sometimes appeared to have fallen disproportionately on the poor. Pricing structures and infrastructure investments are made in ways that ensures healthy mobility for the wealthy and lengthy commutes through polluted and congested streets for the poor. Overall we expect that elitist governance will be more carbon-intensive than more populist styles, but much more analysis is needed of these kinds of issues.

Interventions in land use also have to consider issues of land-use. Finally, carbon management may have more to do with transfer of control and issues of access rather than responsibility and stewardship. Policies with respect to “green-spaces” and “abandoned land” for example often fail to recognize that such areas are in fact used intensely by urban poor for recreation, urban agriculture and low-cost housing.

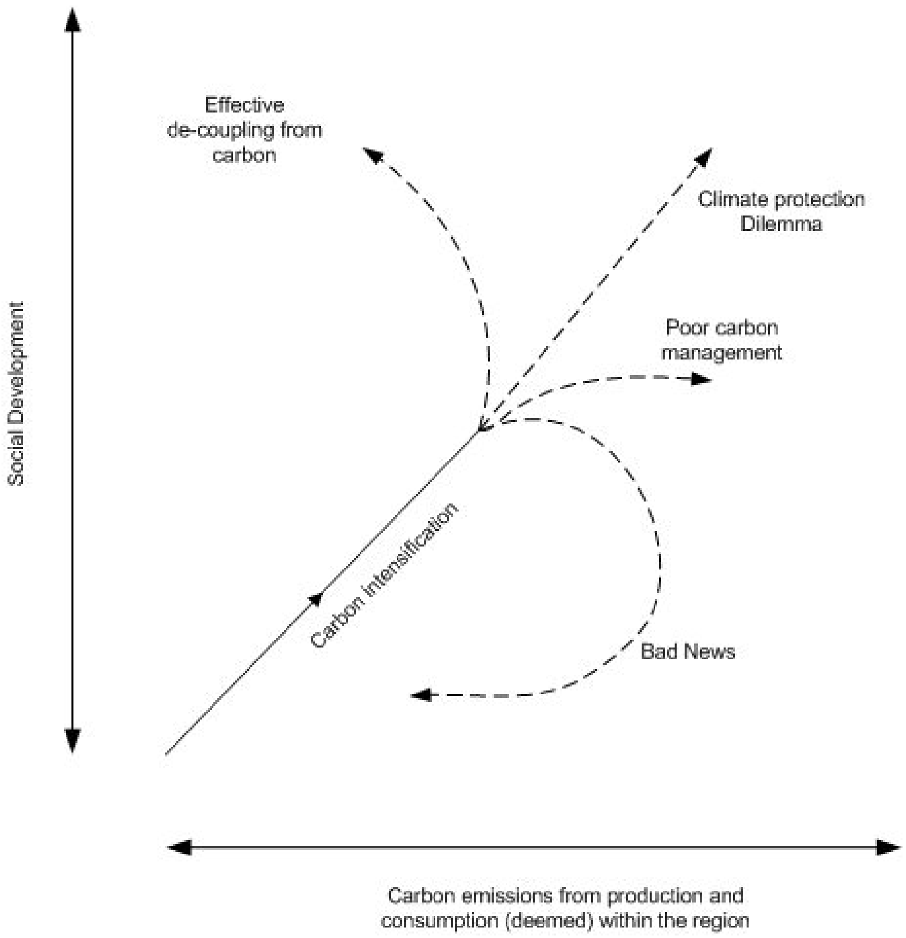
The upshot of social justice perspective on interventions to manage carbon is that sometimes those strategies which would do most to alleviate congestion or improve air quality most in the central business district are not the actions that should be taken first. The issue may rather be one of making polluters pay for better air, ensuring there is low cost housing in health environments not too far from where people can find work. The win-win is that getting it right means that low cost non-motorized transport can also be safe and convenient, and mass transit accessible when the former is not an option.

3.4 Prospects

Decoupling

Ultimately the goal should be to decouple growth in carbon emissions from continued improvements in social development (Figure 1). The dilemma is that with current styles of urban growth and development these are often highly correlated. As shown in the diagram, increasing intensification with declines in social development would be bad and rather than continue likely lead to a breakdown scenario and lower emissions.

Figure 1: Different pathways for de-coupling carbon emissions from social development.



Strategies

The specific strategies available and contemplated by different national, regional and city administrations and publics vary hugely. Several patterns that herald promise and concern were identified in the various case studies. We illustrate with two that are less frequently addressed in urban studies.

First, attention given to renewable energy sources is surprisingly low. A discourse of their "unrealism" with respect to renewables that is more extreme than is warranted appears to have taken hold and be widely accepted. Bio-fuels and solar energy have not been given much space or incentive to develop, nor has much thought been given about how to encourage cities to become "renewable – energy" friendly rather than bemoan that current forms and the lifestyles they engender are hard to serve with such sources. We provocatively suggest that: *Energy is too important to be left to monolithic state or private agencies. Consumers will make progressive choices, if they have one.* Much more thought needs to be given to the contribution of renewable energy in power supply through off-grid and independent production, especially in new estates and satellite towns. Urbanization also creates opportunities to capture energy from waste incinerators, air-conditioners and other industrial processes that generate heat. Progressive taxes on luxury c-intensive products and services into air quality management fund. Technology transfers from CO_2 polluters to developing countries in ways which don't crush domestic research and development are central (Forsyth 1999).

Second, there is a presumption that urban vegetation is important for quality of life, even climate control, but that its' contribution to carbon sequestration itself is irrelevant. Directly speaking this has to be true given relative areas of such spaces, but indirectly g*reen-spaces provide multiple benefits not least of which are impacts on values and attitudes with respect to nature.* Enhance carbon stocks green spaces in and around urban areas with large long-life trees that also provide climate control, protection of non-motorized corridors and quality recreation areas. Improve sense of place and indirectly strengthen inter-city competitiveness through attention to quality of life issues for residents. On the other hand, it may be that because people see lots of green they are "comforted" into inaction on their less visible embedded emissions. Actually, we don't know that much about how environmental values are shaped and changed in Asian cities, and how these in turn translate into practices.

More obvious, but nevertheless important strategies mentioned elsewhere include: designing mobility systems to help shape rather than be shaped by urban form; creating secure nodes and corridors for non-motorized transport with good links to public transport infrastructure; recycling and capturing waste heat energy; decentralizing key education, market and other frequently used services so are most easily accessed by non-motorized or mass transport systems; progressive taxes on luxury c-intensive products and services and feeding these back into air quality improvement programs; making use of information technologies to reduce inefficiencies in transport logistics and non-commuting employment; subsidized transfer of technologies.

The abovementioned strategies taken in isolation are unlikely to lead to lower carbon intensities because of compensatory responses. For example, need to consider how firms and households spend money saved by energy efficiency measures. Even a bid to address air quality problems may not yield net climate protection benefits. A de-carbonization pathway might begin with a walk to a public transport through a landscape of green-spaces and compact living quarters. Coordination among agencies to create and foster such land-use patterns is critical.

We take the threats of disruption of the climate system from greenhouse gas emissions seriously, recognizing the high levels of dependence and vulnerability of the people of Asia to climate change. We also acknowledge that the primary blame for the elevated CO_2 in the Earth's atmosphere lies, especially in cumulative per capita terms, with a minority of wealthy households and firms, mostly in the fully or post- industrial economies. They have already used up their fair share of emissions. Developing countries and the poor, on the other hand, need energy to develop the material basis of well-being.

Politically, and realistically, however, a lack of military and economic might means that most of the countries of Asia, with perhaps the exception of the giants, India and China, are not going to have much influence on practices in other locations through means other than that achieved through discursive processes with their citizens. The influence of such transnational mechanisms (Dryzek 1999) with respect to carbon management, however, should not be under-estimated (Betsil & Bulkeley 2004). Key to this is the building of alliances not only among countries, but also between and among cities and urban centers not only within countries, but also across countries within regions and around the world (e.g. Betsil 2001; Betsil & Bulkeley 2004). The goal here is to build an informed carbon constituency that involves cities and urbanizing regions. However, in all of these Tracks, the key element will always be correct information translated in forms that could be understood and appreciated.

Cities, while not necessarily capturing the totality of representation for a state or society's identity, remain not only as seats of political and economic power, but also as windows to regional and international alliances. The key question that is how cities and countries can position themselves, and what tools are available at their disposal, to bargain for investments and privileges that would be beneficial not only in carbon terms, but in the pursuance of social justice.

Although it would be politically poor strategy to admit it, the weaker developing countries are well aware that one of the most compelling reasons to contemplate carbon management for cities and urbanizing regions is that one day they could be forced to, either by international emission agreements or high costs of key fossil fuels.

3.5 Synthesis

At the beginning of this paper we posed three questions that arise from adopting a carbon's eye view of urbanization in regional development. The varied and nuanced responses to these in each of the case studies provide some insights about where social mobilization and enlightened policy-making for such transformation may come from. Here we synthesize our responses to each in turn.

First, the 5 case studies illustrate development pathways that look relatively similar to those in advanced industrialized countries from the point of energy consumption and carbon emissions. There has been little success with integrating such growth and land-use changes with transport services. On the other hand, taking into account differences in overall wealth and resources of the states in which they sit, the cities and towns of Asia often make very effective use of space with urban agricultural activities, seasonal livelihood activities, and a thriving informal sector and modest built infrastructure. Understanding pathways and processes in smaller and intermediate size cities is crucial because most of the urbanization to come will occur in places like these.

Second, carbon management through influencing process of urban transformation and urbanization has rarely even been considered in national initiatives aimed at the reduction of greenhouse gas emissions (which of themselves are low or at most modest priorities). Specific targets are not deliberated and have not been set. General awareness of greenhouse gas issues remains low and even of more immediate urban air quality and health, modest. Congestion, air pollution and energy efficiency concerns, however, all have potential for significant emission reduction benefits.

Third, issues of social justice beyond the basic level of responsibilities nations states, and their subdivision into Annexe 1 and 2 countries, have not been well addressed in discussions and actions to manage carbon. Who should pay? Are the poor disadvantaged most by changes to taxation, energy price hikes, and so on. A lot of care is required in policy-making to ensure that the burden of "sacrifice" falls on those already consuming too much rather than those who really need to increase their level of emissions.

Urbanization is a key collection of processes driving local and regional environmental changes. In the future these will intersect with, and be confounded by, global environmental changes. Our understanding of these cross-scale issues is modest. There is also an urgent need to integrate understanding of cultural, behavioral and institutional issues with the existing emphasis on inventorying greenhouse gases and other atmospheric pollutants. Studies of households and communities that voluntarily shift to low-carbon lifestyles are needed. We also do not know nearly enough about rural-urban linkages and the shape of these transitions and boundaries on urban form, function and energy and material use. The critical matched comparisons between equivalent groups in urbanized and non-urbanized settings have not really been made and need to be. Finally, the issue of re-location and inter-city interactions through production-consumption relations must be addressed otherwise we risk de-carbonizing development in Tokyo at the expense of Jakarta.

To address these and related questions studies are needed not only of mega-cities in newly industrializing countries but also in the huge number of newly emerging urban areas around the globe. The greatest level of scrutiny however needs to be reserved for analyzing the lifestyles and practices in the bastions of over-consumption in the industrial and post-industrial over-developed economies. Researcher from developing countries need to be part of these endeavors and bring their insights about achieving high qualities of life and well-being at lower material levels of consumption to bear.

The initial findings from our five case studies in Asia confirm that the urbanization process should be central to efforts at integrating carbon management into regional development strategies. They also, however, highlight the need for more experimental and radical interventions through fostering new urban forms and functions that will have impacts that go well beyond current tinkering with efficiencies and emissions and start to decouple social development gains from rising emissions.

4.0 Conclusions

Overall, the project made significant progress against each of three main initial objectives: to establish a network, develop a protocol, and provide guidance to a longer-term research programme.

First, through the collaboration fostered by this project a new network of research groups focused on urbanizing regions and cities was created. As the activity proceeded the group adopted the label U-TURN or Urban Transformation and Urbanizing Regions Network, sometimes suffixed with “-Asia” to encourage thinking there may be other regional networks in the future as part of a more global initiative. The group successfully applied for joint funding for a second collaboration dealing with non-carbon emissions important for human health in the same cities, and associated study of how scientific research is being used (or not used) in urban air quality management. This latter activity was an explicit attempt to better bridge some of the science –policy gaps with respect to emissions management.

Second, a protocol for the conduct of comparative studies of cities and urbanizing regions was developed, explored and revised through its application in 5 cities with different constraints of data, prior research histories and political systems. This technical report is a reflection of these experiences with the evolving protocol. The first version turned out to unrealistically ambitious and vague, but subsequent versions were a much better guide to work. Overall, we think the protocol development exercise which was a key goal of this project should be considered a mixed success. On the one hand, we know have better research questions and understand the assumptions and data constraints for studies of city regions much better, and the implications this has for carrying out individual let alone detailed comparative studies. On the other hand, the findings about carbon management and development change that emerge from our modest case study work are preliminary with most insights confined to individual cases rather than emerging from cross-comparisons using the framework. It is only through combining our modest case study work here with the wider literature that more interesting patterns emerge. A much larger-scale initiative would be needed to pursue most of the comparative questions with rigor.

Third, this technical report is a direct reflection of the new understanding and insights about how urbanization and urban transformation affect carbon stocks and fluxes. We have gone beyond “synthesizing” work of others and generated some new insights that deserve greater exploration, for example, how livelihoods transform, and the suggested links between urban form, function and lifestyles. The technical report as it stands, however, is not yet a major contribution to the “state-of-the-knowledge”.

5.0 Future Directions

There are several initiatives underway by U-TURN network to continue aspects of the work that started through the collaboration stimulated by this APN funded project.

First, we are preparing a synthesis paper about our initial findings using this protocol for publication in the peer-reviewed literature. This technical report includes some examples of the findings and work that this paper will build on. A condensed version of the full paper will be the subject of an invited editorial in the journal Global Environmental Change at the end of 2005.

Second, we have put in substantial effort, not yet fully successful at creating a more international rather than regional network of urban researchers. A similar network in Latin America has begun cooperating in meetings and preparing joint funding proposals as a result of initial sponsorship from IAI based on, in part, interactions with U-TURN.

Third, the Global Carbon Project has continued to articulate and promote research on the cities in regions perspective on carbon stocks and fluxes, and this should help bring the various groups in North America and Europe closer to each other and those in the developing regions.

Fourth, this project raised many technical issues related to the data requirements and assumptions behind emission inventories at sub-national scales. It also re-opened other accounting challenges related to direct and indirect or deemed emissions. Rather than arguing that there is one correct answer, it is clear from the work in this report that calculating things in different ways reveals a lot about how development affects carbon stocks and fluxes. There is clearly much more work needed on how to make better use of alternative calculations in carbon-oriented studies not least of which is for identifying points of leverage in reducing emissions.

Finally, this project raises the exciting prospect of future integrating studies focused on cities and urbanizing regions that not only looks from a carbon perspective, but simultaneously considers water and the impacts of food production and distribution on ecosystems. Integrated place-based research with a global environmental change slant has largely taken place in less human-modified environments or in agricultural systems. The social and biophysical processes in cities and urbanizing regions are distinct and deserve much greater scrutiny by global environmental change research community.

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7.0 Appendix 1: Workshops

7.1) Initial planning workshop, 25-27 September 2003, Manila, The Philippines

The purpose of the initial planning meeting was to 1) draft a protocol, or guide, for the conduct of the individual case studies; 2) draft a realistic work plan for activities and synthesis products (ie initial papers) that are achievable within the 2 year scope of this initial APN activity; 3) draw an initial draft set of recommendations, or framework, for how to link the APN-supported case studies with other initiatives into a global network; 4) draft a plan of action, and providing mutual support, to leverage additional funding and other resources to support research in individual case studies within the region.

List of participants

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7.2) Initial International Workshop for the IAI Project: “Can Cities Reduce Global Warming? Urban development and the carbon cycle in Latin America”: Mai 27-29, 2004 Metropolitan Autonomous University –Xochimilco, Mexico City, Mexico

Goals and Objectives of the Workshop; This workshop intended to contribute to referred project objectives and to:

- Establish a well-coordinated network of case studies
- Promote the discussion on the role of cities in global carbon emissions (GCE)
- Develop common and comparable methodologies
- Provide a platform for collaborative planning, research and synthesis
- Enhance communication with policy makers
- Produce peer-reviewed publications

The first component of the workshop included presentations of research projects on empirical findings, modeling tools and policy programs in the following topics:

1) Current trends and scenarios of energy and land use in selected cities. Inventories, carbon emissions from key sectors and processes (e.g. transportation, land use change, industry, waste generation)

2) Main drivers of urban development: economic and demographic dynamics, institutional settings. The role of “local regimes” - current and possible management strategies

3) Flow accounting analysis, factor decomposition approach, cost-benefit analysis.

During the second component of the workshop, the following tasks were undertaken;

- Draft a protocol for individual and/or comparative case studies
- Establish an activities’ agenda for products achievable within 1 year
- Design a strategic framework for linking the IAI-supported case studies with the Global Carbon Project, the urbanization project of IHDP, and START’s and NCAR’s projects on Urbanization, Emissions and the Carbon Cycle
- Discuss a plan of action aimed at obtaining additional funding from national and international organizations.

Participants and institutions

Participants and institutions	Contribution in the areas of
Enrique Puliafito University of Mendoza, Argentina	Emissions inventories, spatial and temporal modeling of cities' emissions
Shinji Kaneko, Hiroshima University, Shobhakar Dhakal Institute for Global Environmental Strategies, Japan[1]	Assessment of CO2 Emissions and their drivers in selected Asian Cities
Eduardo Behrentz UCLA, US	Greenhouse gas emissions from mobile Sources in Bogota
Sergio Pacca Berkeley, US	Sustainable electricity generation in Latin American cities
Mauricio Osses, Riverside, US and U of Chile (IAI project)	Inventories of Transport Emissions in South American Mega cities
Alejandro León, U of Chile	Socioeconomic and institutional drivers, management options for reducing global warming
Patricia Romero Lankao UAM-X, México	Socioeconomic and institutional drivers, management options for reducing global warming
Claudia Holgate, Monash University, South Africa	Institutions and information flows in South African Government
Pep Canadell Global Carbon Project (GCP), Australia	Urban development and management strategies, two key themes of GCP
IHDP Germany	Urban development within IHDP
Drinya Totrakool USER, Thailand	Carbon Management and development strategies in Asian cities
Adrián Fernández and Julia Martínez National Institute of Ecology, Mexico	Management of carbon emissions in Mexico
Oscar Vázquez Government of the Federal District, Mexico	Inventory of Emissions in Mexico City Strategic Climatic Action in the Federal District
Jorge Escandón Government of the Federal District, Mexico	Greenhouse gas emissions from land use change in Mexico City
Mónica Conte Grand, Argentina	Assessment of local benefits by management of GHG
Angélica Rosas Huerta, Miriam Rodríguez Armenta, Hugo Villafranco and Graciela Ghünther, Research Assistants, UAM-X, México	

7.3) Web based conference, 7 June-17 July 2004

We conducted an electronic (web) conference on “Integrating Carbon Management into the Development Strategies of Cities” on 7 June 2004 – 17 July 2004. The objective of the e-conference was to contribute to the ongoing dialogue among urban researchers, policy makers, and the general public worldwide on the relations of regional pathways, especially urbanization and urban transformations, and the global carbon cycles. There were 157 registered participants, 22 backgrounds materials submitted, and 45 posted messages. The conference lasted for 40 days. The proceedings of the conference can be accessed at http://www.sea-user.org/e_background.php?conf_id=3

Preliminary case study reports of city regions of Jakarta, Metro Manila, Chiang Mai, New Delhi and Ho Chi Minh City were submitted. These reports were posted in the e-conference as background materials. They can also be accessed at USER's working area under Urbanization, Emissions and Carbon (U-TURN) Project (http://www.sea-user.org/wproject.php)

Agenda

Week Theme	Guiding Questions	Agenda Duration
Regional Development Pathways	• What have been the main pathways and processes by which urbanization has unfolded around the world? • What are the likely consequences of these different pathways and processes for carbon stocks and fluxes? Are some less carbon-intensive than others? • What have been the main clusters of factors driving these changes and are these likely to continue into the future?	June 7, 2004 - June 20, 2004
Decarbonization	• What are prospects of accelerating decarbonization through explicitly incorporating carbon management into development strategies, planning and governance of cities and urbanizing regions? • How can the social context of cities that encourages innovation, exploration and exchanges of ideas be harnessed for better carbon outcomes? • What are the main institutional, cultural and social justice considerations that should be taken into account in national, regional or international efforts at decarbonization?	June 21, 2004 - July 4, 2004
Synthesis	• Are certain patterns of urbanization and urban transformation less carbon intensive than others? • Which policies, behavioural changes and institutional mechanisms appear most promising for bring about decarbonization of development and what is the role of urbanisation in these? • What are the main opportunities, limitations and risks of explicitly incorporating carbon management considerations into the development strategies of cities and urbanizing regions? • What are the three highest priorities for future research in the area of urbanization and carbon emissions?	July 5, 2004 - July 10, 2004

7.4) Synthesis workshop, 6-8 January 2005, Chiang Mai, Thailand

This meeting was a combined event for two separately funded projects of the Urban Transformation and Urbanisation Research Network (U-TURN).

The first workshop (6-7 January) was dedicated to synthesising the outcomes of our APN funded project on Integrating Carbon Management into the Development Strategies of Cities.

The second workshop (8 January) was a technical planning meeting where we discussed the design of the next funded activity of the U-TURN which is "Influence of Biomass Burning, Biogenic and Anthropogenic Emissions on Urban Air Quality in South and East Asia: A Two Part Comparative Study of Five City Regions."

Meeting Agenda

6 January 05	1) Introduction to workshop 2) Integrating carbon management into the development strategies of cities: a brief review of the history of U-TURN project, the research protocol and the goals for the workshop 3) Draft synthesis 4) Overview of the main arguments and conclusions in the first draft of the synthesis papers 5) Synthesis discussion 6) Updates on the U-TURN case studies (Part 1) • Manila case study (R.D. Lasco, F.B Pulhin and M.R.N.Banaticla) • Ho Chi Minh City case study (Pham Thi An Chau) • Jakarta case study (Agus Pratama Sari, Nasrullah Salim) 7) Discussion on Urban Pathways-Analysis was carried out in two parallel working groups addressing the same set of questions. • What have been the main pathways and processes by which urbanization has unfolded? • What are the likely consequences of these different pathways and processes for carbon stocks and fluxes? Are some less carbon-intensive than others? • What have been the main clusters of factors driving these changes and are these likely to continue into the future? 8) Updates on the U-TURN case studies (Part 2) • Delhi case study (A.P. Mitra, Chhemendra Sharma) • Chiang Mai case study (Louis Lebel, Darika Huaisai, Po Garden, Drinya Totrakool and Jesse Manuta)
7 January 05	1) Presentations; • Energy use and emissions in Asian Mega-cities (Shabokhar Dakal) • Industrial re-location in Asia (Xuemei Bai) • Urban forms (Danai Thaitakoo) • Carbon accounting: stock and operating emissions (Richard Rockwell) 2) Discussion on Decarbonization Analysis was carried out in two facilitated working groups • What are prospects of accelerating decarbonization through explicitly incorporating carbon management into development strategies, planning and governance of cities and urbanizing regions? • How can the social context of cities that encourages innovation, exploration and exchanges of ideas be harnessed for better carbon outcomes? • What are the main institutional, cultural and social justice considerations that should be taken into account in national, regional or international efforts at decarbonization? 3) Synthesis Reflections Reflections on implications of workshop presentations and discussions for synthesis

8 January 05	1) A brief summary of the SARCS proposal on emissions and urban air quality for the second part of this workshop 2) Discussion around the proposal presentation and a set of key questions raised during the presentation and expanded in discussions. 3) presentations on Urban emission inventories and air quality models • Air quality modelling in Chiang Mai City (Kanyawat Sriyaraj) • Report on the SARCS training workshop on emission inventories and regional air quality modelling (Darika Huaisai, Pham Thi An Chau) • Use of models in policy (Po Garden, Drinya Totrakool) 4) Study design Analysis was carried out in three small working groups focussing on emission inventories, modelling and knowledge-to-action links. The goal of each working group was to draft a short protocol to be followed in each case studies and make a few key recommendations on how this should be carried out. 5) Proposed Designs and Work Plans • Short reports from each of the working groups. • Drafting of and agreement to an initial work plan.

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8.0 Appendix 2: Funding sources outside the APN

A list of agencies, institutions, organizations (governmental, inter-governmental and/or non-governmental), that provided any in-kind support or co-funding for the project and the amount(s) awarded.

Global Carbon Project Office (Canberra, Australia) supported airfares for a Latin American researcher Dr. Enrique Puliafito in first planning meeting of the APN project in Manila (September 2003) to foster cross-linkages between Asian and Latin American urban carbon networks. They also supported airfares for participation of an Asian representative in the corresponding IAI workshop in Mexico City (May 2004).

Each of the individual case studies was able to build their work for this project upon existing and externally funded projects as well as significant in-kind contributions from the researchers organizations. Putting numerical values on this is difficult but in total these contributions were significant. One clear exception is the awarding of 2 small grants from the Taiwan government to the U-TURN network for additional work linking carbon emissions to air quality issues that can reasonably attributed to this project (Total value = 41,700 USD)

9.0 Appendix 3: Case Study Working Paper – Manila

INTEGRATING CARBON MANAGEMENT IN THE DEVELOPMENT OF METRO MANILA-LAGUNA LAKE BASIN, PHILIPPINES

By R.D. Lasco, F.B. Pulhin, and M. R.N. Banaticla

9.1 SUMMARY

Although cities only occupy a small part of the earth's surface they play large and growing role in driving changes to the carbon cycle. The way cities are designed and managed over the next several decades will have a large influence on the future of the carbon cycle.

This study with support from the Asia Pacific Network (APN) is part of a number of regional case studies (Thailand, Indonesia, India, Philippines) that seek to explore ways by which urban development could be directed toward less carbon intensive pathways. For the Philippine case, Metro Manila together with the adjacent Laguna Lake Basin was selected as the study area because of its national importance and large amount of carbon emissions.

The main objectives of the study were to: (a) explore ways by which carbon management can be integrated into development strategies for MM-LLB (b) determine the drivers of carbon emissions in the study area, (c) identify less carbon intensive development pathways for MM-LLB and analyze institutional mechanisms to make carbon management a regular part of the planning process for MM-LLB.

The framework of the study recognizes that there are direct and indirect drivers of carbon emissions. A direct driver can be defined as one that "*unequivocally influences ecosystem processes and therefore can be identified and measured to differing degrees of accuracy*" (WRI, 2003). In contrast, indirect drivers operate more diffusely, from a distance, often by altering one or more direct drivers. In the context of this study, direct or proximate drivers are equated with the IPCC sectors (energy, waste, industry and use of solvents, agriculture and land use change and forestry or LUCF). These are driven by indirect or primary drivers like population, technology, policies, economy and institutions.

The study focuses on two areas in the Philippines: Metro Manila (MM), the country's prime financial, commercial, social, cultural, and educational center and seat of national government, and the adjoining Laguna Lake Basin (LLB), an ecologically important watershed which has directly received the spillover effects of industrialization- and urbanization of Metro Manila.

Recent analysis under a previous APN study (Ajero, 2002) showed that Metro Manila increased GHG emissions from non-LUCF sources from 10,100 Gg CO_2-e (or k ton CO_2-e) in 1980 to 25,100 Gg CO_2-e in 2000. The importance of Metro Manila as a source of carbon emissions is evident in the fact that it contributes 27-63% of total Philippine GHG emissions from energy, transportation and waste (an average of 50% across all sectors). The development path of the metropolis was supported by large emissions of carbon. Recent years saw increasing energy consumption from mainly commercial activities, and overwhelming increase in transport activity from population increase, residential decentralization and manufacturing deconcentration as the important determinants of future carbon emissions. Our Millennium Ecosystems Study showed that net GHG emissions from agriculture and LUCF sectors in the adjacent Laguna Lake Basin amounted to 1,299 and 924 k ton CO_2-e, respectively in the year 2000. Unlike Metro Manila which has been completely urbanized since the 1970's and is supported by a manufacturing base, the LLB can be characterized as having a significant agricultural sector. However, rapid urbanization, especially in the areas adjacent to Metro Manila, is seen as a major factor that drives the path towards increased GHG emissions in the basin. The combined GHG emissions from MM-LLB in the year 2000 amounted to 27,343 k ton CO_2-e. This value gives an idea of the

total emissions of Metro Manila and the Laguna Lake Basin. This could be a fair estimate considering that MM has hardly any forest cover and land cover change emissions while the rest of LLB has much fewer industrial activity. Those portions of LLB with highest industrial activity are within MM. The only exception to this is the export processing zones in the Laguna province, which may be emitting substantial amounts of carbon.

The country has made advances in its efforts to meet its commitments to the UNFCCC by formulating and integrating GHG mitigation strategies into the concerned sectoral plans of the government. For MM-LLB, our view is that the path towards a less carbon-intensive development relies on the successful implementation of these existing national sectoral plans, most important of which are policy and structural reforms in the energy sector. Opportunities to address GHG emissions at the local scale are implicitly included in programs addressing the perceived immediate- and more pressing problems of urban development, such as traffic congestion, solid waste management and air pollution. Economic and political realities in the Philippines dictate that stand -alone programs to reduce GHG emissions may be less politically and socially feasible than those which can be coupled with other development goals. A basic impediment to the formulation and eventual implementation of policies is the scarcity of available information that will facilitate reliable monitoring of GHG emissions from the different sectors/sources. Raising awareness and building the capacity of stakeholders and policymakers are also crucial as the problem of GHG emissions is of a different nature from that of local air pollution, and as such may require solutions that may be in conflict with measures to control the latter. In connection to this, the policy of devolving functions to local governments also presents a potential source of problems if local officials are not adequately prepared.

9.2 INTRODUCTION

Climate change, more popularly known as global warming, is one of the most critical concerns of humanity today.

In the last 200 years, humans have made enormous progress in harnessing natural resources to support an ever-increasing level of consumption. The use of fossil fuels has largely driven this quest for industrial development. A deadly by-product of this development path is the rise in the concentration of so-called greenhouse gasses (GHG), which could lead to a change in the world’s climate. The 2001 IPCC Third Assessment Report (TAR) concludes that there is strong evidence that human activities have already affected the world’s climate.

The impacts of climate change could be disastrous to natural systems and human communities around the world. A warmer world could lead to extinction of certain plant and animal species, the spread of diseases, displacement of people in coastal areas as sea level rises, to cite a few. Developing countries with long coastal areas like the Philippines may be more vulnerable as they lack resources to adequately cope with these impacts.

Among GHGs, carbon dioxide (CO_2) is the most important being responsible for more than half of the radiative forcing associated with GHGs. Thus, there is considerable interest on the role of terrestrial ecosystems in the global carbon cycle.

Although cities only occupy a small part of the earth’s surface they play a large and growing role in driving changes to the carbon cycle. For example, Metro Manila covers approximately 0.21% of the total land area of the Philippines but is responsible for about 50% of the total reported GHG emissions from the Philippines in 1994-1995. The way cities are designed and managed over the next several decades will have a large influence on the future of the carbon cycle. On the one hand, well-designed cities provide many technical opportunities to reduce per-capita carbon emissions. On the other hand, cultural and life-style changes associated with urbanization tend to increase net levels of consumption, fossil fuel use, water use and waste production

This study with support from the Asia Pacific Network (APN) is part of a number of regional case studies (Thailand, Indonesia, India, Philippines) that seek to explore ways by which urban development could be directed toward less carbon intensive pathways. For the Philippine case, Metro Manila together with the adjacent Laguna Lake Basin was selected as the study area because of its national importance and large amount of carbon emissions.

9.3 METHODS

Objectives

The main objectives of the study were to:

- Explore ways by which carbon management can be integrated into development strategies for MM-LLB
- Determine the drivers of carbon emissions in the study area
- Identify less carbon intensive development pathways for MM-LLB
- Analyze institutional mechanisms to make carbon management a regular part of the planning process for MM-LLB.

The study was guided by the common key research questions for all case studies as listed in Table 1.

Definition of Case Study

Recognizing the economic influence and ecological footprints of cities, the case studies look at an urban region comprising the main city and its surroundings. For the Philippines, the focus was on Metro Manila and the Laguna Lake Basin. Pragmatic considerations of data availability by both administrative/political boundaries and present carbon outcomes accounting, however, may determine the actual spatial extent of the case study.

The study focused on the datasets from 1980, 1990 and 2000 (or similar time range). For scenario analysis, 2020 and 2050 time horizon was used. Historical records were also used in the case study narratives.

Data Sources and Analysis

The data and information for the study were primarily taken from secondary data which included, among others, published papers, reports, and government data. The selected "core" case studies were supplemented and complemented with published cases, as well as on-going studies and some unpublished studies in the region.

Major Activities

On the basis of the analysis to be conducted as indicated in Tables 4 and 5, the following were the major activities of the project:

a) Review of relevant literature

Published literature was accessed from the libraries and reading rooms in UPLB and colleges/universities in Metro Manila. In addition, "gray literature" such as project reports and consultant's reports from various government agencies such as the MMDA, DENR, NEDA, and the LLDA were reviewed.

b) Analysis of secondary data

Data collected were analyzed in terms of "pathways" and "decarbonisation" as contained in Tables 4 and 5.

c) Consultation workshops

A launching workshop was organized in April 2004 to introduce the Project to key stakeholders, provide a forum for building linkages between local development planners and agencies and organizations involved in climate change issues, and solicit expert opinion on ways to meet the project objectives.

Table 1: Research themes and questions

Theme	Research Questions
[1] Pathways	1) What are the consequences of different pathways of regional development, especially urbanization and urban transformation, on carbon stocks and fluxes? Are certain patterns of urbanization and urban transformation less carbon intensive than others? 2) How and why different pathways arise? What are the historical underpinnings of the different pathways of regional development? What were the important historical drivers of regional development path? 3) What drive these different pathways at present? What is the role of internal (e.g., local politics) and external (e.g., development agenda) influences?
[2] De-carbonisation	1) What future urban forms, governance, institutional and cultural arrangements might be effective in facilitating the integration of carbon management as an explicit goal in regional development? 2) What are some of the most important technological options (e.g. change, innovations, among others) that could influence carbon emissions, sequestrations and storage? What are the opportunities and constrains of adopting these options as part of regional development carbon management strategies? 3) How could the de-carbonization agenda become an integral component of regional development strategies? Where do changes come from? What kind of instruments are needed? Who needs to be involved? What are the trade-offs of adopting these strategies?

9.4 PATHWAYS – Metro Manila

Biophysical Environment

Metro Manila is the smallest of the 16 administrative regions of the Philippines in terms of land area, but is the prime financial, commercial, social, cultural, and educational center of the Philippines and the seat of the national government. Its natural strategic location makes it the premier gateway to the Philippines (Figure 1). Geographically, the region lies along the flat alluvial and deltaic lands surrounding the mouth of the Pasig River and extends to higher rugged land surrounding Marikina Valley in the east. It is bounded by Manila Bay in the west, the Sierra Madre mountains in the east, the plains of Central Luzon in the north and Laguna de Bay in the south (NSCB, 1999). The region presently covers a total land area of 636 square kilometers (sq.km.) and is geo-politically defined by thirteen cities and four municipalities (Table 2) (MMDA, 2001).

Table 2: The cities and municipalities of Metro Manila and their land areas

City/Municipality	Land Area (sq. km.)	Percent Share
Metro Manila	636.0	100.0
First District	38.3	6.02
City of Manila	38.3	6.02
Second District	254.5	40.02
Mandaluyong City	26.0	4.09
Marikina City	38.9	6.12
Pasig City	13.0	2.04
Quezon City	166.2	26.13
San Juan	10.4	1.64
Third District	128.8	20.25
Caloocan City	55.8	8.77
City of Malabon	23.4	3.68
Navotas	2.6	0.41
Valenzuela City	47.0	7.39
Fourth District	214.4	33.71
Las Piñas City	41.5	6.53
Makati City	29.9	4.70
Muntinlupa City	46.7	7.34
Parañaque City	38.3	6.02
Pasay City	13.9	2.19
Pateros	10.4	1.64
Taguig	33.7	5.30

Source: NSCB, 1999

Figure 1: Location Map of Metro Manila

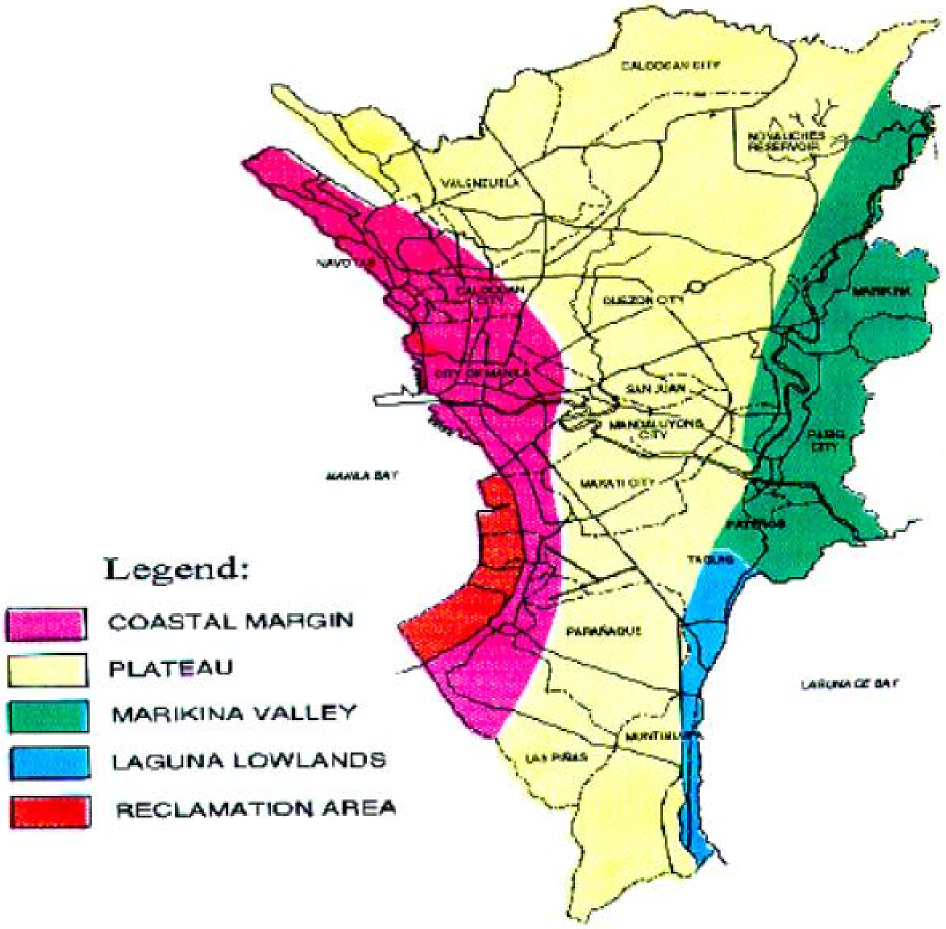
Metro Manila has two pronounced seasons: dry from January to May, with April and May as hottest months, and rainy for the rest of the year (NSCB, 1999). Annual rainfall is around 2,000 mm. The temperature varies from 25°C in January to about 30°C in May. The average annual temperature is 27°C (MMUTIS, 1996).

Metro Manila can be divided into six major geographic zones (Figure 2), namely: a) Manila Bay; b) the Coastal Margin; c) the Guadalupe Plateau; d) the Marikina Valley; e) the Laguna Lowlands, and f) Laguna de Bay (MMDA, 1996).

The Guadalupe Plateau is considered most suitable for urban development because of its elevation and solid geological foundation and is actually where the major block of Metro Manila is situated (MMDA, 1996). The Coastal Margin is located along Manila Bay and has resources for offshore fisheries and fishpond development, with the reclaimed portion of the coast is intended for mixed used urban development (Manasan and Mercado, 1999).

The Marikina Valley has fertile land suitable for crop cultivation and good groundwater supply, while the Marikina River is utilized for industrial uses and discharge. The low elevation of the Valley makes several areas prone to flooding during the rainy season (MMDA, 1996). The Laguna Lowlands has a fertile but less expansive area that is suitable for agri- and aqua-culture and industrial activities (Manasan and Mercado, 1999).

Figure 2: Major geographic zones of Metro Manila (source: MMDA, 1996)

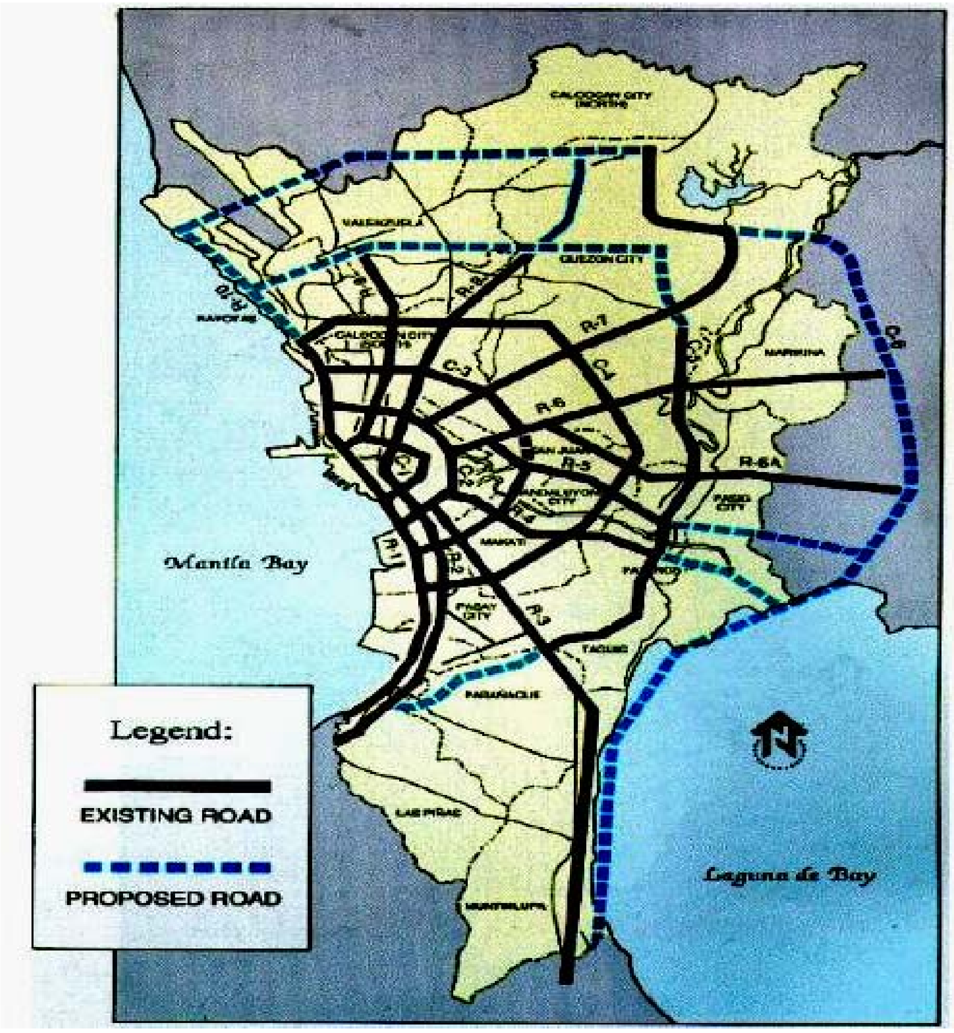


In early planning efforts, Metro Manila has been geographically subdivided into inner-, intermediate- and outer cores based primarily on circumferential road boundaries (Figure 3). As cited in the Physical Framework Plan of Metro Manila 1996-2016 (MMDA, 1996) the inner core of the region was identified as the zone composed of Manila, Pasay, Caloocan, Makati, Mandaluyong and San Juan. This core was also cited in previous plans as the area bounded by Circumferential Road 4 (C-4) or Epifanio delos Santos Avenue (EDSA) and characterized by high intensity development, incompatible land uses and complex socioeconomic problems.

The intermediate core or the zone between C-4 and the proposed C-6 consists of Pasig, Muntinlupa, Valenzuela, Las Piñas, Parañaque, Taguig, Pateros and Marikina and is identified as the transition zone from the inner core to less urbanized areas. Its main features were uniform density residential development and ongoing conversion of agricultural and open spaces to other land uses (MMDA, 1996). This intermediate core formed the suburbs in the 1980’s but has become part of the inner core of an extended metropolitan region by the late 1990’s because of rapid urbanization, as indicated by tremendous increase in traffic volume in EDSA, South Super Highway, and other radial corridors outside EDSA (Reyes, 1998).

The outer core is composed of municipalities beyond the intermediate core and at the outer boundaries of the metropolis. The area outside the proposed C-6 is characterized by “industrial activity and directionless sprawl of communities and agricultural areas” (MMDA, 1996). The outer core include the provinces of Rizal, Cavite, Laguna and Bulacan, which are outside the legal boundaries of the region but are included as part of the regional planning of Metro Manila.

Figure 3: Road network of Metro Manila (source: MMDA, 1996)



A Metropolitan Manila Growth Network has also been identified, which includes the industrial areas of adjacent regions, namely CALABARZON (Cavite-Laguna-Batangas-Rizal-Quezon) and MARILAQUE (Manila-Rizal-Laguna-Quezon) in the Southern Tagalog Region, and the Subic and Clark Special Economic Zones in the Central Luzon Region.

Pre-colonial to Colonial Era[2]

The distribution of human settlements is neither random nor precisely patterned. Historically, people converge in locations that are favorable for making a living. Present-day Metro Manila traces its origins to a prosperous Malay settlement engaged in trading and agriculture, situated at the north of the Pasig River. This ancient settlement's name was *Maynilad*, derived from the name of the shrub *nilad*, which grew along the banks of the Pasig River (MMDA, 2001). The

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[2] Major portions of this section are based from the comprehensive treatment on the topic by Reyes (1998). Spatial structure of Metro Manila: genesis, growth and development.

ancient city has been engaged in trading with Indonesia, Malaysia, Borneo, China, Vietnam, and Kampuchea for 250 years before the Spaniards arrived (Manasan and Mercado, 1999). This settlement of small discrete villages situated along riverbanks and shores was the country's largest pre-colonial indigenous settlement, consisting of several *barangays*[3] with more than 2000 inhabitants, including 40 Chinese and 20 Japanese (Doeppers, 1972; as cited by Reyes, 1998).

The Spaniards discovered *Maynilad* about thirty years after Ferdinand Magellan landed on Cebu island and discovered the Philippines. Led by Marshal Martin de Goiti, the Spaniards conquered the native settlers headed by Rajah Sulayman; the following year, the Spanish *conquistador* Miguel Lopez de Legazpi arrived at the mouth of the Pasig River and claimed the islands in the name of the King of Spain. By virtue of its natural strategic advantages, Manila was declared the capital of the Philippine Archipelago on June 24, 1571 (MMDA, 2001). In the same year the seat of the Church and the Spanish colonial government was established at the walled city of Intramuros (NSCB, 1999).

Intramuros became an exclusive Spanish enclave from where missionaries and armies were sent to conquer the countryside. The rest of the population resided in ethnically segregated districts outside the walled city. The natives, or *Indios* as they were called, resided in the suburbs of what are now the districts of Tondo, Sta. Cruz, Quiapo and Sampaloc in the modern-day city of Manila, while Chinese immigrants were restricted to the district called *parian*, which is now part of Binondo (NSCB, 1999). As the colonial entrepot of Spain, Manila played a vital role in the Manila-Acapulco galleon trade and was characterized as a highly-centralized, urban-based processing and transportation hub of the country (Reyes, 1998).

During the initial stages of development, when a country is still predominantly rural and has a low level of urbanization, it is more economically efficient to concentrate all the investments in infrastructure and manufacturing facilities in one location (Renaud, 1981; as cited by United Nations, 1993). The development of a single city to "primate" status is virtually inevitable under such conditions, following the establishment and expansion of administrative services, industry, commercial and financial activities and transportation and communication networks. Primate cities then serve as the engine that drives the development process for a country in the early stages of modernization, the focal point that the nation could efficiently concentrate its resources and investment capital on to embark on the development process. (United Nations, 1993).

From the 1500's to 1700's, the urbanization and consequent physical expansion of the Spanish colonial capital were attributed to different factors. Once the core of the Spanish and *mestizo* aristocracies, Manila became a popular destination of poor migrants from the rural areas. Residential decentralization occurred as increasing density in the old urban core prompted old rich families to move to either the Makati or Quezon areas, and previously upper-class suburbs in Manila became the site of poor and lower and middle- class homes (Magno-Ballesteros, 2002) (Figure 4). Physically, the city consisted of an urban core where the homes of wage-earners, traders, and others involved in non-farm activities were concentrated, and rural settlements that were situated outside the urban core and developed more slowly. The countryside acted as supplier of agricultural surplus to the city, and *Indios* and Chinese merchants continued to live in districts outside Intramuros. Ethnic segregation and socio-economic clustering of urban and peri-urban population thus characterized the settlement pattern. Population explosion and increasing ethnic diversity led to the expansion of the city's functional territory, as Manila evolved into the first primate city in Southeast Asia – a prosperous, multi-functional and multi-racial capital city and the hub of regional maritime commerce and insular trade. As the Spanish residential pattern became decentralized, Manila became a dominant port capital surrounded by a mass of urban- and semi-urban settlements (Reyes, 1998).

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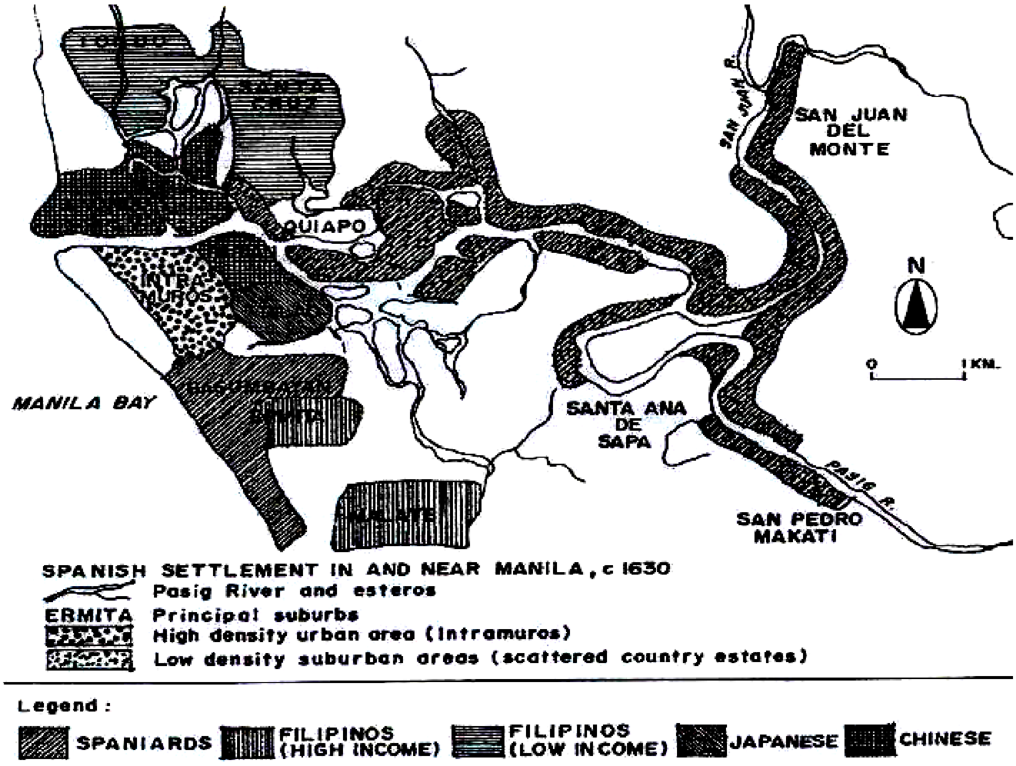
[3] A *barangay* is the smallest socio-political unit in the Philippines.

Figure 4: Map of the ancient city showing Intramuros and Old Manila, c.1630 (source: Reyes, 1998)



The 1790's saw the transition of the world economy from mercantilism to industrial capitalism and the transition of Manila from a colonial entrepot to a satellite economy. In the nascent stages of industrialization, the Philippine economy geared towards the export-import business. Processing of some export products in Manila began, prompting the establishment of factories and manufacturing houses, which attracted more migrants and intensified the urbanization process.

Spain lost control of the colony with her defeat by the American fleet in the Battle of Manila Bay. The Philippines then became a colony of the United States for fifty years and was occupied by Japan for three years during the Second World War (NSCB, 1999). It was during the American Occupation that the city of Manila was incorporated, consisting of the districts of Intramuros, Binondo, Tondo, San Miguel, Sta. Cruz, Sta. Ana, Quiapo, Ermita, Malate, Paco, Pandacan, and Sampaloc (Figure 5).

The trade arrangements that were made between the US and the Philippines reinforced the primacy of Manila over the other regions of the country. In the early years of American colonial rule, a series of tariff laws were implemented (beginning with the Tariff Act of 1902) to lower trading barriers and achieve the unrestricted flow of American and Philippine goods. Minor concessions were given to vested interest groups in both countries (Pernia et al, 1983). During this time, the country specialized in the primary industry where it had an advantage relative to the American economy, and goods traded to the US were mainly agricultural products (Mercado, 2002).

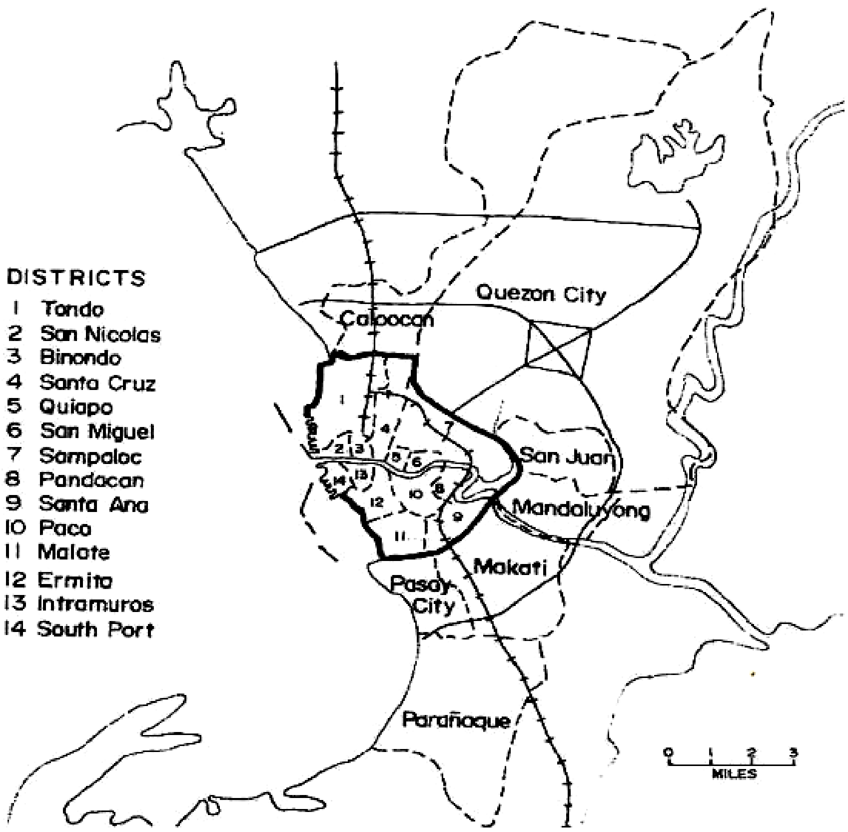
The situation changed following external developments in the US economy and the decline of the agriculture sector's performance in the world market in 1918-1939. These spurred the growth of the industry sector in the Philippines (Pernia et al, 1983, Mercado, 2002). Manila and its environs became the preferred site of manufacturing firms engaged in processing primary goods, particularly food processing, tobacco and wood products. Intensified economic activity attracted larger numbers of people to the city. While colonial policies promoted the development of Manila as primate city during this period, the rest of the country lagged behind. The countryside was "exploited to support the colonial bureaucracy in Manila" (Caoili, 1985; as cited by Manasan and Mercado, 1999).

From the colonial to early post-colonial era, Manila was said to have the structure of a typical Southeast Asian primate city (McGee, 1967; as cited by Reyes, 1998): a) located on or near the sea and on a river which allowed easy access to the sea; b) founded on the site of indigenous settlements; c) laid out in gridiron pattern (i.e. in terms of land use zones); d) witnessed the expansion of foreign population; e) experienced rapid growth due to high rate of migration, especially after decolonization, and f) characterized by multiple functions, the most important of which are economic and port functions.

Post-WW II to the Present

The population in and around Manila continued to increase after the end of Japanese Occupation and the Second World War, particularly the towns of Tondo, Sampaloc, Ermita, Malate, Paco, Pandacan and Sta. Ana. On June 18, 1949, the city of Manila was subdivided into 14 districts, namely: Tondo, Binondo, San Nicolas, Sta Cruz, Quiapo, San Miguel, Sampaloc, Pandacan, Sta. Ana, Paco, Malate, Ermita, Intramuros, and the South Port Area (Figure 5). The growth of Manila during this period was attributed to natural population increase, positive net migration and aerial reclassification.

Figure 5: Post-war Manila (source: Reyes, 1998)



Post-WW II socio-economic policies contributed further to the urbanization of Manila. A major event that boosted the economy of the region was the policy shift from an agricultural export orientation to an industrialization strategy based on import-substitution (Mercado, 2002). The import substitution period of the Philippine economy began following the granting of independence from the US, and persisted until the era of the Marcos administration (1948-1967). The package of policies implemented during this period was characterized by a bias towards capital-intensive industries (Pernia et al, 1983).

Already a favored site for investments because of the presence of a principal port and a developed infrastructure, Manila benefited immensely from this economic policy as it had an early comparative advantage over other regions in terms of average size of firms, labor and capital productivity, and capital intensity (Mercado, 2002). More spatial concentration was observed during this period, whereas before industries in the country were relatively well dispersed (Pernia et al, 1983). The negative consequence of the import-dependent import- substitution policy was the neglect of the agricultural sector, which resulted in low regional productivity and a wide development gap between urban and rural areas in the countries. This regional development inequality further made Manila a magnet for attracting labor, capital and entrepreneurial skills from the neighboring regions (Mercado, 2002).

Rural migration was spurred by the underdevelopment of the countryside and political unrest (Manasan and Mercado, 1999). Migrants from surrounding rural areas moved into the city as urban industries created new jobs. Additional sources of employment were created with the establishment of secondary and tertiary industries to support the primary industries of manufacturing and construction. The influx of migrants continued even after most of the jobs in the city were filled, with the less-skilled filling in the niches of the informal sector with part-time or low-level jobs while they search for more permanent work (United Nations, 1993).

Quezon City experienced high population growth rates during this period, probably due to the government's move to make it the government center in 1948 and later the new capital city of the country (Takeuchi and Iiyama, 1998; Magno-Ballesteros, 2000). The Makati area also experienced rapid growth in the 1950's and this was attributed to the planned development of the Ayala property into a mixed financial, commercial and residential subdivision (Magno-Ballesteros, 2000). The other suburban municipalities of San Juan, Pasig, Mandaluyong, Parañaque, and Marikina drew huge numbers of migrants from the city of Manila and adjoining provinces. Manufacturing industries moved into these areas because of the availability of undeveloped land and lower land values (Caoili, 1988; as cited by Magno-Ballesteros, 2000). By the 1960's, Manila and its adjacent cities contained 10% of the total Philippine population; had 90 out of the country's 100 top corporations, and one-third of all its manufacturing industries (Reyes, 1998).

Towards the end of the import-substitution period, the growth stimulus spilled over the peripheral regions of Southern Tagalog and Central Luzon, and as a consequence, these three regions were also growing at a rate disproportionately faster than the rest of the Philippine economy (Pernia et al, 1983).

A ban on the location of new factories and plants within the 50-km radius of Manila has been imposed since 1973 as a direct effort to decongest Metro Manila. However, this move was not successful in dispersing industries away from Metro Manila and into the other regions of the country, but only dispersed industries in the peripheries of the metropolis (Mercado, 2002). Thus factories and plants were built in peripheral towns of Pasig, Cainta (in Rizal Province), Mandaluyong, Caloocan, Valenzuela, Parañaque and Taguig. Partly due to this, Metro Manila's industrial sector was underdeveloped and unable to absorb the increasing labor force within the region and the labor surplus from rural areas (Reyes, 1998).

The problems of Metro Manila such as congestion, urban poverty, pollution, and peace and order can be traced to unbalanced regional development brought about by previous macroeconomic policies. Realization of the distortions caused by the import-substitution program led to a policy shift to export orientation under the liberalization period. Regional awareness in development began as early as the 1960's but it was only in 1980's when crucial policy reforms were instituted under the Aquino administration (Gonzales et al, 2001).

The chief feature of the Board of Investments' investment incentive structure was an explicit de-emphasis on the national capital region as an investment hub. Tariffication and tariff restructuring were done to remove the bias towards industries producing consumer goods or finished goods with little value added, which was the reason for the concentration of such investments in Metro Manila, Central Luzon, Southern Tagalog and Central Visayas.

The liberalization period saw the promotion of special economic zones and least developed areas outside Metro Manila as growth areas. The Special Economic Zone Act of 1995 was signed into law to spread the benefits of industrialization to areas outside Metro Manila. This was done through the establishment of regional agricultural centers (RAICs), regional industrial centers (RICs) and special economic zones (SEZs). Enterprises located in identified ecozones were granted fiscal incentives. According to the Special Economic Zone Act, "each ecozone shall be provided with transportation, telecommunications, and other facilities needed to generate linkage with industries and employment opportunities for its own inhabitants and those of nearby towns and cities." Large-scale, export-oriented and foreign-financed industries have been set-up. Most of these SEZs are located in four regions, namely NCR (Metro Manila), Southern Tagalog, Central Luzon and Central Visayas. From six ecozones in the early 1990's, the number has increased to 150 (2000 figure). More than two of five existing ecozones can be found in Laguna and Cavite provinces in the Southern Tagalog region (Pernia and Quising, 2003). Under the Ramos administration, the liberalization policy was articulated with the establishment of growth corridors, particularly the CALABARZON and the Cagayan de Oro-Iligan Corridor (CIC), to achieve urban decentralization. However, subsequent analyses of the impacts of these strategies indicate that these efforts were largely ineffective in dispersing industries to the poorer regions of the country (Gonzales et al, 2001)

Economic liberalization greatly influenced the present spatial structure of Metro Manila. The globalization of production, mainly through the operation of trans-national corporations (TNC's) deepened the integration of the country to the world economy through Metro Manila and other rising urban centers, enabling the latter to assume new functions and capture investments.

Incentives coming from the industrial dispersion policy of the government and technological innovations that allowed the spatial separation of the production process enabled TNC's to locate their production units in industrial enclaves in the fringes of the metropolis, allowing the metropolitan core to retain its commercial nature. Starting in the 1990's, the passage of liberal foreign investment laws, establishment of uniform tariff structures and allowing 100% foreign ownership of several industries such as the banking and telecommunications sectors, and the policy of deregulation in the transport, communications, shipping and energy industry intensified the competition for real estate properties and hiked up the prices of land prices and rents in the metropolis, as new commercial business districts (CBD's) sprung up and the old ones were redeveloped (examples of these emerging CBD's are the Fort Bonifacio Global City, Filinvest Corporate City, and Boulevard 2000- to be built along the coast of Manila Bay). Thus, only the highest bidders for commercial and business space occupied prime real estate and high-end residential land uses in the region. The vitality of the CBD's is due in part to the continued rise of the service economy in the region.

From the 1960's to the 1990's, Metro Manila underwent what Reyes (1998) described as a process of tertiary urbanization. Previously non-metropolitan areas were spatially integrated in the metropolitan region, with no accompanying shift in the sectoral and occupational structure of the regional economy. Although there was a shift to the non-agricultural employment, labor shift was not from primary to secondary but to tertiary services, particularly the service sector. Thus, "urban growth was largely cosmetic, and the underlying process of urbanization and overall structure of city remain largely unaltered" (Reyes, 1998).

Institutional Arrangements

There is no strict universal definition of what constitutes a metropolis. Angotti (1993), as cited by Mercado and Manasan (2001) defined a *metropolis* as a large urban settlement with at least 1 million people. Another unique feature of a metropolis is that its geographical area usually extends across several local government bodies. Metropolitanization is a recent phenomenon in the Philippines, except for the case of Metro Manila.

Metropolitan Manila, or Metro Manila is the result of the integration of 17 previously distinct municipalities. Metropolitanization started with the chartering[4] of the cities of Quezon and Pasay and their inclusion with the urbanized zone of Manila in the 1940's. This was followed by the chartering- and inclusion of Caloocan City in 1963 (Magno- Ballesteros, 2000). Prior to 1975, the City of Manila and environs were called *Manila and suburbs*, the latter term referring to the area made up of the three chartered cities (Quezon, Pasay, Caloocan) and the municipalities of Mandaluyong and San Juan in Rizal province (MMDA, 2001). The following years would see the addition of new cities and towns to the metropolitan fringes. Metropolitanization occurred as the older central urban core expanded and new urbanizing areas emerged. These new urbanizing areas, in turn, encroached into non-metropolitan areas.

Rapid post-war population growth from natural population and rural migration contributed to the economic growth of the Manila but also brought social problems, such as rampant poverty, inadequate housing as shown by the expansion of slums and squatter settlements, pollution, traffic and inadequate public transportation system, poor health and sanitary conditions, lack of potable water and sewerage system and worsening peace and order situation. These problems remained unsolved because the approaches employed by the local government units were largely piecemeal and uncoordinated, and efforts were further hindered by party politics, jurisdictional disputes over responsibility on the delivery of basic services, and the wide disparity in wealth among local government units (Caoli, 1995; as cited by Mercado, 1999).

It was in 1975 that the first serious attempt to integrate the administratively discrete cities and municipalities of Metro Manila was made, with the issuance of Presidential Decree 824, creating Metropolitan Manila with the status of a public corporation. The metropolis was now legally defined as the area consisting of the city of Manila, the cities of Quezon, Caloocan, and Pasay, and thirteen municipalities, namely, Las Piñas, Makati, Malabon, Mandaluyong, Marikina, Navotas, Parañaque, Pasig, Pateros, San Juan, Taguig, Muntinlupa in Rizal province and Valenzuela in Bulacan province.

The Metropolitan Manila Commission (MMC) was created as governing body, to establish and administer programs and provide services common to the metropolitan area, and perform general administration, executive and policy-making functions including the power to tax (MMDA, 2001). The MMC had a Manager-Commission form of government with an executive structure of the MMC consisting of a Governor, Vice-Governor and Commissioners for Planning, Operations and Finance. Funding was taken from the contributions of the constituent municipalities and cities representing 20% of their annual incomes. During the Marcos administration, the Governor of Metro Manila, First Lady Imelda R. Marcos, also happened to be the head of the Ministry of

[4] The act of chartering a city removes it from the direct supervision of the provincial government.

Human Settlements. According to Mercado (1999), despite the Governor's enormous political clout, the MMC failed to evolve as a separate metropolitan entity "because of its overdependence on the Governor" and on national agencies whose Ministers also served as action officers of the Commission. Furthermore, the MMC concentrated on high-visibility projects that were not sustainable, and a regional development plan to guide Metro Manila's development did not even exist until the 1980's when a Commissioner of Planning was appointed (Mercado, 1999).

The MMC was eventually abolished on January 9, 1990 by Executive Order 392 issued by President Corazon C. Aquino. An interim administrative body called the Metropolitan Manila Authority or MMA was created by the same legal edict to govern over the metropolis until Congress shall have passed a law creating a metropolitan authority in the area. The MMA had jurisdiction over the delivery of basic urban services that included land use, planning and zoning; public safety, urban development and renewal; traffic management; management and control operations during calamities and emergencies, and sanitation and waste management (MMDA, 2001).

By act of Congress, RA 7924 was enacted on March 1995, designating Metro Manila as a "special development and administrative region" subject to the direct supervision of the President of the Philippines. This also created the Metropolitan Manila Development Authority (MMDA) to "perform planning, monitoring and coordinative functions, and in the process, exercise regulatory and supervisory authority over the delivery of metro-wide services within Metro Manila, without diminution of the autonomy of the local government units over local matters" (Mercado, 1999). The MMDA is headed by a Chairman with a cabinet rank and has jurisdiction over services that are metro-wide in impact and transcend legal political boundaries or impose a huge financial burden if provided by the individual local government units (LGU). These services include: development planning; transport and traffic management; solid waste disposal and management; flood control and sewerage management; urban renewal, zoning, land use planning and shelter services; and health and sanitation, urban protection and pollution control and public safety (MMDA, 2001).

Since the creation of Metro Manila as a public corporation in 1975 under PD 824, its basic geopolitical composition did not change much except for the reclassification of some municipalities into cities, namely Makati, Mandaluyong, Pasig, Marikina, Las Piñas, Parañaque, Malabon, Muntinlupa and Valenzuela. According to Reyes (1998), however, *de facto* metropolitanization is occurring as adjoining cities and towns in Cavite, Laguna, Bulacan and Rizal have been functionally integrated into the expanding metropolitan region, with the growth rates of adjoining urbanized towns and cities in 1985-1995 being higher than that of Metro Manila's 1% posted during that same period.

Land Use

Land use in Metro Manila is said to be largely determined by the socioeconomic demands of a growing population and not necessarily according to plan. According to the Physical Framework Development Plan of Metro Manila (MMDA, 1996), four trends characterize land use in the metropolis: a) an increase in the size and density of squatter settlements in city centers; b) the rise of medium-scale residential subdivisions for the upper- to upper middle income groups in the peripheries of the inner and intermediate cores; c) the growth of big commercial centers along EDSA and major thoroughfares, and d) the infilling of urban area with high density housing.

The existing landscape is a combination of old (port zone) and new (industrial estates) zones, as well as residential and commercial zones which have existed during colonial times or were formed during the years following decolonization. Examples of new land uses are peripheral master-planned suburbs for the middle class located side by side with large industrial estates located in the metropolitan fringes.

Residential land use is the most dominant land use activity, accounting for 65% of the total land area of the region as of 1991. Declining densities in the inner core of Metro Manila suggests residential deconcentration as the growing middle class tends to avoid high land prices and overcrowding. This led to the formation of suburban communities in the peripheries of the metropolis, with low-cost housing units being located farther away from the outer core in the provinces of Bulacan, Cavite and Laguna. However, it is also near CBD's and industrial areas in the metropolis where large squatter settlements can be found.

Commercial land use is about 3% and is mainly in the form of shopping- and consumer-related activities that are found along major roads and adjacent areas. Industrial land use accounts for 4%, with small and medium- scale industries situated in Marikina, Las Piñas, Parañaque, Muntinlupa, Valenzuela and Novaliches. Government policies that promote balanced regional growth and development directed the decentralization of industries towards the periphery of Metro Manila, particularly to the CALABARZON growth area. The core of the metropolis remains largely commercial in character because of these policies and also because it is able to outbid all other sectors (or land uses) for expensive, accessible land (Reyes, 1998). The 1990's saw an increase of high-rise developments and buildings, specifically in the Guadalupe Plateau, and the conversion of industrial properties and properties originally developed for residential use to commercial use. Tremendous growth of real estate activity at the urban fringes began in the late 1980's, with most of the land conversions taking place in the CALABAR region between 1988-1997 (Magno-Ballesteros, 2002).

Institutional land uses (government offices, hospitals and schools) make up 5% of the total area, with most national government offices being situated in Quezon City. About 9% are lands used for agriculture and are located mainly in the fringes and in idle lands in the inner core of the metropolis. Open spaces make up 8% of the total area of Metro Manila although these lands are already diminishing.

Land use change analysis conducted by Osakaya (2002) showed that in 1986, 50.6% of the total area of Metro Manila was developed land, while 36.2% was transformable land (i.e., agricultural land and forests). After a decade, at least half of this transformable land was already developed. By 2006, the study predicts that if the rate of land-use change continues, all transformable land will be converted and green space will likely disappear. Conversion of agricultural lands to urban use was found in a separate study by Takeuchi and Iiyama (1998) to be occurring most rapidly in areas experiencing high population growth rates, but with low population densities. This integration of rural and urban land use is said to be a distinct feature of Asian urbanization.

Table 3: Land use classification in Metro Manila (figures in parentheses represent percent contribution of each land use)

Land Use	1972	1980	1991
Residential	13, 750 (28.0)	18,948 (29.4)	41,405 (65.0)
Commercial	530 (1.0)	2,573 (4.0)	1,911 (3.0)
Industrial	1,365 (3.0)	3,07 (4.7)	2,548 (4.0)
Institutional	1,800 (4.0)	2,892 (4.5)	3,185 (5.0)
Utilities		890 (1.4)	637 (1.0)
Open Space*	30,980 (64.0)	14,380 (22.3)	5,096 (8.0)
Agricultural		7,806 (12.1)	5,733 (9.0)
Cemetery/Memorial Parks			637 (1.0)
Recreation/Parks/Sports		13,012 (20.2)	637 (1.0)
Rivers/Waterways			1,911 (33.3)
Reclamation		671 (1.0)	
Agro-industrial		236 (0.4)	
Total	48,425 (100)	64,445 (100)	63,700
*open space and others			

Basic sources: 1972 figures from Manosa (1974) NEDA Journal of Development, vol ½

1981 figures from Metro Manila Commission (1983)

1991 figures from NCR Regional Development Plan (1993-1998) as cited by Manasan and Mercado, 1999.

Population and Demographic Trends

The total population of the National Capital Region as of 2000 is 9.93 million and is estimated to reach 14.7 million by 2015, with the rank of 13th largest urban agglomeration in the world (United Nations, 1996). With a projected population of 11.1 million in 2004[5], Metro Manila is also now part of the world's megalopolises or mega-cities[6] (ADB, 1994; as cited by Mercado and Manasan, 2001). Among the thirteen (13) cities and four (4) municipalities that make up the region, Quezon City had the highest share of the total population in 2000 at 2.17 million persons, followed by the city of Manila with 1.58 million persons, and Caloocan City with 1.18 million persons. Pateros had the smallest population at 57 thousand persons (NSO, 2000). The average household size is 4.62 persons, down from the 1995 figure of 4.74 persons (NSO, 2000). The population of Metro Manila grew at the rate of 1.06 % in the second half of the nineties. If the

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[5] Projection conducted in 1999 by the National Statistics Office using medium assumptions (NSCB, 1999).

[6] A *mega-city* is defined as a city with a population of 10 million and more. Recognizing the rise of big metropolises world-wide, the United Nations has defined some metropolises as megalopolises, *megalopolis* referring to a metropolis having a population of 8 million and more (United Nations, 1994; as cited by Mercado and Manasan, 2001).

average annual growth rate of the population continues at 1.06 %, then the population of this region is expected to double in 65 years (NSO, 2000).

The average population density in Metro Manila in 2000 was 16,091/ sq. km., which was about 63 times higher than the national average of 255. Manila was the most densely populated city at 63,294 persons/sq. km., while the least densely populated municipality was Pateros at 5,520. Other cities and municipalities that were heavily congested were Mandaluyong, Caloocan, Malabon, Navotas, Makati, and Pasay (Table 4).

From the period 1970 to 1990, Metro Manila's growth rate was higher than the growth rate of the total population of the country (Table 5). For instance in 1970-1980, Metro Manila's growth rate is a staggering 4.10% while the rate for the whole Philippines was 2.75% only. However, the trend changed in the past decade 1990-2000, when Metro Manila's growth rate became slightly lower than that of the whole country. In contrast, the growth rates of the adjacent regions of Central Luzon (Region III) and Southern Tagalog (Region IV), appear to be on the rise for the past three decades, exceeding the national average. As mentioned earlier, these are regions that are benefiting from the spillover effects of development activities in Metro Manila. Projections to year 2020 (Table 6) show that population growth in Metro Manila will continue to decelerate, at growth rates lower than those predicted for the two adjacent regions, and the Philippines as a whole.

Table 4: The municipalities and towns of Metro Manila, land area, population, and density

Region and Province	Land Area (sq. km)	Total Population	Density (persons/sq.km)
Philippines	300,000	76,504,077	255
National Capital Region	617.3[a]	9,932,560	16,091
City of Manila	25.0	1,581,082	63,294
Quezon City	171.7	2,173,831	12,660
Marikina City	21.5	391,170	18,177
Pasig City	48.5	505,058	10,422
San Juan	6.0	117,680	19,778
Mandaluyong City	9.3	278,474	29,976
Caloocan City	55.8	1,177,604	21,104
City of Valenzuela	47.0	485,433	10,324
City of Malabon	15.7	338,855	21,569
Navotas	8.9	230,403	25,772
Makati City	18.3	444,867	24,296
Pasay City	14.0	354,908	25,405
Pateros	10.4	57,407	5,520
Taguig	45.2	467,375	10,338
Parañaque City	46.6	449,811	9,659
Las Piñas City	32.7	472,780	14,463
Muntinlupa City	39.8	379,310	9,542

[a] Total land area estimate is less than 636,000 sq.km. The land area estimates for each local unit were based on the 2001 Estimated Land Area certified to the to the Department of Budget Management by the Lands Management Bureau. Source: NSCB, 2003

Table 5: Annual population growth rates of the Philippines and Metro Manila and neighboring regions, census years 1970-2000

Period	Philippines	Metro Manila	Central Luzon	Southern Tagalog
1970-1980	2.75	4.10	2.88	3.22
1980-1990	2.35	2.98	2.58	3.05
1990-2000	2.34	2.25	2.62	3.62

Source: NSCB, 2003

Table 6: Projected average annual geometric growth rates of the Philippines and Metro Manila and neighboring regions 1990-2020 (data refer to medium assumption)

Period	Philippines	Metro Manila	Central Luzon	Southern Tagalog
2000-2005	1.94	1.55	1.81	2.36
2005-2010	1.69	1.21	1.54	2.16
2010-2015	1.46	0.94	1.29	1.97
2015-2020	1.26	0.72	1.08	1.75

Source: NSO, 1995.

In general, the growth rates of individual LGU's comprising Metro Manila appear to have slowed down from the period 1970 to 2000. Except Caloocan City which continues to exhibit very high population growth, LGU's which traditionally comprise the inner core of the metropolis, some of which also happen to be the most heavily-congested areas, are experiencing negative growth rates starting in the mid-1990's, while those areas in the intermediate core still have high positive growth rates, notably Las Piñas, Parañaque, Taguig and Valenzuela (Table 7). Population projections for 1995-2010 conducted by JICA/MMDA (1998) tend to confirm this movement of population growth away from the inner core of the metropolis. Las Piñas, Muntinlupa, Taguig and Parañaque, in particular will continue to have large populations due in part to development activities in the south of the metropolis (Mercado, 1998). As mentioned earlier, land use conversion is observed to be occurring at rapid rates in these relatively less dense areas of the region. However, future increases in population will occur at slower rates.

Table 7: Average annual growth rates of LGU's comprising Metro Manila

City/Municipality	Annual Average Growth Rates[a]			Projected Annual Average Growth Rates[b]	
	1970 - 1980	1980 – 1990	1990 – 2000	2000 - 2005	2005 - 2010
City of Manila	2.05	-0.18	-0.13	-0.1	-0.2
Caloocan City	5.48	5.02	4.43	3.4	2.9
Las Piñas City	11.56	8.09	4.76	4.4	3.7
Makati City	3.47	1.98	-0.18	1.5	1.1
City of Malabon	3.04	3.90	1.92	2.8	2.4
Mandaluyong City	3.23	1.91	1.16	1.9	1.6
Marikina City	6.44	3.90	2.34	3.1	2.6
Muntinlupa City	7.71	7.37	3.14	6.7	5.8
Navotas	4.24	4.04	2.08	2.2	1.8
Parañaque City	7.93	3.98	3.85	3.8	3.2
Pasay City	3.39	2.50	-0.37	2.1	1.7
Pasig City	5.55	4.00	2.42	3.4	2.8
Pateros	4.69	2.47	1.11	1.9	1.5
Quezon City	4.45	3.66	2.67	3.2	2.7
San Juan	2.21	-0.25	-0.75	1.9	1.3
Taguig	9.27	7.11	5.77	5.2	4.4
City of Valenzuela	7.99	4.83	3.62	4.4	3.7

[a] Source: NSCB, 2003

[b] Source: JICA/MMDA, 1998

The level of urbanization in a country refers to the percentage of the total population living in urban places; however urban is defined in the national context[7]. Urban population growth is the net result of natural increase, migration from rural areas, re-classification of areas, and annexation or boundary expansions (ASEAN, 2000). In less developed regions of the world, the urban population is often, but not always concentrated in a single primate city. Countries that exhibit primacy generally have all the major functions being performed by the primate city. The rise of secondary cities signals the diversification of economic activity and an increase in regional equity (United Nations, 1993).

The primacy of Metro Manila rose from the post-war period (1948) until 1970 when it reached its peak at 34% (Table 8), coinciding with the protectionist policy of the government during the import-substitution period (Gonzales et al, 2001). By this time, the region was already 100% urban. Since then Metro Manila's primacy has been on the decline, the rate of change of urban growth dropping from 11.2 % in 1970 to 4.39% in 1990 (Manasan and Mercado, 1999).

[7] In the Philippines, an area is classified as urban based on criteria set in 1970 by the National Census and Statistics Office (now National Statistics Office), which include parameters such as population density, population size, presence of urban physical elements and occupation, and included spatial considerations. Areas that do not meet these requirements are considered rural.

Table 8: Population and demographic trends for Metro Manila

	1948	1960	1970	1980	1990	1995	2000
Metro Manila Population (millions)	1.569[a]	2.462	3.967	5.926	7.948	9.454	9.933[b]
Metro Manila Urban Population (millions)	1.526	2.427	3.967	5.926	7.948	9.454	9.933
Philippine Population (millions)	19.234	27.088	36.684	48.098	60.703	68.617	76.504[b]
Level of Urbanization-Metro Manila (%)	97.3	98.6	100.0	100.0	100.0	100.0	100.0
Level of Urbanization-Philippines (%)	27.0	29.8	31.8	37.1	47.0	55.0	58.6[c]
Metro Manila Primacy (%)	29.4	30.1	34.0	33.2	27.8	25.1	22.2
Metro Manila Population as % of Total Philippine Population	7.9	9.0	10.8	12.3	13.1	13.8	13.0
Growth Rate of Metro Manila Population (%)		3.8	4.9	4.1	3.0	3.3	1.1[d]
Growth Rate of Philippine Population (%)		2.9	3.1	2.7	2.4	2.3	2.3[d]
Growth Rate of Urban Metro Manila Population (%)		3.9	5.0	4.1	3.0	3.3	1.1
Growth Rate of Urban Philippine Population (%)		3.8	3.8	4.3	4.8	5.7	---

a. 1948 - 1995 figures from Manasan and Mercado, 1999

b. Basic source: NSCB, 2003.

c. Basic source: ADB & ESCAP, 2000; as cited by ASEAN, 2000

d. Basic source: NSO, 1995

Internal migration has been regarded as a policy instrument that could direct population and employment growth towards regions with economic potential (Gonzales et al, 2001). In the 1970’s to the early 1980’s two groups of policies were pursued to redirect migration flows away from Metro Manila. The first include schemes that provided restrictions or incentives for industries to locate outside Metro Manila, while the second pursued rural development programs that aimed to retain rural populations. These policies however, failed to restrain migration during this period (Magno-Ballesteros, 2000).

Nakanishi’s (2002) analysis of interregional migration to Metro Manila shows that from 1970 to 1990, Bicol, Eastern and Western Visayas and Ilocos regions were the top sources of migrants to the metropolis, making up 42.7% of all gross migrations to Metro Manila from 1985-1990. These areas are recognized as typically depressed regions of the country. The same author also found a negative correlation between Human Development Index (1991) of a province and net migration rate to Metro Manila, indicating that poorer regions of the country send more people to the metropolis. Despite the link between migration to Metro Manila and poverty of other regions in the Philippines, the percent contribution of migrants to the total population of Metro Manila appear to be declining, from 18.2% in the period 1975-1980, to 11.5% percent in 1985-1990

(Nakanishi, 2002). Another notable finding was that Southern Tagalog was the only region that exhibited negative migration volume and rates. A total of 111,515 persons migrated from Metro Manila to CALABARZON in 1985-1990, which accounted for 56% of the total volume of migrations to CALABARZON. This signifies the declining contribution of migration to urban growth, which in turn contributes to the trend of primacy reversal (Gonzales et al, 2001).

The declining primacy is seen as the consequence of the exhaustion of agglomeration economies and the start of urban diseconomies - manifested in increasing congestion, increasing value of land, and pollution, and the delayed effects of the industrial dispersion program implemented in the 1970's (Pernia and Israel, 1994; Gonzales, 2001). For instance, the observed significant movement of industries outside Metro Manila and the possible decline in migration may be attributed not to any direct government intervention but to high land values in Metro Manila, due to the real estate boom between 1990 and 1997 (Magno-Ballesteros, 2000). Agricultural and industrial use of lands in Metro Manila became too expensive that industries moved to regions where lands were cheaper. The CALABARZON region became the alternative site for industrial- and real estate development.

Economy

The Philippine economy has a highly uneven spatial development, with Metro Manila dominating all other regions. This was attributed by previous studies (Pernia et al, 1983; Mercado, 1999; Reyes, 1998; Manasan and Mercado, 1999; Gonzales et al, 2001; Pernia and Quising, 2003) to the region's natural strategic advantage, historical antecedents, and past macroeconomic policies. For an update, the following discussion on recent regional development trends is taken from the analysis of the urban growth nexus in the Philippines conducted by Gonzales and co-workers (2001).

One salient finding of the study is that urbanization in the country proceeded with little economic growth, as indicated by a stagnant gross regional domestic product (GRDP) per capita from 1990-1996 in regions experiencing high levels of urbanization, namely Central Luzon, Southern Tagalog, Northern Mindanao and Southern Mindanao. When the rate of industrialization (as measured by the percentage contribution of the industry sector in regional GDP) is compared with the speed of urbanization, regional data for 1980 vs. 1994-1995 show that industrial growth has been stalled or declined as urbanization proceeded slowly (Figure 6).

The weak link between urbanization and industrialization has been attributed by Pernia and Israel (1994) and other succeeding studies to the decline in the proportion of manufacturing output in all regions, the manufacturing subsector being the core of industrial growth. Shares of employment in manufacturing showed a corresponding gradual decline, recovering only in the 1990's (Figures 7a & 7b). In contrast, there has been remarkable growth in the output and employment shares in the services sector from 1975-1996 across regions, with Metro Manila experiencing the greatest gains. Employment in the service sector accounted for almost three-fourths of total employment in Metro Manila in 1996 (Figure 8). The service sector is diverse and includes financial services, insurance and real estate, community and personal services, and wholesale and retail trade. Non-traded personal and community services may have the strongest influence on urbanization trends in the Philippines, as indicated by an apparent positive correlation between a region's urbanization level and its output and employment rates in personal, community and social services. The informal sector of the economy thus serves as a major source of income and employment for the region. These trends indicate that in recent years, the urbanization process in the Philippines is largely driven by the growth of the services sector.

Figure 6: Industrial growth has been stalled or declined as urbanization proceeded slowly

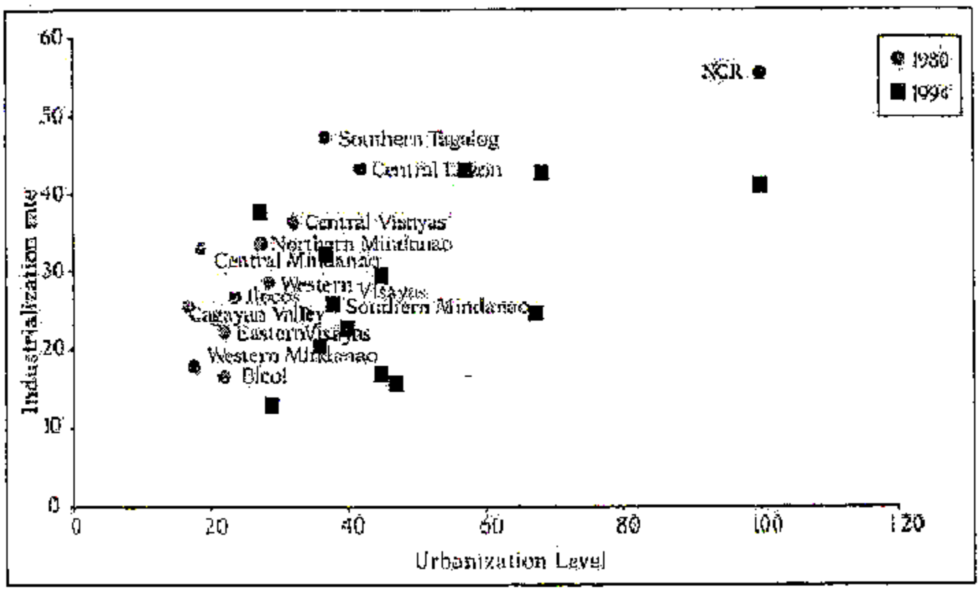


Figure 7a: Decline in the proportion of manufacturing output in all regions

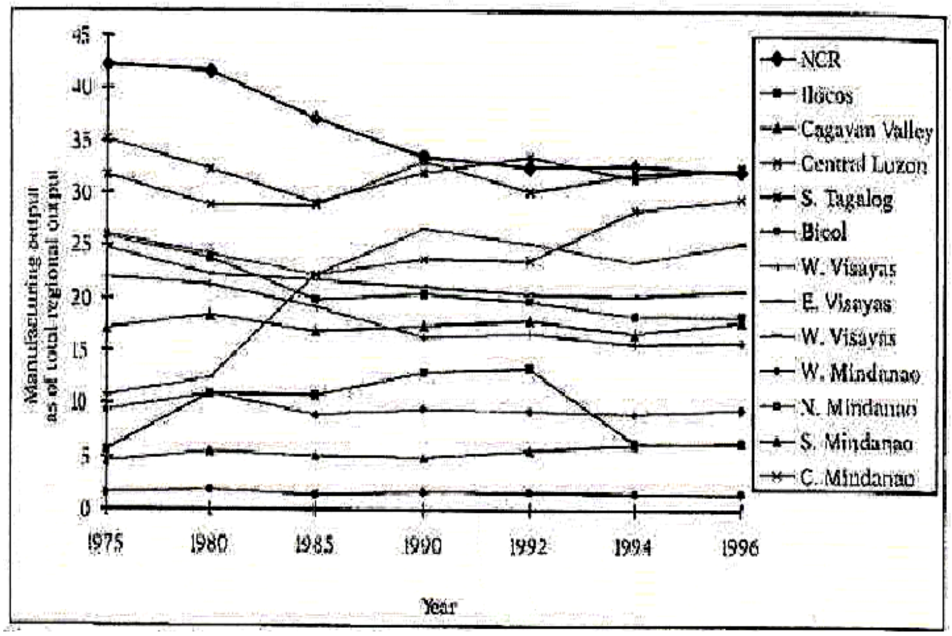


Figure 7b: Decline in the proportion of manufacturing employment in all regions

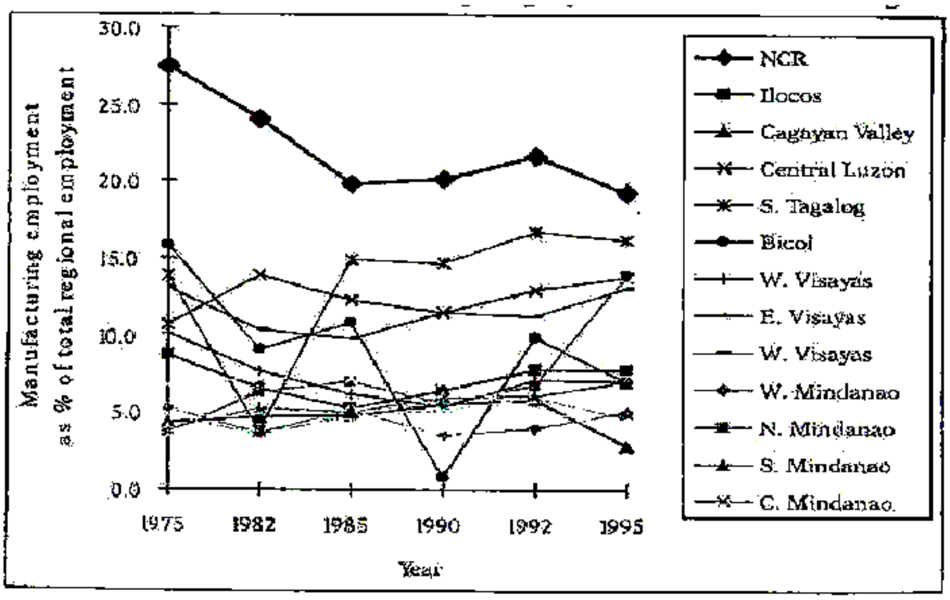
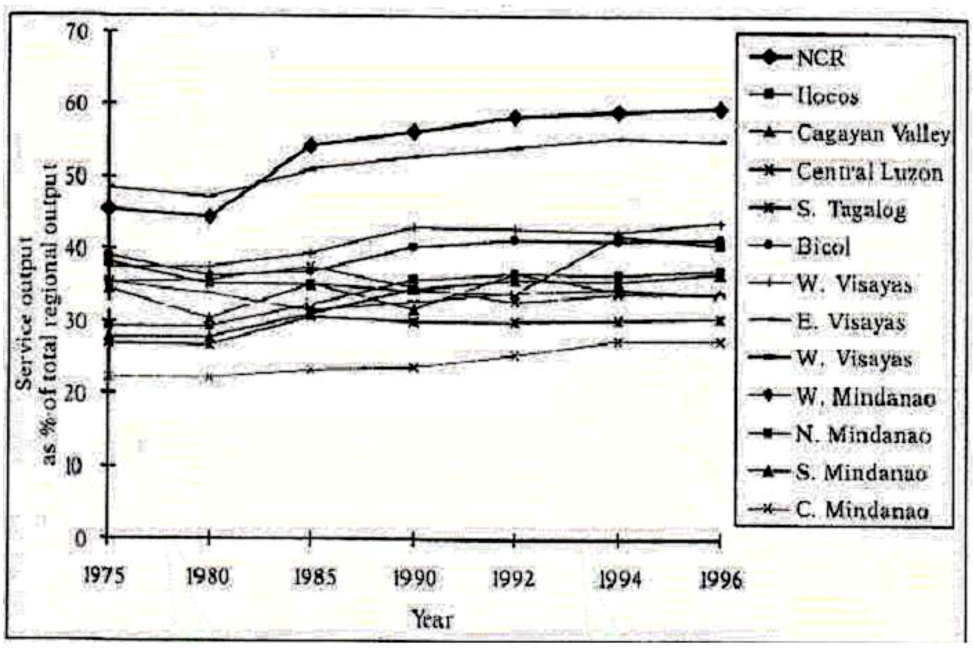


Figure 8: Rise in the proportion of services output in all regions



In terms of percent share in national gross value added (GVA), the share of Metro Manila's industry sector declined from 1975 to 1990, and seems to be recovering slowly until the late 1990's (Table 9). The general decline was attributed to the dropping share of the manufacturing sub-sector, which may be due in part to the deconcentration of manufacturing activity from Metro Manila to Southern Tagalog and Central Luzon in the late 1980's (Manasan and Mercado, 1999). Pernia and Israel (1994) identified this trend of slow industrial (i.e., manufacturing) deconcentration in the region from the period 1975 to 1992. Similarly, the interregional input-output (IO) table analysis for 1980-1994 conducted by Secretario and co-workers (2002) show the tendency of Metro Manila's economy to progress towards de-industrialization, based on interregional DPG (deviation from proportional growth) index. However, it should be emphasized that Metro Manila's industry sector is still the greatest contributor to total industry sector's share in gross national domestic product, with a share of 38.32%, followed only by Southern Tagalog with 19.47% (NSCB, 2003b). This is supported by regional data shown in Figure 9, which indicates Metro Manila's industrial primacy from the 1970's to the late 1990's.

Table 9: Metro Manila Gross Domestic Product structure

	1975	1980	1985	1990	1992	1997
Metro Manila's Share in National GDP/GVA						
GDP	28.99	30.16	28.35	32.27	32.39	32.74
GVA in Industry Sector	44.18	40.94	42.97	38.32	38.30	38.41
GVA in Manufacturing	47.86	48.02	45.80	42.97	42.03	43.26
GVA in Construction	38.40	32.84	40.97	36.49	34.09	30.08
GVA in Service Sector	37.84	37.89	35.06	43.29	43.69	44.09
Rate of Growth (in constant prices)						
MM GDP		6.28	-1.88	5.01	-1.43	5.04
MM GVA in Industry Sector		6.84	-2.20	2.16	-3.68	5.16
MM GVA in Manufacturing		6.45	-2.00	2.13	-3.51	4.63
MM GVA in Construction		9.16	-6.37	5.72	-10.13	7.10
MM GVA in Service Sector		5.69	-1.52	7.54	0.26	4.96
Rate of Growth (in constant prices)						
Phil GDP		6.21	-0.54	3.30	-0.12	4.43
Phil GVA in Industry Sector		7.34	-2.82	4.97	-1.61	5.33
Phil GVA in Manufacturing		5.82	-1.42	4.09	-1.09	4.45
Phil GVA in Construction		12.54	-9.83	8.76	-6.93	9.59
Phil GVA in Service Sector		5.76	-0.40	4.05	0.59	4.71

Source: Manasan and Mercado, 1999 (basic sources: National Income Accounts, NSCB)

Despite indications of a weakening urban primacy and the slow growth of the industry sector, Metro Manila still dominates the country's economic landscape. In 2002, Metro Manila's GRDP was valued at PHP320 billion (in constant prices), which accounted for the largest share of the country's GDP at 30.6%, followed by a wide margin by Southern Tagalog (15.6%), Central Luzon (9.0%), Central Visayas (7.2%) and Western Visayas (7.1%). The GRDP of Metro Manila is attributed mainly to the service sector (63%) and the industry sector (37%), with no shares coming from the agriculture, fishery and forestry sectors (NSCB, 2003b). The region was badly affected by the economic crisis in 1983-1985, but was able to perform better with the turnaround in the economy in late 1980's and 1990's (Manasan and Mercado, 1999).

Metro Manila's economy remained resilient in the presence of local uncertainties in recent years. GRDP growth rate increased from 3.1% in 2001 to 4.5% in 2002. Metro Manila's industry sector also grew by 2.1% (behind Southern Tagalog's 1.7% growth rate), but this pales in comparison to the 5.9% growth in the service sector in 2002 from 4.7% in 2001 (Table 10).

Table 10: Philippines and Metro Manila GDP growth rates at constant prices, 2000-2002

Industry/Year	00-01		01-02	
	Philippines	Metro Manila	Philippines	Metro Manila
I. Agriculture, Fishery, Forestry	3.7	-	3.3	-
a. Agriculture and Fishery	3.9	-	3.7	-
b. Forestry	-27.3	-	-66.4	-
II. Industry	0.9	0.6	3.7	2.1
a. Mining and Quarrying	-6.5	-	51.0	-
b. Manufacturing	2.9	3.3	3.5	4.2
c. Construction	-5.0	-17.2	-3.3	-17.4
d. Electricity and Water	-0.7	-0.3	4.3	3.8
III. Service Sector	4.3	4.7	5.4	5.9
a. Transport, Communication & Storage	8.8	10.5	8.9	10.5
b. Trade	5.6	6.3	5.8	4.7
c. Finance	1.2	1.0	3.4	3.2
d. Dwellings and Real Estate	-0.5	-0.8	1.7	0.2
e. Private Services	4.4	4.5	5.5	5.9
f. Government Services	0.9	1.3	4.7	6.5
Gross Domestic Product	3.0	3.1	4.4	4.5

Source: NSCB, 2003b

The distribution of employment in Metro Manila closely follows the distribution of GVA across sectors. Starting in the 1980’s, the share of the service sector in total employment shot up that by 1997, almost three-quarters of total employment in the region were made up of the services sector. In contrast, the share of the manufacturing sector in employment has been declining (Manasan and Mercado, 1999).

Global influences are identified as possible drivers in the growth of the service sector. As export platforms of the government failed to advance industrial dispersal and counteract the agglomeration advantage of Metro Manila, foreign direct investments (FDI) continue to concentrate in Metro Manila and Southern Tagalog. Overseas workers’ earnings may have also contributed to the growth of non-traded services sectors as Metro Manila and Southern Tagalog, which receive the highest share of remittances, also have the highest output shares in private services. These regions also happen to be the most urbanized (Gonzales et al, 2001).

In 1990, 70% of all employed persons in Metro Manila were from the tertiary sector; 28% were involved in non-primary production of goods and 2% were into agriculture and related activities[8]. After twelve years, the distribution of employment continues to be dominated by the tertiary industries, mainly the wholesale and retail trade, transport, storage and communication, real estate, renting and business, and health and social work services (Figures 10 and 11). As seen in

[8] Primary industries include agriculture, fishing, forestry, mining and quarrying; secondary industries - manufacturing, construction, and electricity, gas and water, and tertiary industries - services.

Table 10, transport, communication and storage, private services and government services are the occupation groups that exhibit high growth rates. Employment in real estate and ownership of dwellings recovered from a –0.8% growth rate from 2000-2001 to 0.2% in 2001-2002, while the trade service's growth rate declined from 6.3% to 4.7% during the same intervals.

Figure 9: Metro Manila's industrial primacy after the economic boom

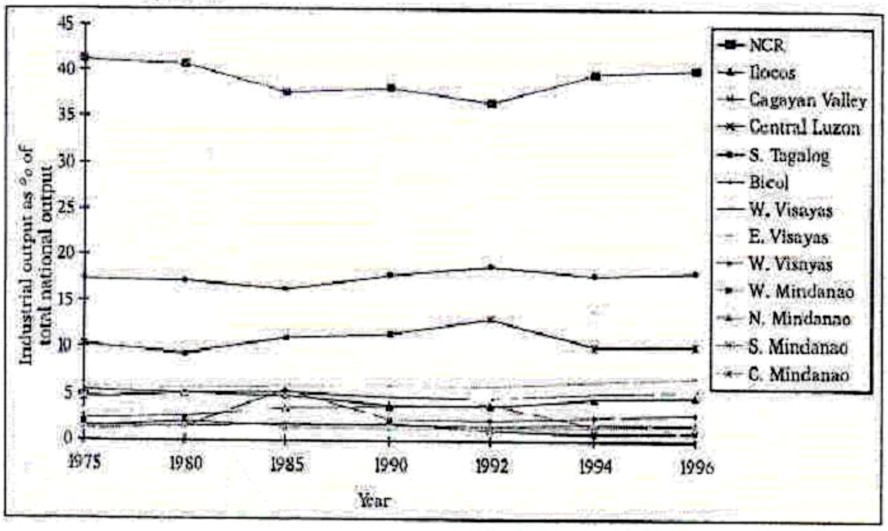


Figure 10: Employment by major industry/occupation group in Metro Manila, 2002 (source: NSCB, PSY 2003)

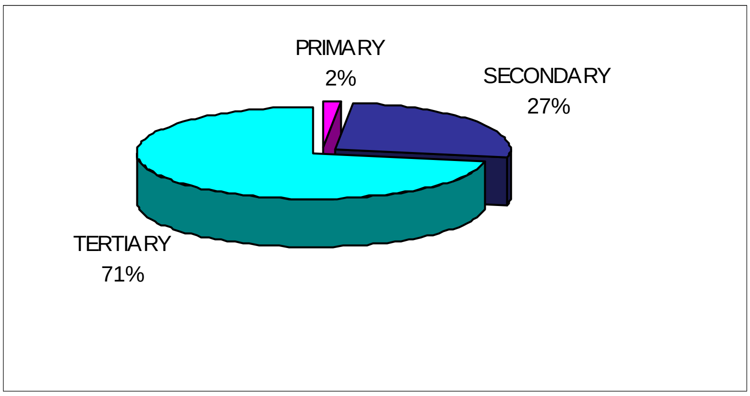
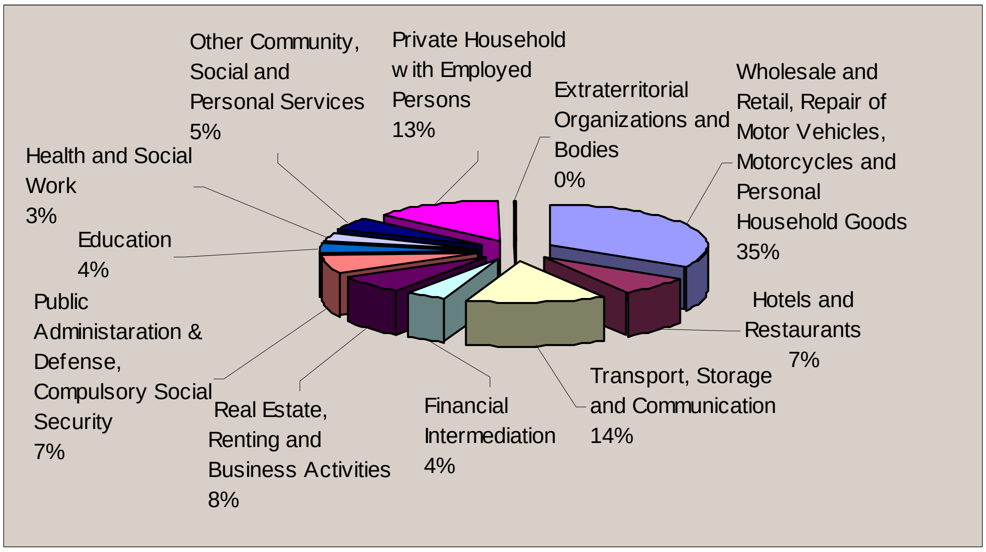


Figure 11: Employment in tertiary industries in Metro Manila, 2002 (source: NSCB, 2003)



GDP on a per capita basis shows a declining trend from 1995-2000 (Table 11). Despite this, Metro Manila continues to have the highest income per capita, valued in 2000 at PHP 29,577 (in constant prices). This is 2.4 times the national GDP per capita, and about twice the GDP per capita of the second richest region, Cordillera. The dominance in terms of GDP is reflected in the trend in poverty reduction across regions (Table 12). As of 2000, poverty incidence in Metro Manila based on headcount ratio was estimated by Pernia and Quising (2003) at 5.6%, which was much lower than the national estimate of 27.3%. Another indicator used by the same authors was expenditure per capita of the poorest quintile, which reflects the poor's living standards. This was also highest in the region (PHP 29,577) and above the national-level estimate (PHP 12,178). Social indicators such as functional literacy (>90%), cohort survival rate for secondary education (75.6%), and life expectancy at birth (70.1 years) are similarly the best for Metro Manila and more economically advanced regions of the country (Pernia and Quising, 2003).

Table 11: Gross regional domestic product per capita (constant 1985 prices)

Region	GRDP Per Capita					
	1975	1980	1985	1990	1995	2000
Metro Manila	6,691	13,471	25,020	43,249	65,997	29,577
CAR				17,580	30,644	14,952
Ilocos	1,432	3,023	7,033	9,114	15,460	6,873
Cagayan Valley	1,576	3,415	6,634	10,083	15,920	7,150
Central Luzon	2,493	5,092	10,752	14,726	23,071	10,673
Southern Tagalog	3,240	6,413	13,078	18,639	27,514	13,179
Bicol	1,301	2,535	5,352	8,114	12,920	5,227
Western Visayas	2,626	4,389	8,381	13,969	22,869	9,869
Central Visayas	2,262	4,958	9,815	15,315	24,217	11,118
Eastern Visayas	1,230	2,193	5,378	9,197	14,213	5,828
Western Mindanao	1,471	3,500	7,515	9,796	18,930	7,494
Northern Mindanao	2,194	4,730	10,339	13,817	22,070	11,659
Southern Mindanao	3,050	5,320	11,736	18,475	28,063	11,181
Central Mindanao	1,957	4,213	8,728	11,828	23,217	7,786
ARMM Muslim Mindanao					9,397	--
Philippines	2,726	5,502	11,207	17,611	27,778	12,178

Source: Manasan and Mercado, 1999; Pernia and Quising, 2003 (basic data from NIA, NSCB)

Table 12: Poverty incidence and expenditure per capita of poorest quintile

Region	Poverty incidence (%)		Annual Change in Poverty (%)	Expenditure per capita Poorest Quintile (at constant prices)		Annual Change Expenditure per capita Poorest Quintile (%)
	1988	2000	1988-2000	1988	2000	1988-2000
Metro Manila	9.48	5.6	-4.29	3,183	3,680	1.22
Cordillera Administrative Region	24.13	19.85	-1.61	2,021	2,063	0.17
Ilocos	28.4	20.31	-2.76	2,087	2,236	0.58
Cagayan Valley	43.22	29.57	-3.11	1,849	2,344	2.00
Central Luzon	24.7	16.13	-3.49	2,536	2,924	1.20
Southern Tagalog	38.2	19.56	-5.43	1,917	2,516	2.29
Bicol	53.84	53.32	-0.08	1,546	1,487	-0.32
Western Visayas	37.58	28.15	-2.38	1,785	1,949	0.74
Central Visayas	47.57	39.3	-1.58	1,256	1,365	0.70
Eastern Visayas	53.44	46.82	-1.10	1,433	1,493	0.34
Western Mindanao	48.03	55.48	1.21	1,536	1,446	-0.50
Northern Mindanao	30.62	30.24	-0.10	1,722	1,703	-0.09
Southern Mindanao	34.84	25.29	-2.63	1,797	2,089	1.26
Central Mindanao	30.45	36.16	1.44	1,813	1,709	-0.49
Philippines	34.31	27.27	-1.90	2,002	2,266	1.04

Source: Pernia and Quising, 2003

9.5 PATHWAYS - The Laguna Lake Basin[9]

Physical Characteristics

The Laguna Lake Basin (LLB) is situated between 119º57’- 121º35’ longitude and 13º51’- 14º51’ latitude. It has a total area of approximately 382,000 ha. This encompasses the whole of Laguna and Rizal provinces including parts of Batangas, Cavite and Quezon or collectively known as the CALABARZON, one of the fastest growing economic zones in the country. It traverses 12 cities, 49 municipalities and 2,656 barangays (See Figure 12).

The watershed comes from igneous and sedimentary rocks overlain by alluvial deposits (Reconnaissance survey 1966). The landscape is characterized by mixed topography where 35 % is gentle, 45 is % rolling, 15 % is steep and 5 % is very steep slope. In the shoreline, the topography is relatively flat.

[9] This section from the Draft Report of the Ecosystems and People: the Philippine MA Sub-Global Assessment, 2003.

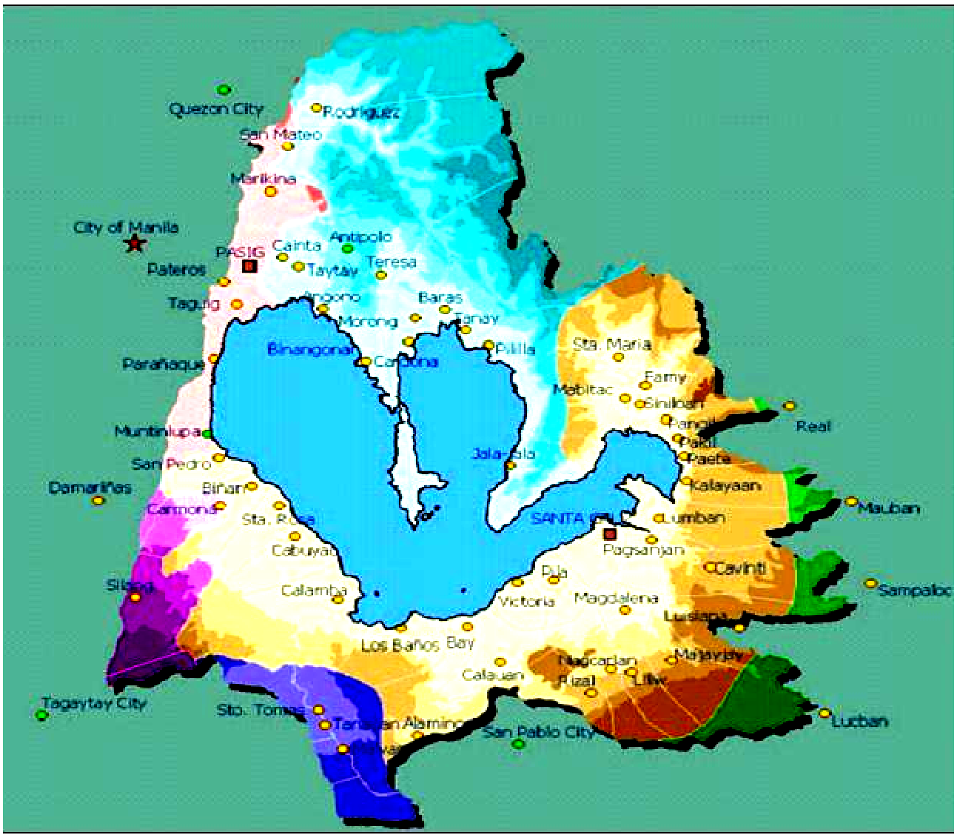
The whole region is under two climatic conditions Type 1 and Type IV. The former is distinguished by two distinct seasons, dry from November to April and wet from May to October while Type IV is characterized by evenly distributed rainfall all throughout the year. The lowest air temperatures and highest wind velocities occur from December to February. This causes high water turbulence resulting to high water turbidity. As a consequence, low fish growth is experienced even with ample supply of free nutrients.

The Laguna de Bay is one of the five largest freshwater lakes in Southeast Asia and considered as one of the Living Lakes in the world. It occupies a total surface area of approximately 90,000 ha with a shoreline of 238 km. It has an average depth of 2.5 m and a maximum water holding capacity of about 2.9 billion cu. m.

In the dry season, the functional minimum water level of the lake is about 10.5 m. At the end of summer, water level may drop below the high tide level of Manila Bay allowing the influx of seawater to the bay through the Pasig River. This permits highly polluted waters to enter the lake which causes an increase in water salinity (Francisco 1985).

There are a number of uses for the lake. While the most dominant use is fisheries, it is commonly used for transport, waste sink, electricity generation, irrigation and industrial cooling. In addition, the lake is used for recreation, as floodwater reservoir and finally, as source of potable water.

Figure 12: Geographical boundary map of the Laguna Lake Watershed



The total land area of the watershed is approximately 290,320 ha. As of 2000, agricultural lands were 150,966 ha (52 %), open unproductive grasslands were 40,645 ha (14 %), forested lands were 14,516 ha (5 %), and built-up/industrial were 84,193 ha (29 %). The emergence of built-up/industrial areas as a new landuse and the contraction of forest lands within the basin reflects how the region is transforming into a more industrialized zone.

Flatlands bordering the lake are intensively farmed with a variety of crops e.g. rice, sugar cane, etc. In 1963, the total irrigated rice-cropping areas were estimated to be 18,453 ha. Twenty years later, it rose to 38,120 ha giving a 100 % increase.

Mountainous areas such as former forestlands, grasslands and areas with moderate slopes are planted to bananas and coconuts (Francisco 1985). Sometimes in marshy places near the coastal regions, fishponds and duck farms are established.

One important forest resource within the watershed is the 4,244 ha of Makiling Forest Reserve (MFR). As a natural resource, the MFR is very vital to the region, providing irrigation, industrial and domestic water supply to the surrounding communities. The reserve acts as an important catchment area for the bay while Mt. Banahaw and Mt. Makiling as a whole helps in the generation of electric power through the Mt. Makiling-Banahaw Geothermal Power Plant.

There are a total of 3,773 industries situated within the watershed. From this, 599 establishments are wet industries, 591 are dry, 890 are considered as wet and dry while 229 are unclassified.

Because of its proximity to Metro Manila, the spill over effect has greatly affected the change in land use in the region. The previously planted rice paddies, coconut fields and sugar plantations have been converted into residential lands and industrial areas. This uncontrolled urbanization has led to the permanent loss of precious land resources.

Biological Components

The watershed is rich in biodiversity. The Makiling Forest Reserve alone has an estimated flora of at least 225 families, 949 genera, 2,038 species, 19 subspecies, 107 varieties and many cultivars of flowering plants. This excludes the 37 species of mosses, 67 species of fungi, 29 species of fern and 42 species of liverworts (Rebugio et al. 1998).

In terms of faunal diversity, a total of 313 species of vertebrates inhabit MFR. This includes 22 species of amphibians, 65 species of reptiles, 181 species of birds and 45 species of mammals. From this, 135 species are endemic to the place where 60 % of these are amphibians and 40 % are birds, mammals and reptiles.

The Laguna Lake Basin is equally rich in aquatic flora and fauna. The floral diversity includes 156 species of algae where 27 species are Euglenophyta, 24 species are Cyanophyta, 51 species are Chlorphyta, 51 species are Chrysophyta, and 3 species are Pyrrophyta (Martinez 1978). Aquatic angiosperms contribute 24 genera and species representing 19 families of marginal, littoral and limnetic plants (Aguilar et al. 1990). All these serve as food, shelter and nesting ground for a variety of marine wildlife.

LLB's faunal diversity includes 23 species of fish belonging to 16 families and 19 genera (Delmendo and Bustillo 1968). Its fishe diversity is considered as one of the most richest in the world (Guerrero 1982).

Socio-Economic Conditions

The region represents about 1.3 % of the country's land area. Within this limited space, 6,601,514 people reside or 9 % of the total population of the country (Census 2000). This is with an estimated annual growth of 4.99 % which includes natural births and in-migration from other parts of the country.

Because of the proximity of the watershed to Metropolitan Manila, the spillover into rapid urbanization of the suburbs of Rizal and Laguna has resulted to the expansion of the Metropolis. The watershed offers its communities both a chance to work in the industrial as well as in the agricultural sector being at the heart of Southern Tagalog and at the hub of economic activities.

In 1990, the watershed contributed about P 101.3 billion to the Gross Regional Domestic Product (GRDP) of Region IV. It produced a total of $ 257.073 million worth of exports excluding the P 38.84 billion worth of local and foreign investment. The watershed also has an estimated labor force of 6.1 million that is projected to increase to 8.5 million in ten years. All these factors sum up to the suitability of the watershed for economic development.

Eighty percent of the people living in the watershed are highly educated. This could be attributed to the different learning institutions e.g., UPLB, IRRI, etc. situated in the region. As a result, the annual family income and standard of living in the region is higher compared to other parts of the country.

Institutional Arrangements

Republic Act 4850 of 1966 created the Laguna Lake Development Authority (LLDA) as a government-owned corporation to carry out the development of the Laguna de Bay Region. Presidential Decree (P.D.) 813 of 1975 further expanded LLDA's mandate to address environmental concerns and conflicts over jurisdiction and control of the lake. Executive Order (E.O.) 927 of 1983 further strengthened the institutional, financial and administrative responsibilities of the Authority including its regulatory functions in industrial pollution.

Although LLDA is administratively attached to the Department of Environment and Natural Resources (DENR), it maintains its separate policy-making functions through the Board of Directors. The LLDA acts and decides upon policy matters; not all are necessarily elevated to the DENR Secretary for final approval. The LLDA Board sets the policies and directions for the operations of the Authority. It has the authority to formulate, prescribe, amend and repeal rules and regulations governing the conduct of business of the LLDA.

Through a series of enabling laws, LLDA's mandate has significantly expanded. It covers planning and policy making, environmental regulation, and infrastructure development.

The all-encompassing powers of LLDA are shown in its authority to pass, approve, or disapprove all plans, programs, and projects proposed by all LGUs and public and private corporations. In 1997, LLDA pioneered the implementation of a EUFS (Environmental User Fee System) as a market-based instrument to induce polluters to abate wastewater discharges. LLDA's mandate allows it to introduce a wide range of innovative policies. It was the first agency in the Philippines to apply concepts of natural resource pricing in the form of fishpen fees and, more recently, the imposition of wastewater discharge fees.

Because there are a number of stakeholders in the LLB, coordination will be a key role for LLDA in overseeing the management of the Laguna Lake. However, coordination will remain difficult if policy making does not involve those who have a direct stake in the problems.

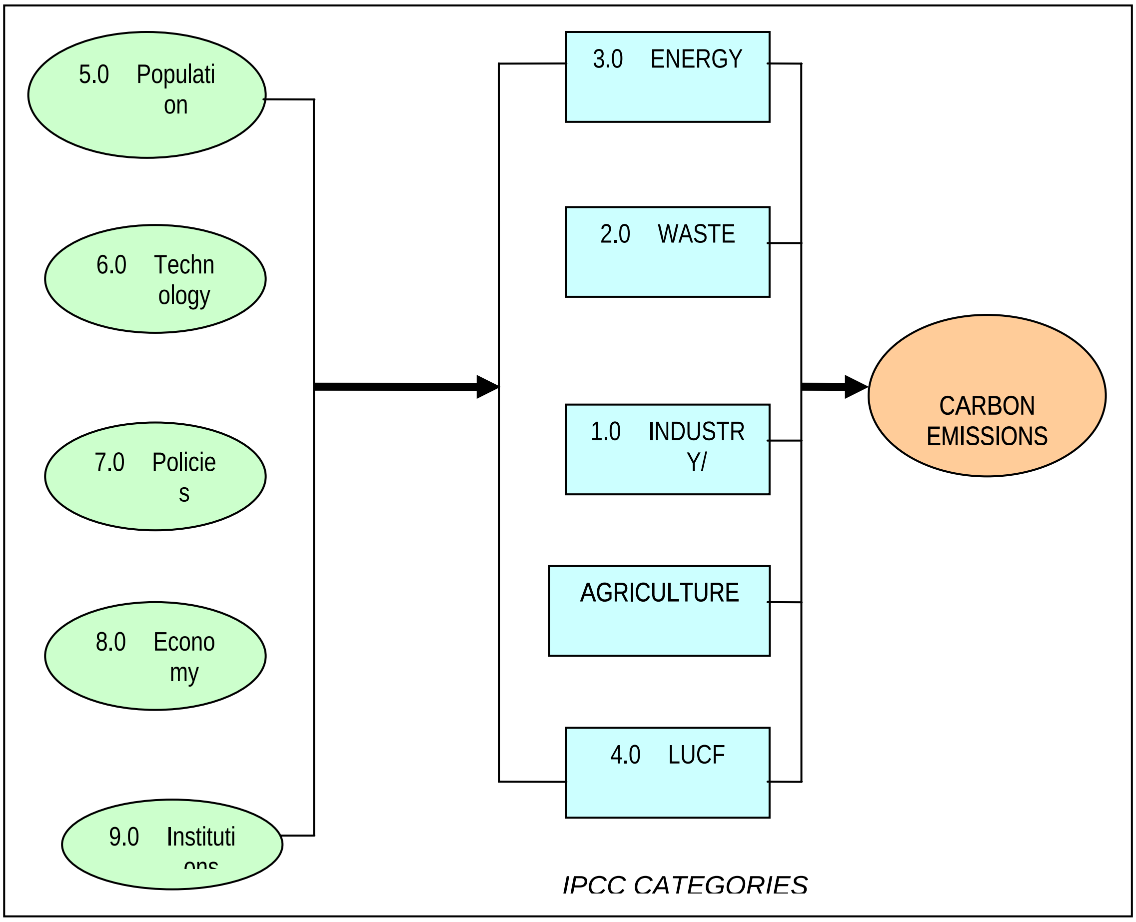
9.6 IMPLICATIONS TO CARBON BUDGETS

Drivers of Carbon Emissions

The framework of the study shows that the there are direct and indirect drivers of carbon emissions (Figure 13 and 14). A direct driver can be defined as one that "unequivocally influences ecosystem processes and therefore can be identified and measured to differing degrees of accuracy" (WRI, 2003). In contrast, indirect drivers "operate more diffusely, from a distance, often by altering one or more direct drivers. This typology is parallel to "primary" and "proximate" drivers that are widely used in the landuse change and climate change literature (Lambin et al., 2003; Turner et al., 1992; IPCC, 2002). Typically, indirect drivers are demographic, economic, sociopolitical, scientific and technological, and cultural and religious (WRI, 2003). In contrast, direct drivers are mainly physical, chemical and biological such as climate change, air and water pollution, and use of fertilizers.

In the context of this study, direct or proximate drivers are equated with the IPCC sectors (energy, waste, industry and use of solvents, agriculture and landuse change and forestry or LUCF). These are driven by indirect or primary drivers like population, technology, policies, economy and institutions.

Figure 13: Analytical Framework of the Study



Metro Manila

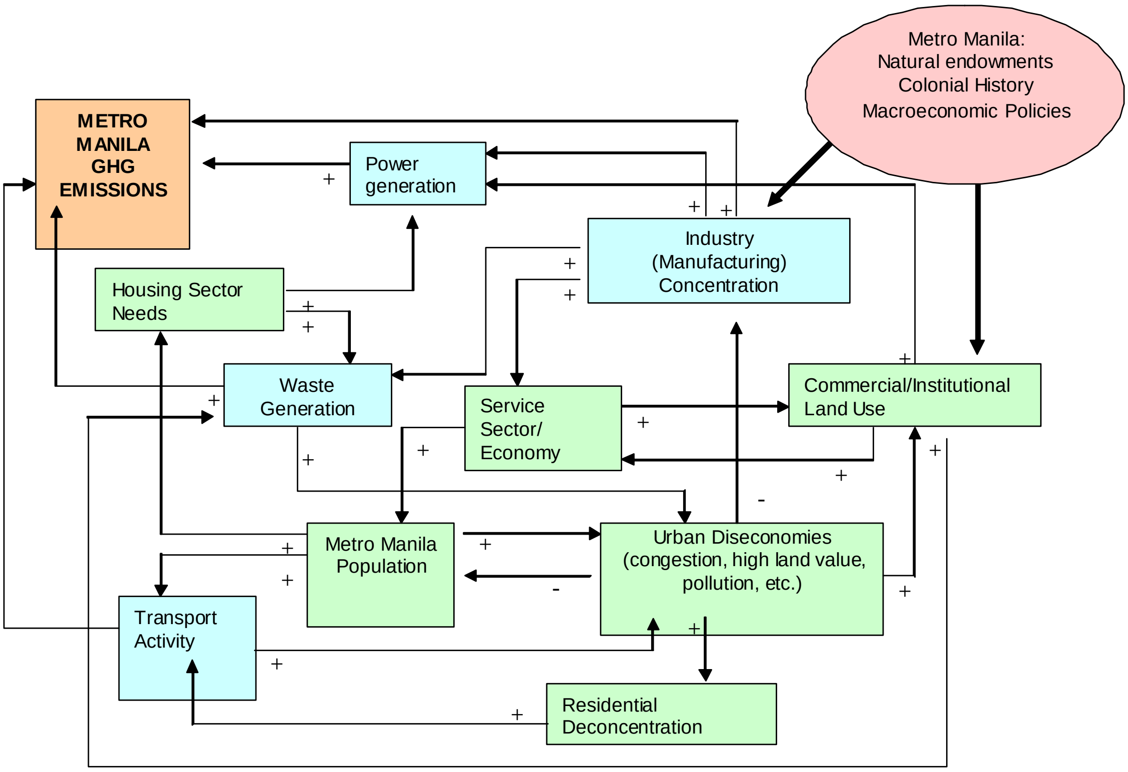
Metro Manila's natural strategic location as entry point to the country, its colonial past, the government's macroeconomic policies, and global economic forces shaped it into the country's dominant region and showcase for the national government's thrust on economic development. It is for these reasons, also, that the largest concentration of large- to small-scale industries is found in Metro Manila. It is estimated that 16% of the country's 19,000 industrial firms are located within its boundaries of 636 sq. km. (Corpuz, 1997). The problem of pollutant emissions from industrial activities are traced to macroeconomic incentives that promoted the use of technology intensive intermediate outputs in the Philippines, particularly during the import-substitution period (1948-1967) when fiscal and trade policies promoted the importation of intermediate input, particularly energy-intensive technology. As production levels of industry increases, the use of energy-intensive inputs become limitless. This results to larger industrial waste stream from the greater discharge of residuals, more energy use, and more post-consumer waste (Cruz and Repetto, 1992, as cited by Corpuz, 1997). Attempts to change the locational patterns through the setting up of industrial estates and export processing zones had little impact (Pernia and Israel, 1984). This concentration of activity, rather than the rapid growth of the manufacturing sector led to the increasing concern about the impacts of industrial pollution in Metro Manila.

Meanwhile, the ballooning contribution of the services sector in the regional economy and the high value of land, which is a disincentive for other competing land uses (residential, industrial), reinforce the dominant commercial function of the metropolis. The flurry of commercial activities and natural population growth, particularly in the fringes of the metropolis, are expected to push further the demand for electricity and other goods and services from both the commercial and residential sectors.

Residential decentralization in Metro Manila is suggested by the declining densities from the inner core of MM. The suburbanization of the metropolitan fringes and the adjacent provinces is foreseen as the reaction of the growing middle class to high land values, traffic congestion and overcrowding in the metropolitan core. This expansion of urban areas directly affects transport activity in the metropolis by increasing the distance traveled from the residence to the workplace, and that required for hauling good and services.

The anticipated growth in transportation activity in Metro Manila is a major problem to contend with because the metropolis and adjoining areas are already suffering from severe traffic congestion. As of 2003 the total number of motor vehicles registered in Metro Manila was 1.4 million, or 32% of the country's total number of registered vehicles (LTO Statistics). Average travel speed in Metro Manila is 10 km/hr, only slightly faster than that of Bangkok, which is the major Asian city with the slowest travel speed (World Bank, 2001). The Metro Manila Urban Transportation Integrated Study (MMUTIS, 1999) predicted that the share of private vehicle use in all motorized trips in Metro Manila would increase from 21% in 1996 to 34% in 2015, mainly due to the increase in car ownership, while public transport will have a corresponding decline-79% to 66% during the same period. The anticipated shift from public transport to private transport due to increase in incomes and car ownership, and the increase in average trip length brought about by the expansion of urban areas would cause heavier traffic load in the future (MMUTIS, 1999). Globally, transport already accounts for about 21% of total CO_2 emissions and this will likely remain until 2020 (Gorham, 2002). Transport CO_2 emissions are predicted to grow by 92%, unmatched by any other sector except power generation. Since the amount of CO_2 emissions from the combustion of a given quantity of gasoline remains constant regardless of emission controls, trends in CO_2 emissions will closely follow the future increase in the consumption of fuel, further exacerbating the greenhouse effect (World Bank, 2001). Experience in developed countries has shown that growth in transport emissions is overwhelmingly driven by the growth in transport activity (i.e., increase in vehicle use *per se*), such that the effects of emission mitigation efforts, such as improvements in the fuel economy of vehicles and the C composition of fuels will likely be muted (Gorham, 2002).

Figure 14: Drivers of carbon emissions in Metro Manila.



Laguna Lake Basin

Unlike Metro Manila which has been completely urbanized since the 1970's and is supported by a manufacturing base, the LLB can be characterized as having both significant industrial and agricultural sectors. The major land use in the LLB is agricultural, accounting for 52% of the basin's total land area (LLDA website, 2003). From this sector, domestic livestock raising and rice paddy cultivation are important sources of methane emissions. A portion of the rural sector is also dependent on the forest for their livelihood; these extractive activities, particularly fuelwood collection, mining and quarrying, illegal logging and shifting cultivation emit CO_2 and other GHG's into the atmosphere.

Rapid urbanization, especially in the areas adjacent to Metro Manila, is also seen as a major factor that drives the path towards increased GHG emissions in the basin. This is seen as the consequence of the basin's proximity to the industrial capital of the country, making it a direct recipient of any spillover effects of development activities in Metro Manila, and the industrial dispersal and export promotion polices of the government which directed a large portion of the country's foreign direct investments into the area and led to the rise of industrial estates, particularly in the provinces of Cavite, Laguna and Batangas starting in the 1990's. These have important implications to the problem of GHG emissions. The population of the basin is estimated at 6.6 million in 2000 and is growing at a rate of 4.99%, higher than that observed for Metro Manila and the whole Philippines; to accommodate the influx of people, large tracts of agricultural lands, grasslands and open areas are being developed for residential use. With the growth of the local economy also comes the building of commercial, industrial and transportation infrastructures that require large quantities of energy-intensive materials such as cement and steel. As industry and labor force become more concentrated in rapidly urbanizing municipalities, food and materials will be hauled over longer distances and thus directly affects transportation activity. These anticipated changes affect GHG emissions not only because of increases in the absolute amounts of energy requirements, waste generation, and process emissions in the basin. The lifestyle changes associated with urbanization may cause a shift of preference from traditional biomass fuels (wood, crop wastes, animal dung), to commercial (fossil-fuel based) fuels and technologies if and when they are affordable, thus affecting the carbon intensity of energy use.

9.7 Characterization of Carbon Emissions from Metro Manila and the Laguna Lake Basin

According to the Philippines' Initial National Communication on Climate Change (1999), the country released into the atmosphere a total of 100,738 Gg of CO_2-e in 1994. Sources of emissions are the four sectors of Energy, Industry, Agriculture and Wastes, while a net CO_2 uptake of 126 Gg is associated with the LUCF sector. Excluding the contribution of the still-controversial LUCF sector, the national emissions in 1994 amount to 100,864 Gg of CO_2 equivalents (Table 13)

Table 13: Summary of the Philippine greenhouse gas inventory (GGI) for 1994

Sector	CO_2 Emissions (Gg)
Energy	50,038
Industry	10,603
Agriculture	33,130
Wastes	7,004
Land Use Change and Forestry	-126[a]
Total	100,864[b]

[a] the LUCF sector was considered a net sink of CO_2 in 1994

[b] values do not add up due to rounding

Of the non-LUCF sectors, Energy accounted for 50% of total GHG emissions, followed by Agriculture (33%), Industry (10%) and Wastes (7%). From the Energy sector, GHG emissions come mainly from the subsectors of power generation and transportation, while for the Agriculture sector, these would be rice paddy cultivation and domestic livestock raising. Emissions from the Industry sector are attributed mainly to process emissions from cement and metal industries, while solid wastes account for most of CH_4 emissions. Projections for the year 2008 peg the total national GHG emissions at 195,091 Gg, or an increase of 94% relative to 1994 levels. This translates to an annual growth rate of 4.8% (across all sectors considered). Because only future emissions from the major subsector- sources were projected and those from minor sources were kept at 1994 levels, the figure can be considered a conservative estimate (Merilo, 2001).

Considerable efforts have been spent analyzing the air pollution problem of Metro Manila (URBAIR, ENRAP, Rolfe), but most of these address local air pollutants (mainly particulate matter, SO2 and NOx), or indirectly refer only to GHG's. An inventory of GHG-related emissions from Metro Manila was prepared by the EMB (Environmental Management Bureau) as part of government's initiatives to meet its commitments to the UNFCCC. However, our major source of information is the study conducted by Ajero (2002a & b). To date, it is the most comprehensive treatment that we have encountered in literature, in that the author attempted to trace emissions by major sector and constructed both historical- and predicted emissions data. Perhaps reflecting the growing concern over the impacts of mobile sources, two studies (ARRPEEC-II, 2003; Borlaza, 2004) made independent projections of CO2 emissions from the transport sector. CO2 emissions from power plant operations in Metro Manila were estimated in two other studies (Corpuz, 1997; Krupnick et al, 2003) as part of case studies on mitigation options for controlling air pollution from the industrial sector. No estimates on emissions from LUCF in Metro Manila were given in the Ajero study; the contribution of the LUCF sector is small because sizable forest areas are located only in LLB. The work of Ono and others (2003) found that even if 80% of the total area of Metro Manila becomes covered with forests, only 0.8% of the region's annual emissions can be sequestered by the vegetation10. Different procedures, assumptions and parameter estimates were used in these studies, and in some, non-CO2 GHG gases were not included in the emission estimates.

An inventory of emissions from Agriculture and LUCF sectors within the LLB for year 2000 was conducted by Lasco and Pulhin (2003). Agriculture and LUCF are considered to play a major role in GHG emissions because of the dominant agricultural land use of the LLB, unlike in Metro Manila where their impacts are considered insignificant. An inventory on the Energy, Industry and Wastes sectors specific to LLB is yet to be conducted, which presents a large information void. For estimating GHG emissions from the Industry sector, the nearest reference that we came across was the Initial Report on Greenhouse Gases Emission from the EMB (EMB, 2003), containing a partial estimate of industrial emissions from the CALABARZON region, which encompasses a larger area. The fact that a portion of Metro Manila falls within the geographical boundaries of the Basin also presents another level of difficulty for tracking emissions, because of still- largely unavailable disaggregated (i.e., municipal-level) data. Bearing these data limitations in mind, carbon emissions from the two study areas are characterized.

For Metro Manila, power generation (electricity consumption from the residential, commercial and industrial sectors) and transportation shared the larger part of total carbon emissions (Table 14). For instance in 1980, power generation contributed around 47% of the total carbon emissions, while the transportation sector contributed 42%. In 1990, the power generation and the transportation sector contributed 36% and 52%, respectively while in 2000, 39% of the total carbon emission came from power generation and 51% came from the transportation group. This trend is expected because Metro Manila houses around 10 million people and a number of commercial establishments and industries. Together, the two sub-sectors under Energy make up 90% of total emissions for the region, which is much higher than the 50% share of Energy in national GHG emissions. The percent contribution of Wastes and Agriculture are rather small. In 1980 and 1990, waste sector contributed 11% only of the total carbon emission in each inventory period while in 2000 the sector mentioned contributed around 9%. The agriculture sector shared 0.5% in 1980 while in 2000 it added 1.2% in the total carbon emission. The agriculture sector has little contribution to the total emission of Metro Manila because of the small area devoted to agriculture and most spaces are allocated for establishment of industries, commercial buildings and houses.

[10] The same study estimated the net CO_2 sequestration from vegetation in Metro Manila at 29.4 Gg/year, which is only 0.2% of annual emissions, estimated at 14,500 Gg/year.

Table 14: Carbon emissions (Gg CO_2) in Metro Manila and Laguna Lake Basin by sector (figures in parentheses are percent contribution)

Sector	1980		1990		2000	
	Metro Manila	Laguna Lake Basin	Metro Manila	Laguna Lake Basin	Metro Manila	Laguna Lake Basin
Energy (Electricity Consumption)	3858.63 (46.8)		4663.55 (36.3)		9053.27 (38.7)	
Energy (Road Transportation)	3456.94 (42.0)		6632.57 (51.6)		11846.63 (50.6)	
Waste (Solid waste)	885.36 (10.7)		1453.41 (11.3)		2219.91 (9.5)	
Agriculture	39.24 (0.50)		92.02 (0.72)		283.63 (1.2)	1,298.7
Land use change and forestry						924
Total	8240.17		12,841.55		23403.44	2222.70

Sources: Ajero, 2002a (for Metro Manila); Lasco and Pulhin, 2003 (for LLB)

GHG emissions from agriculture and LUCF sectors in the adjacent Laguna Lake Basin amounted to 1,299 and 924 k ton CO_2, respectively in the year 2000 (Tables 15 and 16). In the agriculture sector of the LLB, sources of GHG emission include: (1) domestic livestock; (2) ricefields; (3) grassland burning; (4) burning of agricultural residues; and (5) agricultural soils. Domestic livestock accounts for the largest contribution of emissions from this sector (54%), followed by rice cultivation (24%).

Table 15: Summary of GHG emissions from agriculture sector of LLB for 2000

Source	b) Emission type				CO_2 Equivalent (k ton)	% Share
	CH_4	N_2O	NO_X	CO		
Domestic Livestock	33.1	0.0			694.2	53.5
Rice Cultivation	14.8				310.4	23.9
TOTAL	48.0	0.9	0.1	3.0	1,298.7	100.0
CO_2 Equivalent	1,007.6	291.1				

Source: Lasco and Pulhin, Second Draft (2003)

In the LUCF sector, anthropogenic activities in the form of land use conversions and deforestation activities emit CO_2 to the atmosphere through biomass burning, decay, and carbon release from the soil. However, the LUCF sector becomes a sink of carbon when there is biomass growth of existing forest and non-forest stands, and biomass regrowth in abandoned lands. Biomass growth resulted to more than 2,000 Gg CO_2 sequestered from the atmosphere, which is about 3% of the Philippines' total removals by sinks based on the 1994 national GGI. However, the LLB is a net source of GHG's, releasing around 924 Gg CO_2 in the year 2000. This may be attributed to high fuelwood consumption by the residents of the Basin, and burning and decay, which are primarily associated with the clearing of forests for agricultural purposes.

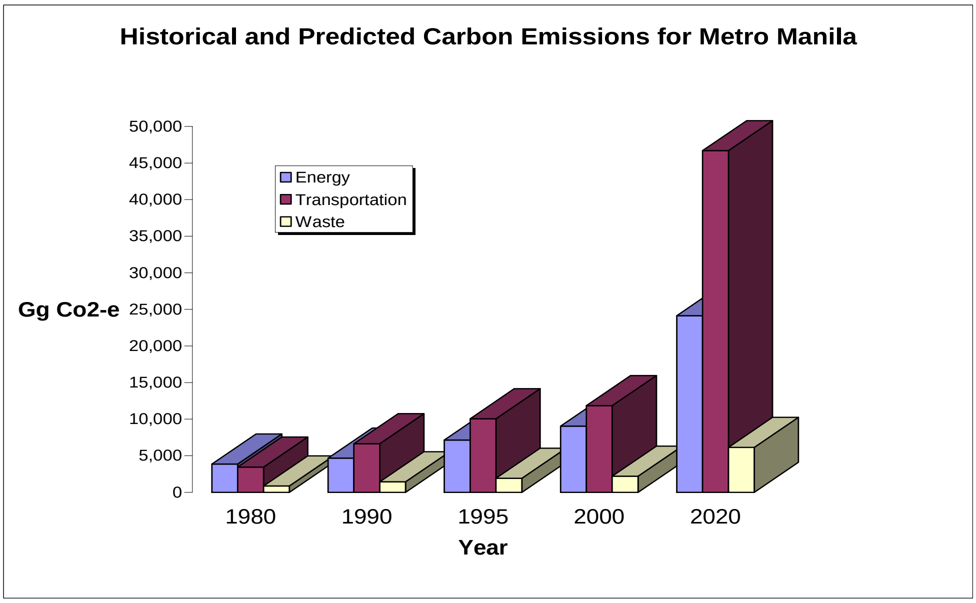
Table 16: Summary of GHG emissions and uptake of the LUCF sector in the LLB for 2000

Sub Sector	CO_2 Equivalent Emissions(+) and Uptake(-) (k ton)
Change in Forest/Woody Biomass	800
Biomass Growth	-2,148
Roundwood/Fuelwood Harvests	2,948
Forest/Land Use Change	124
On Site Burning	52
Off Site Burning	12
Decay	59
TOTAL	924

Source: Lasco and Pulhin (2003)

The analysis by Ajero (2002b) showed that Metro Manila increased GHG emissions from non-LUCF sources from 10,100 Gg CO_2 in 1980 to 25,100 Gg CO_2 in 2000 (Figure 15). Emissions from the three studied sectors will continue to rise in the future. In particular, the transportation sector is foreseen to contribute to more than half of the total future emissions, with a projected three-fold increase in 2020 relative to 2000 emissions. The shares of the energy and waste sectors, meanwhile, will decline (Ajero, 2000b). The increasing trend in GHG emissions is parallel to the growth of Metro Manila in terms of population and industrialization. If this trend continues, total emissions from these sectors is expected to rise even more. Clearly this pathway of development will have adverse impacts on the earth's climate.

Figure 15: GHG emissions from Metro Manila from 1980 to 2000 and predicted emissions in the year 2020. (Note: data from Ajero, 2002a,b; Agriculture and LUCF sectors not included)



The combined GHG emissions from Metro Manila-LLB in the year 2000 amounted to 27,343 k ton CO_2-e (Figure 16). This value gives an idea of the total emissions of Metro Manila and the Laguna Lake Basin. This could be a fair estimate considering that MM has hardly any forest cover and land cover change emissions, while the rest of LLB has much fewer industrial activity. Those portions of LLB with the highest concentration of industrial activity (west bay of Laguna Lake) are within Metro Manila. The only exception to this is the export processing zones in the Laguna province which may be emitting substantial amounts of carbon.

The importance of Metro Manila as a source of carbon emissions is evident in the fact that it contributes 27-63% of total Philippine GHG emissions from energy, transportation and waste (an average of 50% across all sectors) as can be seen in Figure 17. The preceding sections of this paper show how Metro Manila evolved to its present state. This pathway of development was supported largely by increasing carbon emissions. The challenge is to find ways by which cities like Metro Manila can develop and moderating the increase in the intensity of carbon/GHG emissions.

Figure 16: Total GHG emissions from MM-LLB for the year 2000 (data from Ajero, 2002 and Lasco *et al*., 2003)

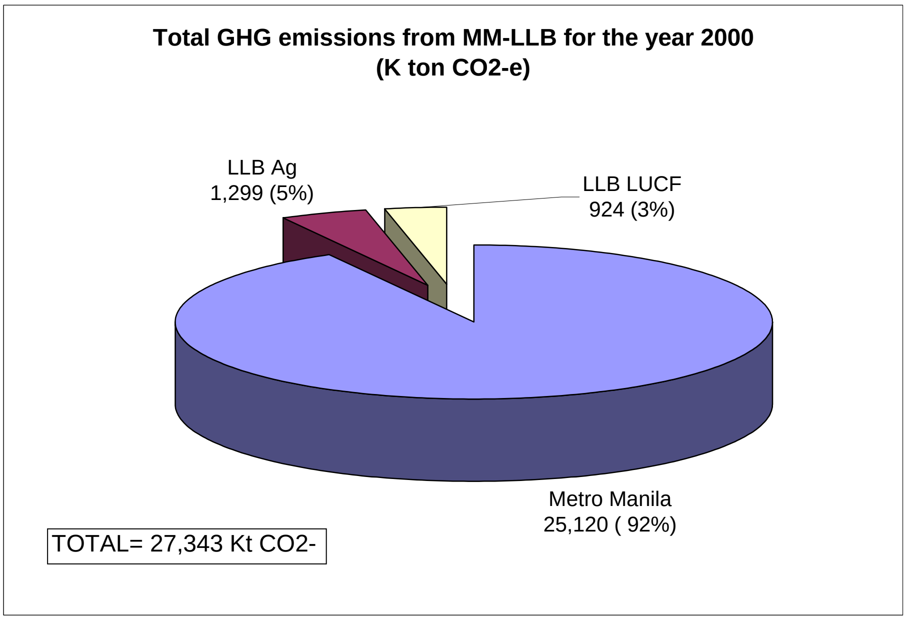
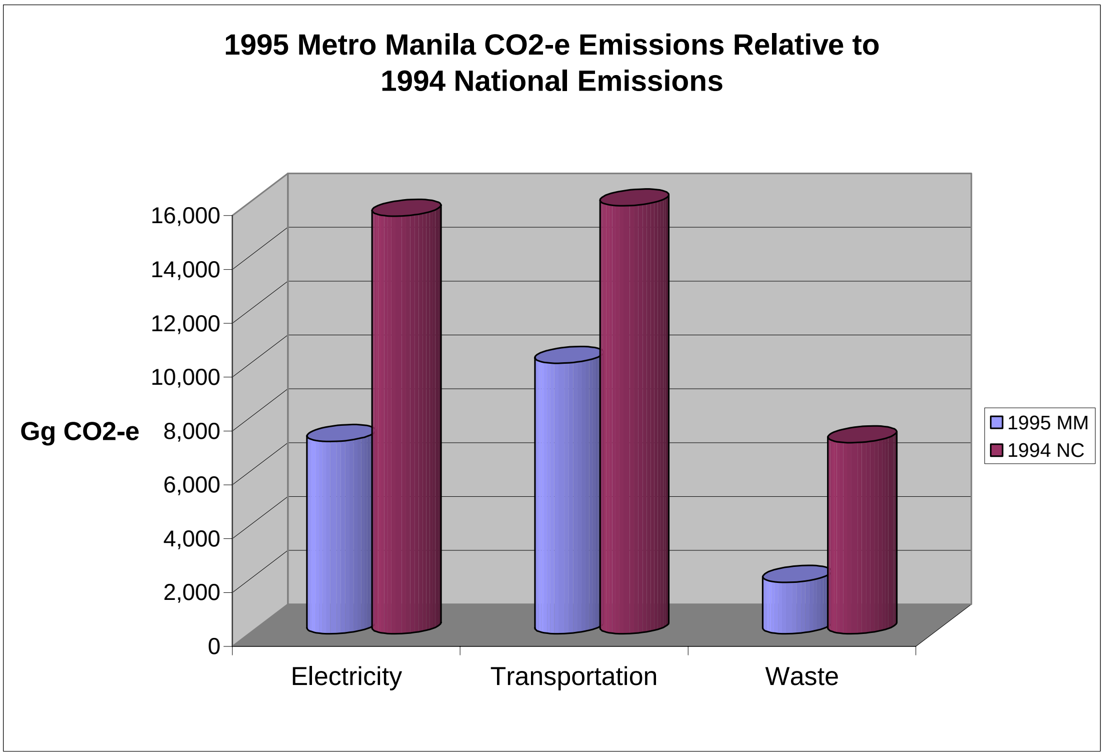


Figure 17: GHG emissions from Metro Manila relative to the emissions from the whole Philippines.



9.8 PATH TO DECARBONIZATION

In the Philippines, while urban centers like Metro Manila drive economic growth, urbanization in recent years is closely associated with the expansion of non-traded personal services. Gonzales and co-workers (2001) contend that to achieve long-term economic growth, the links between urbanization and industrial growth should be reestablished. Adequate industrial capacity in the form of light and medium industries will be needed to fuel economic growth because of the locational flexibility, higher-value added, greater employment-generation capacity it offers. At the same time these industries need to be dispersed in order to achieve balanced regional growth (Gonzales et al, 2001). This drive towards industrialization and the needs of the growing population will depend on increased energy supply.

Data indicate that developing nations like the Philippines are replicating the development paths pursued by OECD nations in terms of their energy and mineral demands (Clark, 1993). Several factors may impact and retard this path; these include declining rates of economic and population growth, conservation, substitution, increased efficiency of energy use and alternative development paths. However, Clark (1993) grimly points out that these factors mainly extend the time frame of energy and mineral consumption and development, and will not decrease total demands in the nations of Southeast Asia over the long term. For many developing countries GHG mitigation has a negative connotation because of the perception that this will deny them of their basic right to growth in human services and economic activities; the prospects of “reduced growth” or “no growth” are not feasible, although more efficient growth is certainly desirable. According to Schipper and Marie-Lilliu (1998) the key to erasing this perception is “ to link GHG mitigation efforts to policy initiatives in other sectors with goals that are perceived to be of far immediate and greater relevance than GHG mitigation, and to try to uncouple or at least flex the heretofore rigid link between economic growth and GHG emissions.”

Policy and Institutional Responses, Technological Options and Mitigation Measures

The Philippines is a non-Annex I Party to the UNFCCC, and as such does not have any obligation to reduce or limit its anthropogenic emissions of GHG’s. However, even in the early 1990’s, the country has already initiated efforts to address the issue of climate change. These consist of policy and institutional developments that significantly respond to the ultimate objective of the UNFCCC (Merilo, 2001).

In 1991, the Philippine Inter-Agency Committee on Climate Change (IACCC) was created by Presidential Order No. 220 and consists of 15 government and non-government representatives. It is tasked to coordinate climate change-related activities, develop, update and publish information on GHG inventories, propose climate change policies and prepare government Positions in UNFCCC negotiations. Under its supervision, a National Action Plan on Climate Change was formulated to integrate climate change concerns into the government’s development plans and programs.

The last decade also saw the approval of laws that address climate change concerns in the Philippines. One is the Agriculture and Fisheries Modernization Act (AFMA) of 1997, which provides for the development of methodologies for monitoring the effects of global climate changes for the forecasting and formulation of programs for agriculture and fisheries production in the country. Another is the Clean Air Act (CAA), signed into law in 1999, which aims to provide a comprehensive air pollution control policy for the country. The implementation of the IRR of the CAA is designated to several government agencies (Appendix 2).

In the past, national laws on energy have been formulated to ensure an adequate supply of energy, rather than provide for energy systems that maximize efficiency and equity in use among all users

(Robinson, 2002). As a result, energy law has developed without much regard for the negative environmental impacts of energy generation, leaving nations with little experience to face the challenges that will be imposed by the implementation of international agreements such as the reduction of CO_2 emissions required under the Kyoto Protocol, or the application of the environmental impact assessment to energy sector projects as is required by national EIA laws (Robinson, 2002). There are pending bills in Philippine Congress that aim to address these challenges in the energy sector, namely, 1) New and Renewable Energy Program Act; 2) An Act to Institutionalize Energy Conservation and Enhance Efficient Use of Energy, and 3) An Act to Strengthen the National Program for the Development and Promotion of the Use of Non-Conventional Energy Systems.

Mitigation measures to limit GHG emissions are reflected in various sectoral plans of the government. The specific programs and projects under each sectoral plan (as discussed in Merilo, 2001) are listed in Appendix 3. Various programs and projects have also been launched by government- and non-government initiatives in cooperation with international agencies. These include the Asia Least-Cost Greenhouse Gas Abatement Strategy (ALGAS) which identified twelve least-cost mitigation options for the Philippines; the National Action Plan on Climate Change, and the Enabling Activity on Climate Change, which aims to strengthen capacity-building, education, training and raising awareness of the IRR of the Philippine Clean Air Act.

The DENR through its EMB Air Quality Management section, together with other organizations, is presently implementing strategies to reduce air pollution in the major airsheds[11] of the country. These strategies come in the form of policy reforms and investment requirements integrated within a policy matrix known as an Air Quality Action Plan. The Air Quality Action Plan components include a motor vehicle inspection system, an industrial emissions pollution abatement program, production of cleaner fuels, introduction of anti-pollution devices, traffic management and road rehabilitation program, ambient air quality monitoring, raising public awareness, capacity building and institutional development (EMB Updates, 2001).

Non-government organizations (NGO's) also play an active role in the formulation of policies and measures to address climate change. The Philippines has one of the most developed NGO communities and people's organizations (PO's) in the Asia-Pacific region (JICA, 2002). NGO's and PO's can exert pressure on the government to make prompt policy and institutional reforms favoring the climate change mitigation agenda. One example that shows the enormous political influence of the non-government sector in pushing specific environmental agenda is the successful inclusion of a provision in the Philippine Clean Air Act banning the use of all forms of incinerators. This was successfully lobbied by environmental NGO's despite the garbage crisis that was happening in Metro Manila at the time the Act was being deliberated on in the Philippine congress (Katayama, 2003).

Local Initiatives Related to GHG Mitigation

For Metro Manila and the Laguna Lake Basin as well as other developing urban centers in the country, our view is that the path towards a less carbon-intensive development relies on the successful implementation of existing national sectoral plans on GHG mitigation, most important of which are policy and structural reforms in the energy sector. Our review of literature shows that opportunities to address GHG emissions at the local scale are implicitly included in programs addressing the perceived immediate- and more pressing problems of urban development, such as traffic congestion, solid waste management and air pollution. The economic and political realities

[11] An airshed is a contiguous area with common sources of air pollution and weather or meteorological conditions which affect the interchange and diffusion of pollution in the surrounding atmosphere. The Metro Manila airshed includes Metro Manila, Region III (except Nueva Ecija) and Region IV A (except Quezon).

in the Philippines dictate that stand -alone programs to reduce GHG emissions may be less politically and socially feasible than those which can be coupled with other development goals. In the case of Metro Manila, two relevant programs would be the Metro Manila Urban Transport Integration Project (MMURTRIP) and the Metro Manila Air Quality Improvement Sector Development Program (MMAQISDP).

The Metro Manila Urban Transport Integration Project (MMURTRIP) is currently being implemented by the Urban Roads Project Office of DPWH, together with MMDA and towns and cities of Metro Manila, with funding from the World Bank to the amount of $60 million. It has the aim of improving the operational efficiency and safety of the transport system of the metropolis with better access to public transport and non-motorized transport. The component projects include traffic management improvements along major line corridors in Metro Manila; MARIPAS (Marikina, Rizal, Pasig) access improvements in the Marikina Valley, a secondary roads program for 15 road sections, a non-motorized transport component in the city of Marikina, and institution building/technical assistance. Improved traffic management and the provision of necessary infrastructure support for promoting public transport imply a reduction of GHG emissions from excessive and inefficient vehicle usage and more GHG-emitting modes of transport. This benefit of the project, however, was not further elaborated nor quantified. More directly, the GEF-supported component of the project, also known as the Marikina Bikeways Project, leads to avoidance of GHG emissions by promoting bicycle and pedestrian transport in the city of Marikina. The decrease in GHG emissions from this pilot demonstration project was estimated at around 400 Gg through the project's life cycle of 20 years (World Bank, 2001). It is interesting to note that this project was realized largely through the efforts and the strong commitment of the local government involved (Box 1).

Box 1: The Marikina Bikeways Project[a]

The Non-Motorized Component of MMURTRIP started from the work of the Urban Roads Project Office of DPWH with the NGO Green Forum and was subsequently endorsed by the city of Marikina for funding under the Global Environmental Facility of the World Bank. The project serves as a demonstration project of MMURTRIP that addresses GHG emissions from transport through the provision of spaces dedicated to a network of bikeways on existing roads and along the riverbanks of the city. The feasibility study for the project was followed by Bicycle Network and Institutional Studies conducted from 1999 to 2001. Marikina received the US$ 1.3 M WB-GEF Grant in 2002 for the implementation of 66 kms. of bicycle lanes in the city; pilot stretch of bikeways were inaugurated the same year.

Marikina has a high population and employment density and mixed land use. The factors that made this kind of project suitable for the city were the following: a) Many trips in Marikina are very short and all internal trips are cycling distance; b) the local people are used to discipline on the sidewalk, and c) there is a strong institutional support for cycle policy in the Marikina local government. At present, the improvement and expansion of bikeways in suitable existing roads and on the riverside is complemented by programs such as safety programs for bikers; biking lessons and promotion of biking among students and livelihood trainings on the repair of bicycles, all of which help sustain the project.

The Philippine Clean Air Act came into force as a response to the air pollution problem of Metro Manila. Air quality in Metro Manila is said to have worsened over the past 25 years, with mobile sources being the major source of local air pollutants (EMB 2003). Total emissions from vehicles increased significantly from 1990 to 1998, coinciding with the growth of registered vehicle fleet in Metro Manila from 675, 310 in 1990 to 1.2 million in 1998 (World Bank, 2000; as cited by JICA, 2002). The Metro Manila airshed has the largest concentration of industrial firms in the country. In 2002, three-fourths of industrial plants surveyed in Metro Manila were found to pollute the air, and 46% of these had no permit to operate (EMB, 2003).

A combination of pricing and administrative measures is being pursued by the government to lower emissions to healthier levels. The Metro Manila Air Quality Improvement Sector Development Program (MMAQISDP) is an ADB-funded program that aims to promote the use of cleaner fuels and implement a vehicle inspection program. The program components include a motor vehicle inspection system; industrial air emissions pollution abatement program; production of cleaner fuels; introduction of antipollution devices such as catalytic converters; anti-smoke belching; road rehabilitation; ambient air quality monitoring; public awareness raising, capacity building and institutional development. While these mainly address local air pollution, potential synergies with GHG mitigation may come in several forms. One of these may be the use of market-based instruments (MBI's) such as the application of pollution tax for industrial emissions of GHG's and precursors. Although in its infancy stage, the use of MBI's as incentives for companies and as revenue-raising option for the government has found acceptance in the Philippines and is even featured prominently in the Clean Air Act (Corpuz, 1997; Krupnick et al, 2003). Emissions fee, in particular, have been used in the Philippines and has strong political support. The LLDA has been implementing an environmental user's fee (EUF) to lower the BOD (biochemical oxygen demand) load of industrial effluents flowing into Laguna de Bay. The program has been well received, and there has been a 75% reduction in the BOD load of the lake waters from 1993 to 2000, although to what extent the reduction can be attributed to the implementation of the EUF was not formally investigated (Krupnick et al, 2003).

For the transport sector, the economic and technological feasibility of several GHG mitigation options have been analyzed (ARRPEEC-II, 2003; Borlaza, 2003). Among those feasible options identified included the use of alternative fuels, engine design improvements and travel demand management and driver education. Likewise, subtle forms of mitigating measures in the areas of urban land use planning and architecture have been proposed for Metro Manila (Hoyano *et al*. 2002; Moriwake et al, 2002) (Appendix 4). There are no policies or programs directly addressing climate change in general, for the Laguna Lake Basin. For the agriculture and LUCF sectors, however, there are many policies and programs that are relevant either in enhancing adaptation or in helping mitigate climate change (Appendix 5).

Workshop Findings

A multi-stakeholder workshop for the project was organized last April 2, 2004 at Balay Kalinaw, U.P. Diliman, Quezon City, Philippines, with the aim of providing a forum for building linkages between local development planners and agencies and organizations involved in climate change issues, and getting expert opinion on ways to successfully integrate carbon management into local development planning. It was participated by thirty-six (36) officers/heads of different government agencies, non-government organizations, planning officers from Metro Manila and municipalities within the Laguna Lake Basin, and scientists and researchers from the University of the Philippines. A separate proceedings of this workshop can be found at the end of this report, and our observations/critique of the activity are in the next section.

Our synthesis of the workshop outputs (Appendix 6) reflect the findings of the literature review, in that, while the participants viewed climate change as a common major concern, their proposed measures to address carbon management at the local level are subsumed under sectoral programs that address "more felt" problems commonly associated with rapid urbanization, such as urban poverty, congestion, and health issues. Another interesting finding is that while major drivers such as energy and transport were commonly cited as priority areas, there were proposed mitigation measures that are only slightly- or not related to reducing carbon emissions (e.g. no smoke-belching, testing emissions from vehicles), indicating that the level of awareness of the underlying causes, as well as the magnitude of the interventions that need to be made towards the path to decarbonization is not high/uneven among the participants. A prominent issue arising from the discussions was the perception that while policies and programs for climate change mitigation do need to be imposed, past environmental efforts tend to fail, and among the reasons cited included the lack of a holistic approach to implementing programs and link them with strong regulation, the inability to carry out plans according to sound tehnological/scientific principles ("good intentions, bad practice") and follow through programs and projects because of the "ningas-kugon" attitude.

Opportunities and Constraints for Localized Integrated Carbon Management

The country has made advances in its efforts to meet its commitments to the UNFCCC by formulating and integrating GHG mitigation strategies into the concerned sectoral plans of the government. The enactment of the Philippine Clean Air Act is a significant development in that it has provided for an institutionalized, comprehensive approach to managing local air pollution and allows for the development of strategies that would be co-beneficial with climate change concerns. The country also stands to benefit from the Clean Development Mechanism of the Kyoto Protocol. The Philippines is still in the process of expanding its energy and production capacity to meet the demands of its growing population and the industrialization thrust, thus it has an enormous opportunity to take part in energy projects under the CDM such as renewable energy and other less carbon-intensive systems. Participation of the LUCF sector in the CDM through carbon sequestration projects can also potentially enhance the sink capacity of Philippine forestlands. Efforts are already under way to establish a national authority that will act as governing body to evaluate projects and issue certified emission reductions or credits.

A basic impediment to the formulation and eventual implementation of policies is the scarcity of available information that will facilitate reliable monitoring of GHG emissions from the different sectors/sources. Raising awareness and building the capacity of stakeholders and policymakers are also crucial as the problem of GHG emissions is of a different nature from that of local air pollution, and as such may require solutions that may be in conflict with measures to control the latter. In connection to this, the policy of devolving functions to local governments also presents a potential source of problems if local officials will not be adequately prepared.

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9.10 Appendices to Manila Case Study

Note: Lengthy appendices 1-4 from original report are not reproduced here as they are already available from government sources.

10.0 Appendix 4: Case Study Working Paper – Ho Chi Minh City

Integrating Carbon Management into the Development Strategies of Cities

Case Study: Ho Chi Minh and Surrounds

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10.1 Abstract

The integration of carbon management into the development strategies of cities in East and Southeast Asia is one of the approaches in the framework for internationally coordinated research on the global carbon cycle that was launched by the Global Carbon Project (2003) within the Earth System Science Partnership (ESSP). This report argues whether this attempt is a reality or a scientific streamline of the transition economies in which urbanization and industrialization are considered as high priorities in development. Moreover, the report also analyses appropriate policies in management of urbanization that can be more effective than trying to control migration flows to cities with accepting that there is usually a link between growth in population with increasing consumption demands and environmental issues.

10.2 Introduction

Although environmental protection has been a part of the National Plan of Environmental Protection and Sustainable Development launched by the Government in 1991, the degradation of natural resources and pollution in cities and industrial zones have not declined. In fact, economic development of the country remains the first priority in all areas of planning and decision making from the local to the central level (Institute of Economics, Ho Chi Minh City, 2000). There are a lot of constraints such as lack of appropriate policies, non-involvement of stakeholders and communities, lack of funds and unclear regulatory and financial mechanisms. In addition, law enforcement and implementation of regulations are weak.

10.3 Population pressure

During the last 25 years, the population of the city has increased from 2.5 million in 1975 to 5.2 million in 2000; around 800,000 people are permanent residents and about 400,000 are migrant or floating population. The average density is over 2,800 people per square kilometers (km^2). The density in urban areas is ten times compared with the common density. The issue of rural-to-urban migration is of major concern for the city planners.

Table 1: Projection of population growth in Ho Chi Minh City (1999-2030)

Annual growth (%)	Population in urban areas (thousand people)		
	2000	2015	2030
2.5	3,749	5,430	7,864
3.0	3,768	5,870	9,116
3.5	3,786	6,343	10,627
4.0	3,804	6,851	12,338
4.5	3,823	7,399	14,318

Source: Hong et al. 2002.

There are some arguments that the majority of the migrants (including poor rural migrants) who come to Ho Chi Minh City contribute to the prosperity of the city and not to its poverty problem (Bon, 1999). However, the increasing population of migrants in the city is leading to a corresponding increase in the need for land and material consumption as well as degradation of the urban environment.

The increase in emissions from vehicles is another direct consequence of the growing population in the city. Moreover, rising living standards in the city is leading to higher demands on energy consumption as well as purchase of domestic appliances. For instance, refrigerators (that are the main source of Chlorofluorocarbons (CFC), are the most popular domestic utility with 46.3 percent of households having refrigerators in 2002. Ranked second are electric and gas cookers in 39.5 percent of the city’s households; Air-conditioners (another source of CFC) are less used - only about 7.8 percent of families in 2002.

Table 2: Percentage of households purchasing house appliances which produce gases in Ho Chi Minh City from 1996 to 2002 (Source: Ho Chi Minh City statistical yearbook 2002)

Main items	1996	1997	1998	1999	2000	2001	2002
Refrigerators	38.4	39.3	39.5	40.8	43.4	44.8	46.3
Air-conditioners		6.7	6.8	7	7.4	7.6	7.8
Electronic and gas cookers	29.8	31.2	32.2	39.3	39.4	39.4	39.5

Hiep pointed out that the air pollution problem in Ho Chi Minh City is rapidly becoming as serious as other large cities in the Asia-Pacific region such as Bangkok, Tokyo and Manila (Hiep, 1996). Among air emissions, the dust from streets, motorways and infrastructure works as well as storage of materials and wastes at construction sites are major component of PH_{10}, especially in the dry season (Hien et al. 2002).

10.4 Economic growth and air pollution in Ho Chi Minh City

Ho Chi Minh City (HCMC) is facing rapid economic and social changes as well as serious degradation of its living environment. A recent government in 2000 stated that HCMC is one of the most active cities for economic development of the country. It is a big industrial centre sharing 30% of the total industrial output of the country with annual growth rate of 17.4% in year 2000. The main industrial sectors that have high growth rates and large share of the country's industrial production include food processing and beverages, textile garments, leather, plastic and rubber, chemical, and consumption goods. The proportion of industrial goods in the total exports has increased from 25% in 1991 to 58% in 2000. The city's economy has thus continuously grown especially since the years since economic reform (Doi Moi).

During the ten year period from 1990 to 2000, GDP increased at an average of 12.8% per year; GDP per capita from $US 644 in 1991 to 945 in 2000. Department of Science, Technology and Environment (DOSTE) pointed out that the city contributes significantly to reducing poverty rates, creating jobs and social welfare and enhancing the quality of life because of increasing economic growth (DOSTE, 2000). However, in reality, the city is also facing environmental problems: increased pollution of the air and water as well as growing quantity of urban waste.

DOSTE also reported that air pollution results mainly from emissions of vehicles and industrial production. The number of vehicles registered in the city is about two million with an annual growth rate of 13.7%. Air pollution is especially severe during the "rush hour traffic". Air, water and noise pollution are also a result of industries scattered in residential areas. It is estimated that industrial emissions including from oil-fired power plants are the major source of SO_2. Cement plants in particular are a significant source of particulate emissions. However, emissions of PM from cement plants cause localized exposure only, whereas emissions from vehicles cause widespread exposure. Some other industries such as brick, furnaces and construction are also significant sources of PM emissions (Economic Institute of HoChiMinh, 1996; General Statistical Office of Vietnam, 2003).

Table 3: Ambient monitoring results compared to national standards

Pollutants	Vietnam's Standards	Concentrations (mg/m^3)		
		1997	1998	1999
Dust	0,3 mg/m^3	0.37-1.47	0.49-1.91	0.53-1.96
NO_2	0,4 mg/m^3	0.039-0.116	0.052-0.216	0.059-0.214
CO	40 mg/m^3	8.79-17.97	7.32-18.48	6.97-18.28
Lead	-	0.0020-0.0032	0.0022-0.0032	0.002-0.0032

Source: DOSTE, HCMC 2000.

Air pollution is now acknowledged as an important public health issue as well as contributing to increased global warming by the accumulation of carbon in the atmosphere. There are currently no known studies in Vietnam conducted on the effects of gaseous pollutants on asthma or on the death rate, nor are the levels of disturbed carbon cycle due to pollution emission known (Institute of Tropical Techniques and Environmental Protection, 1998)

10.5 Calculation of air pollution by using Input-Output model

In fact, the human-based pollution in general and air pollution are caused by whole system of social-economic activities or sectors. Otherwise changes of each sector relate to the rest ones. The estimation of pollutant emissions from transportation, for instance, is not only deal with this sector but contributed from energy, construction, consumption and others (Economopoulos, 1993). The input-output (I-O) tables in national accounts are deal with the subject, in which every sector receives inputs from others and gives outputs to others, and whole system of natioanl economy is an integrity (Miller and Blair, 1985). The I-O framework and models have been used to estimate residuals from land-based pollutions to coastal zones areas in Malaysia, Philippines, Thailand and Vietnam in 1996-1999 within The LOICZ core projects in SEA countries (Nguyen Hoang Tri and al. 2001)

There is an other issue that relate to the estimation of pollutions based on the system of social-economic sectors including production, consumption, import and export among others is the estimation should be account flows of products and services which cover not only the internal area but propagation and external area relevant to import and export. The use of Miyazawa framework or multiplier model contributes to resolve these difficulties (Miyazawa, 1976; Bui Trinh, 2001).

In this project, an economic-environmental impact analysis is applied for HCMC by using the input-output table in micro socio-economic studies. This particular study is made possible with the availability of the just-completed research project on the compilation of the 2000 Bi-region Inter-Regional i-O (IRIO) Table for the Vietnam’s economy, with Ho Chi Minh City as the area of interest. As such, this two-region table specifically divided the country into: Region 1 - Ho Chi Minh City, and Region 2 – the Rest of Viet Nam. The IRIO table shows compact form, the intra- as well as the inter-regional economic transactions at the two-region level of spatial delineation. (See Annexes 1 and 2)

The Inter-regional I-O model: As in national I-O models, the basic relationship in intra-regional I-O models are:

$$AX + Y = X \qquad \text{or} \qquad (I - A).X = Y \qquad (1)$$

For the purpose of inter-regional I-O analysis, let’s assume that an economy is divided into 2 regions: region 1 and region 2. Then the direct input matrix A can be further divided into 4 sub-matrices:

$$A = \begin{pmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{pmatrix}$$

Where: A_{11} and A_{22} are the matrices of direct inputs within region 1 and region 2 (i.e. intra-regional), respectively; A_{12} and A_{21} are the matrices of direct inputs from region 1 to region 2 and from region 2 to region 1 (i.e. inter-regional), respectively. Moreover,

$$X = \begin{pmatrix} X_1 \\ X_2 \end{pmatrix} \quad \text{and} \quad Y = \begin{pmatrix} Y_1 \\ Y_2 \end{pmatrix}$$

Therefore, (1) it may be exhibited as:

$$\begin{pmatrix} I - A_{11} & -A_{12} \\ -A_{21} & I - A_{22} \end{pmatrix} . \begin{pmatrix} X_1 \\ X_2 \end{pmatrix} = \begin{pmatrix} Y_1 \\ Y_2 \end{pmatrix} \qquad (2)$$

Now, the form (2) of an equation system can be written as follows:

$$(I - A_{11})X_1 - A_{12}X_2 = Y_1 \qquad (2a)$$

$$(I - A_{22})X_2 - A_{21}X_1 = Y_2 \qquad (2b)$$

Given a vector of changes in final demands in two regions, we can find the consequent changes in gross outputs in both regions. Let's assume, for simplicity, that $Y_2 = 0$ (i.e. the impacts on both regions of a change in final demand in region 1 only can be assessed). Under these conditions, solving equations (2a) and (2b) for X_1 and X_2 may yield:

$$X_2 = (I - A_{22})^{-1}.A_{21}.X_1 \qquad (3)$$

$$X_1 = (I - A_{11})^{-1}.A_{12}.X_2 \qquad (4)$$

It can be observed that $(I - A_{11})^{-1} A_{12}$ in eq. (4) is a measure of the total output multiplier or propagation effect of X_2 on X_1, implying that in case of no change in region 1's final demand, one unit increase in total output of region 2 may cause an increase in total output of region 1 by the amount of amount of $(I - A_{11})^{-1} A_{12}$. Similarly, $(I - A_{22})^{-1} A_{21}$ is considered as the propagation effect of X_1 on X_2, and has the analogous interpretation.

Miyazawa's Internal and External multipliers*:* In Miyazawa's work, it is pointed that the total output multiplier can further be multiplicatively separated into 3 matrices:

$$(I - A)^{-1} = \begin{pmatrix} \Delta_{11}B_1 & \Delta_{11}P_1B_2 \\ \Delta_{22}P_2B_1 & \Delta_{22}B_2 \end{pmatrix} = \begin{pmatrix} \Delta_{11} & 0 \\ 0 & \Delta_{22} \end{pmatrix} . \begin{pmatrix} I & P_1 \\ P_2 & I \end{pmatrix} . \begin{pmatrix} B_1 & 0 \\ 0 & B_2 \end{pmatrix} \quad (5)$$

From this equation (5), the Leontief inverse may be decomposed into three matrices: the first refers to external effects, the second refers to push/pull effects and the third implies the internal effects. Interpretation of each term in equation (5) can be presented as follows:

$B_1 = (I - A_{11})^{-1}$: Internal matrix multiplier for the first region.

$B_2 = (I - A_{22})^{-1}$: Internal matrix multiplier for the second region.

$P_1 = (I - A_{11})^{-1} A_{12}$: push/pull matrix multiplier

$P_2 = (I - A_{22})^{-1} A_{21}$: push/pull matrix multiplier

$\Delta_{11} = (I - P_1P_2)^{-1}$: External matrix multiplier of the first region.

$\Delta_{22} = (I - P_2P_1)^{-1}$: External matrix multiplier of the second region.

For the internal impact equations, we have:

$X_1 = B_1.Y_1$

$X_2 = B_2.Y_2$

For the propagation impact equations: According to (3) and (4), we have:

$X_1 = (I - A_{11})^{-1} A_{12}.X_2 = P_1.X_2$

$X_2 = (I - A_{22})^{-1} A_{21}.X_1 = P_2.X_1$

External and Total impacts equations: We have the following Leontief equation for a 2-region inter-regional I-O model in a generalized matrix form:

$$\begin{pmatrix} X_1 \\ X_2 \end{pmatrix} = (I - A)^{-1} \begin{pmatrix} Y_1 \\ Y_2 \end{pmatrix} \qquad (6)$$

Replacing $(I - A)^{-1}$ by $\begin{pmatrix} \Delta_{11} B_1 & \Delta_{11} P_1 B_2 \\ \Delta_{22} P_2 B_1 & \Delta_{22} B_2 \end{pmatrix}$ yields:

$$X_1 = \Delta_{11}.B_1.(Y_1 + A_{12}.B_2.Y_2) \qquad (7)$$

$$X_2 = \Delta_{22}.B_2.(Y_2 + A_{21}.B_1.Y_1) \qquad (8)$$

In (7), Y_1 is the final demand of region 1 which is equal to the total of Y_{11} (goods and services produced and consumed in region 1) plus Y_{12} (goods and services produced in region 1 and consumed in region 2); $A_{12}.B_2.Y_2$ is the requirement on products of region 1 for production of region 2; $Y_1 + A_{12}.B_2.Y_2 = (Y_{11} + Y_{12}) + A_{12}.B_2.Y_2 = Y_{11} + (Y_{12} + A_{12}.B_2.Y_2) = Y_{11}$ + domestic export of region 1. Miyazawa calls $Y_1 + A_{12}.B_2.Y_2$ as *Total non-production*. $\Delta_1 = \Delta_{11}.B_1$, which is interpreted as the external impact of region 1 under the influence of inputs from the region 2, now reveals in (7) the implication of the requirement on output of region 1 for a unit increase in *Total non-production* of region 1. Analogous interpretation can be done for equation (8): $\Delta_2 = \Delta_{22}.B_2$, which is interpreted as the external impact of region 2 under the influence of inputs from the region 1, now reveals in (8) the implication of the requirement on output of region 2 for a unit increase in *Total non-production* of region 2.

Air-pollution calculation: The I-O framework has been extended to account for pollution emissions as in the following equation: $V = V^*.X$ in which V^* is the matrix of pollution emission coefficients and V is the matrix of pollution levels. Since $X = (I - A)^{-1}.Y$, pollution levels V can be expressed as a function of final demand, we have:

$V = V^*.(I - A)^{-1}.Y$

Back to the internal, propagation and external matrix multipliers mentioned above, environmental impacts could be computed by adding into the equations, as shown below:

Internal pollution levels: $V_1^{int} = V^*.B_1.Y_1$	Internal pollution coefficients: $V^*.B_1$
Propagation pollution levels: $V_1^{pro} = V^*.P_1.X_2$	Propagation pollution coefficients: $V^*.P_1$
External pollution levels: $V_1^{ext} = V^*.\Delta_{11}.B_1.(Y_1 + A_{12}.B_2.Y_2)$	External pollution coefficients: $V^*.\Delta_{11}$
Total pollution impact:	Total pollution coefficient: $V^*.\Delta_1$

$V_1^{total} = V^8.\Delta_1.(Y_1 + A_{12}.B_2.Y_2)$	

In the case of HCMC, the matrix of pollution or economic-environmental coefficient (V^*) is presented in the Annex 3. This matrix is built based on Rapid Inventory Techniques in Environmental Pollution, WHO, Geneva (Economopoulos, AP, 1993) with references from field data provided by Institute of Tropical Techniques and Environmental Protection (1998), HCMC

Output Multipliers

The 2-region Vietnam IRIO table for 2000 was referred to in this study. For simplicity, the 45-sector IRIO table was collapsed into an integrated 15-sector table. From this 15-sector IRIO table, two intra-regional I-O tables can be derived, namely: the 2000 I-O Table of HCMC and the 2000 IO Table of ROV. Both tables are the competitive-import types wherein no distinction is made between domestic and imported inputs. Environmental data used is the matrix of pollution coefficients by the 15 sectors, as estimated by the Institute of Tropical Techniques and Environmental Protection, HCMC. This set of data covers 3 pollutants for air pollution: CO_2, CO and NOx. In this report, we only present a calculation of air pollutions for HCMC.

As shown in the table 4, the total 473,401.81 tons CO_2 were emitted to the air from social-economic activities, in which 61,477.38 tons of propagation and 85,204.78 tons contributing to outside HCMC. The highest value is from construction sector because it includes land-use changes for urbanization, usage of oil-engine machines and others. The high values are also in processing foods, consumer and industrial goods because of using oil and gas during production and consumption. The transport has a highest value or good and commodity transportation. However, the value of total CO_2 emission is still not so high to compare with other mega-cities in the world.

Table 4: The calculation of CO_2 emissions based on the gross output of sectors in HCMC, 2000 (Tons per year)

Note: Inter CO_2 indicating the emission within HCMC

Propagation CO_2 indicating the emission to be transmitted

External CO_2 indicating the emission outside HCMC

Sectors	Internal CO_2	Propagation CO_2	External CO_2
1. Agriculture and fishery	201.01	557.96	711.63
2. Forestry and mining products	1,522.07	34.72	102.79
3. Processed food, beverage & tobacco	47,400.49	2,927.96	801.47
4. Other consumer & industrial goods	28,895.52	14,866.62	10,718.03
5. Industrial materials	64,200.76	14,997.74	10,812.55
6. Capital goods	631.04	3,911.43	113.33
7. Electricity, gas & water supply	62,296.87	494.78	265.02
8. Construction	145,830.61	7,963.73	2,767.01
9. Trade	1,675.59	2,077.34	94.42
10. Passenger transport services	21,370.17	512.90	275.46

11. Good transport services	77,363.83	1,258.75	878.67
12. Communication services	979.13	777.52	2,743.98
13. Business, science and technology	362.91	3,029.50	15,867.51
14. State management, defend and security	2,355.96	1,870.86	6,602.54
15. Other services	18,315.85	6,195.59	32,450.36
Total	473,401.81	61,477.38	85,204.78

The emission of CO from HCMC presented in the table 5 is much less than CO_2. The amount of 44,793.24 tons are from major contribution of transportation and construction then oil and gas uses of processing, industrial goods and consumption. The value of CO_2 and CO emission from both transportation of goods and passengers is among top high, because the growth rate of economy of industrial sectors and services are basically depend on transportation and it will be still high in some next years. The propagation of 4,668.45 tons and external value of 2,645.88 are low to compare with other pollutants.

Table 5: The calculation of CO emissions based on the gross output of sectors in HCMC, 2000 (Tons per year)

Note: Inter CO indicating the emission within HCMC

Propagation CO indicating the emission to be transmitted

External CO indicating the emission outside HCMC

Sectors	Internal CO	Propagation CO	External CO
1. Agriculture and fishery	203.82	41.07	9.12
2. Forestry and mining products	29.54	2.94	0.20
3. Processed food, beverage & tobacco	4,366.73	341.79	14.09
4. Other consumer & industrial goods	4,834.31	995.99	783.54
5. Industrial materials	4,963.94	1,238.45	693.45
6. Capital goods	890.39	406.43	234.79
7. Electricity, gas & water supply	4,239.69	36.73	71.48
8. Construction	5,308.65	499.70	21.80
9. Trade	1,401.76	114.91	39.56
10. Passenger transport services	3,835.11	37.74	61.75
11. Good transport services	7,971.79	85.36	130.69
12. Communication services	156.74	63.40	27.19
13. Business, science and technology	201.71	19.60	153.71
14. State management, defend and security	209.61	61.85	94.69
15. Other services	6,179.45	722.47	309.81
Total	44,793.24	4,668.45	2,645.88

Regarding the emission of NOx form social-economic activities in HCMC, the total of 140,464.39 tons within the city, 16,498.29 tons of propagation and 10,934.63 tons of external emission are estimated. The major contribution is also from construction, transportation, industrial and service sectors, seeing table 6.

Table 6: The calculation of NOx emissions based on the gross output of sectors in HCMC, 2000 (Tons per year)

Note: Inter NOx indicating the emission within HCMC

Propagation NOx indicating the emission to be transmitted

External NOx indicating the emission outside HCMC

Sectors	Internal NOx	Propagation NOx	External NOx
1. Agriculture and fishery	58.72	172.78	69.37
2. Forestry and mining products	175.38	9.79	17.12
3. Processed food, beverage & tobacco	11,353.15	762.93	839.45
4. Other consumer & industrial goods	17,793.22	4,169.28	2,977.88
5. Industrial materials	18,458.92	3,972.38	3,248.68
6. Capital goods	5,211.61	1,274.82	270.92
7. Electricity, gas & water supply	13,077.21	401.15	540.24
8. Construction	26,130.15	1,337.94	1,506.77
9. Trade	6,219.26	636.10	532.12
10. Passenger transport services	10,373.10	100.80	279.65
11. Good transport services	21,512.07	300.80	0.60
12. Communication services	568.99	217.88	35.87
13. Business, science and technology	2,924.62	641.08	206.83
14. State management, defend and security	124.46	17.95	0.43
15. Other services	6,483.54	2,482.63	408.69
Total	140,464.39	16,498.29	10,934.63

As seen in the table 7, the calculation of air-pollution is significantly depending on the gross output of the city. The sectors with high value of output are also high emissions such as processing food, consumption, industrial materials. However, the sectors of transportation, construction and electricity, gas and water supply with low outputs contribute high emissions because of basically using the fossil energy in implementation. Sectors of trade and other services have a high output but low emissions. This is main reasons to support decision-makers to develop the sector “non-emission industry” in the future.

Table 7: The calculation of internal emissions of CO_2, CO and NOx based on the gross output of sectors in HCMC, 2000 (Tons per year)

Sectors	Gross Output (billion VND)	Internal CO_2	Internal CO	Internal NOx
1. Agriculture and fishery	171.15	201.01	203.82	58.72
2. Forestry and mining products	12.24	1,522.07	29.54	175.38
3. Processed food, beverage & tobacco	1,602.15	47,400.49	4,366.73	11,353.15
4. Other consumer & industrial goods	1,737.20	28,895.52	4,834.31	17,793.22
5. Industrial materials	1,752.52	64,200.76	4,963.94	18,458.92
6. Capital goods	662.65	631.04	890.39	5,211.61
7. Electricity, gas & water supply	229.57	62,296.87	4,239.69	13,077.21
8. Construction	936.56	145,830.61	5,308.65	26,130.15
9. Trade	1,077.27	1,675.59	1,401.76	6,219.26
10. Passenger transport services	123.07	21,370.17	3,835.11	10,373.10
11. Good transport services	426.81	77,363.83	7,971.79	21,512.07
12. Communication services	128.52	979.13	156.74	568.99
13. Business, science and technology	716.09	362.91	201.71	2,924.62
14. State management, defend and security	309.25	2,355.96	209.61	124.46
15. Other services	1,464.47	18,315.85	6,179.45	6,483.54
Total	11,349.52	473,401.81	44,793.24	140,464.39

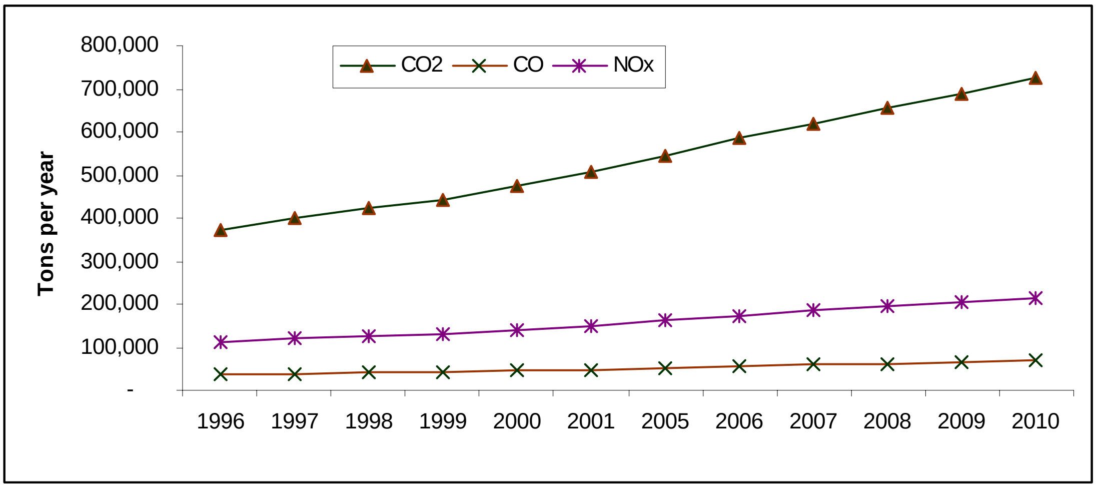
Because of supporting whole system of social-economic activities, the development of sectors relating the transportation are significantly to emit air-pollutions. During less than ten years, the transportation means have increased 2-4 times, especially trucks and buses. As mentioned above, the growth rate of transportation is lower than other sectors but the sector is very considerable to emit air-pollution, especially green house gases. The master plan of the city should be included this issue when composing policies and regulations to move up the economy in harmonizing between economic development and measures of pollution control.

Table 8: The increased number of transportation means in HCMC during 1995-2002

Transportation means	1995	2000	2001	2002
Truck	6,250	18,304	17,292	16,254
Car	3,555	6,637	6,792	6,822
Bus	378	1,458	1,620	1,721
Moto-car	8,227	8,902	8,697	8,070
Tugboat	39	47	54	57
Lambretta-motorcycles	1,598	1,180	1,125	1,068
Lambretta-passenger car	3,245	1,193	1,013	583
Motor carrier tricycle	1,911	2,083	2,065	1,858

As shown in fig. 1, the projection of CO_2, CO and NOx emissions based on GDP (in billions VND) during 1996-2010 of Ho Chi Minh City in the case of without any measures to control emissions or ‘do nothing’ presents that the air-pollution are continuously increased even though the growth rate will be decreased 5 or 6 % in the last years of the decade.

Fig 1: Projection of CO_2, CO and NOx emissions based on GDP (in billions VND) during 1996-2010 of Ho Chi Minh City (Tons per year)



Projection of CO_2, CO and NOx emissions based on GDP

However, the projection is not considering the fact that the income of people will be increased with double or triple GDP per capital (2,000 – 3,000 $US) (DOSTE, 2000) and the vehicle ownership per thousand person will be increased up to 7-10 times according to the Earth city’s statistics.

10.6 Urban management and environmental policies

There is no single technology or approach to mitigate air pollution and carbon emissions. The right mix of options is needed depending on social, cultural and environmental circumstances. A number of changes to technology, policy and human behavior can reduce energy demands with benefits for economic productivity with small costs for efficiency of transport, better urban planning, cogeneration and changes to diet that require less energy inputs (Gupta et al. 2001).

The Ho Chi Minh People’s Committee has recognized that air pollution is causing rapid deterioration of environment and is impacting on human health and economic development. The city has set up a network of permanent air-quality monitoring stations and launched a program to enforce compliance of road vehicles with emission regulations (DOSTE, 2000). The “National Strategy for Environment Protection” and “Orientations for Environment Protection Strategy of HCMC to 2020” have been announced and implemented in recent years. However, these programs are yet to take up carbon management.

From expectation to practice of policies

The city has launched regulations to use unleaded petrol to reduce lead levels as well as low sulfur diesel fuel for reducing CO_2 emission, and set up standards for emission control of vehicles before registration, on-road travel and the establishment of permanent air-quality monitoring stations. The city has also mobilized and persuaded people to use public transport. However, the quality of air has not improved, with the situation becoming worse in some places in the city. DOSTE has argued that the economic growth rate of some sectors is so rapid that their measures have not compensated enough to reduce emissions. Hong pointed out that the implementation of launched 1998's regulation is not respected and there is a lack of evaluation or feedback systems as well as unclear mechanisms for implementation and control of emissions (Hong et al. 2002).

Recently, the government has initiated a program to provide daily information/forecasting service of air pollution levels in the city, introduced transport planning to reduce traffic congestion, funded studies on the impacts of air pollution on people's health and the economy as well as to understand the characteristics of airshed in relation to stationary and mobile sources. There are also studies on the transport mechanism of the air due to meteorology and emission inventory. The airshed model can be used as a tool to study the different scenarios for different control strategies to find the best way to formulate an appropriate response to the air pollution problem. However, the effectiveness of these activities is not at a maximum due to lack of human resources and financing support.

The rate of air pollution is increasing due to the ineffective implementation of government regulations, weak law enforcement, and corruption (Ha Huong 1999). Sometimes industrial or interests also put pressure on officials involved in environmental impact assessment or monitoring programs to ensure that findings report lower than the actual amounts of pollution or emissions in order to be seen as following the environmental standards.

Globalization and transition-economy

According to the 'innovation policy', the government has determined that the country would develop as a market economy with fair competition but with socialist orientation. But state policy of opening the country to foreign investors is leading to environmental damage. In fact, the rapid growth of different economic components without environmental controls creates a lot of waste as well as air pollution. Investors are eager to make quick and easy profits. For instance, car-assembling factories ignore regulations for fitting gas filters as an obligatory part of their production cycle. In most cases, multinational corporations use outdated equipment and technology in the production process causing toxic pollution but refuse to pay or take responsibility (Ha Huong 1999). During 1998-2002, the city's decision makers introduced environmental prices into the investment processes as a way to prevent the abuse or waste of natural resources and to control pollution and emissions. This extra price made the investment opportunities of the city less competitive and resulted in investment going to the two bordering provinces of Dong Nai and Binh Duong that had less stringent environmental standards and no environmental pricing mechanisms.

Moving forward

As Yamagata and Alexandrov (2001) pointed out, a land-based option that provides environmental and development benefit is reforestation, afforestation and land restoration for potential carbon sequestration. Changes in forest management could sequester carbon at 0.175 PgC yr-1 while deforestation contributes about 20-25% of total anthropogenic emission. Green space development in the city would be the most cost-effective measure to control the air pollution in general and carbon management in particular. However, the tree-covered percentage of the urban areas is 3.9% of total area in which 1.48% is from parks, 1.42% from roadside green, and 1% from gardens. The average area of green foliage per capita in the urban areas is 1.95m^2 in which 0.74 m^2 from parks, 0.71 m^2 from roadside green and 0.50 m^2 from gardens (DOSTE, 2000). The distribution of types of green areas is uneven in the urban areas.

The City's 40,000 ha of mangroves (consisting of 77 mangrove species - 35 true mangroves and 42 associates) - the city's "Green Lung" – is a vital carbon sink as well as environmentally import buffer to reduce coastal vulnerability from storms and other natural impacts. The Can Gio Mangrove Biosphere Reserve has been designated for inclusion in the World Network of Biosphere Reserve by the International Coordinating Council of the Program on Man and the Biosphere on January 21, 2000. The forest is currently under other pressures from increased tourism and infrastructure development (Tri et al. 2000). The city's efforts to conserve and rehabilitate the mangrove forests are one of the most cost-effective measures for integrating carbon management into city planning.

Ho Chi Minh City is possibly a good example of the consequences of different pathways of the city's development especially urbanization and urban transformation, air pollution in general and carbon in particular with different pathways emerging from the economic and social requirements of the country's growing economy. This is also an historical underpinning of the different pathways of the city and Vietnam as whole. The development of the economy in closely related with carbon issues as important historical drivers of the city's development path. The role of the politics of the city as well as the regional and international development agenda is crucial in seeking solutions to issues of air pollution and carbon emissions.

10.7 Conclusion

The city has policies and actions for adopting technical measures to control air pollution in general and carbon management in particular. However, there are constraints concerning confusion over law enforcement, lack of staff capacity and stakeholder involvement especially community participation, and absence of financial investment. The institutional factor is very important in influencing management options in terms of taxes, credits, subsidies, sectoral strategies, property right regimes and other formal control and prevention mechanisms. It also contributes effectively in facilitating the integration of carbon management into future urban forms, governance, institutional and cultural arrangements in development. The most important technological options should be an integrated measure of law enforcement, value change of stakeholder involvement, clean technology innovations and greening that could influence emissions and sequestrations.

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11.0 Appendix 5: Case Study Working Paper – Chiang Mai

A carbon's eye view of urbanization in Chiang Mai: improving local air quality and global climate protection

Reference: USER Working Paper 2004-07 [12]

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11.1 Introduction

Chiang Mai is in a critical stage of its development as a regional hub. Two decades of rapid economic growth and infrastructure development have made people wealthier, healthier and much more mobile (Lebel et al. 2004). Improved services make it one of the most tourist-easy and –friendly destinations in Southeast Asia. Visitors come to experience an aesthetic environment of old Buddhist temples with Lanna, Shan, Thai and other influences and the even more diverse languages, designs and foods of an ethnically diverse society. Wealth and health have undoubtedly improved for the vast majority of residents. But it is far from clear that the "drive for modernization" and the "quaint historical Lanna capital image" are compatible. Nor is it clear that the commitment to a motor-vehicle oriented city and an evolving urban form that reinforces the need and use of private cars will continue to lead to what are perceived as improvements in quality of life.

There are indicators of problems. For a city of rather modest size air quality is already poor, especially towards the end of the dry season (February – April). Congestion as the sweeping newer multi-lane highways converge on the old narrow streets of the old capital is worsening. There has been no local public bus or rail transport system for more than decade though one is promised.

The problems and opportunities facing Chiang Mai are not unique. The context of rapid and late urbanization in a globalizing world is shared by many cities in the developing world during the past two decades (Marcotullio 2003; McGranahan & Satterthwaite 2003). A key consequence is that the environmental challenges that many cities in industrialized countries faced sequentially over a century, like installing sewerage systems, providing clean drink water, and then controlling pollution from industries and cars now need to be addressed simultaneously and within the space of a few decades. This time compression of urban development could also be seen as an advantage. Opportunities for coordinating management of waste water, drinking water supplies, road and public transport infrastructure, architectural and zoning abound.

Either way, the way urbanization and urban transformation unfolds will have profound implications for vehicle, land and energy use.

In this paper we take a "carbon's – eye" view of urbanization and regional development (Global Carbon Project 2003.). Through this analysis we hope to understand both the limitations and opportunities of linking the issues of reducing greenhouse gas emissions critical for global climate protection to other aspects of urban environmental governance, in particular, improving local air quality for health of residents. With this focus on carbon we are not suggesting that Chiang Mai's growth in emissions - fast as they are likely to be - are of any significance to risks

[12] This draft was prepared for the U-TURN synthesis workshop in Chiang Mai 6-8 January 2005. Comments and feedback are welcome. Please send to: louis@sea-user.org

of climate disruption. Rather our purpose is to illustrate that there may be lessons from looking in detail at development and governance of an intermediate sized city that have wider relevance for strategies to integrate carbon management of other urbanizing regions and cities both in developing and developed countries. Ultimately it is the combined efforts of states, municipalities, corporations and individual consumers that will matter.

The rest of this paper is organized around three main sections. The first describes some of the key urbanization trends and processes that are likely to have carbon implications. The second synthesizes this information into an initial regional carbon budget and explores qualitatively some of the prospects for decoupling under different scenarios of regional development. The third section explicitly discusses the potential and limitations of urbanization in carbon management. The paper ends with a short summary of the key findings and unanswered questions.

11.2 Urbanization and its carbon implications

Ribbon and sprawl from an old centre

In this study the urbanizing region of Chiang Mai is defined as the districts of Chiang Mai and Lamphun provinces containing at least some of the built up area of Chiang Mai or Lamphun cities or immediately adjacent to these (Figure 1). The total area of the region covers just over 2,900 km^2 of which the state classified 178km^2 as urban in 2000 and only 40km^2 falls within Chiang Mai municipality. The censused population in 1980 was 808 thousand and rose slowly to 914 thousand by 2000, an annual growth rate of just 0.7%. The estimated population in two provinces was 1.9 million in 2000, having increased at about 1.4% a year since 1980, in part, reflecting more complete registration of people living in remote areas.

Figure 1: ASTER Image from 2001 of the Mae Nam Ping with Chiang Mai town near the middle of the picture.

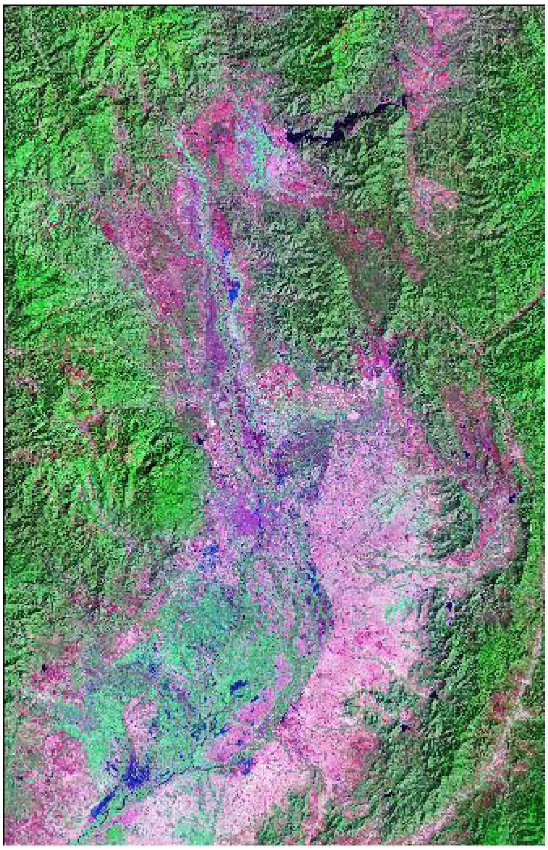
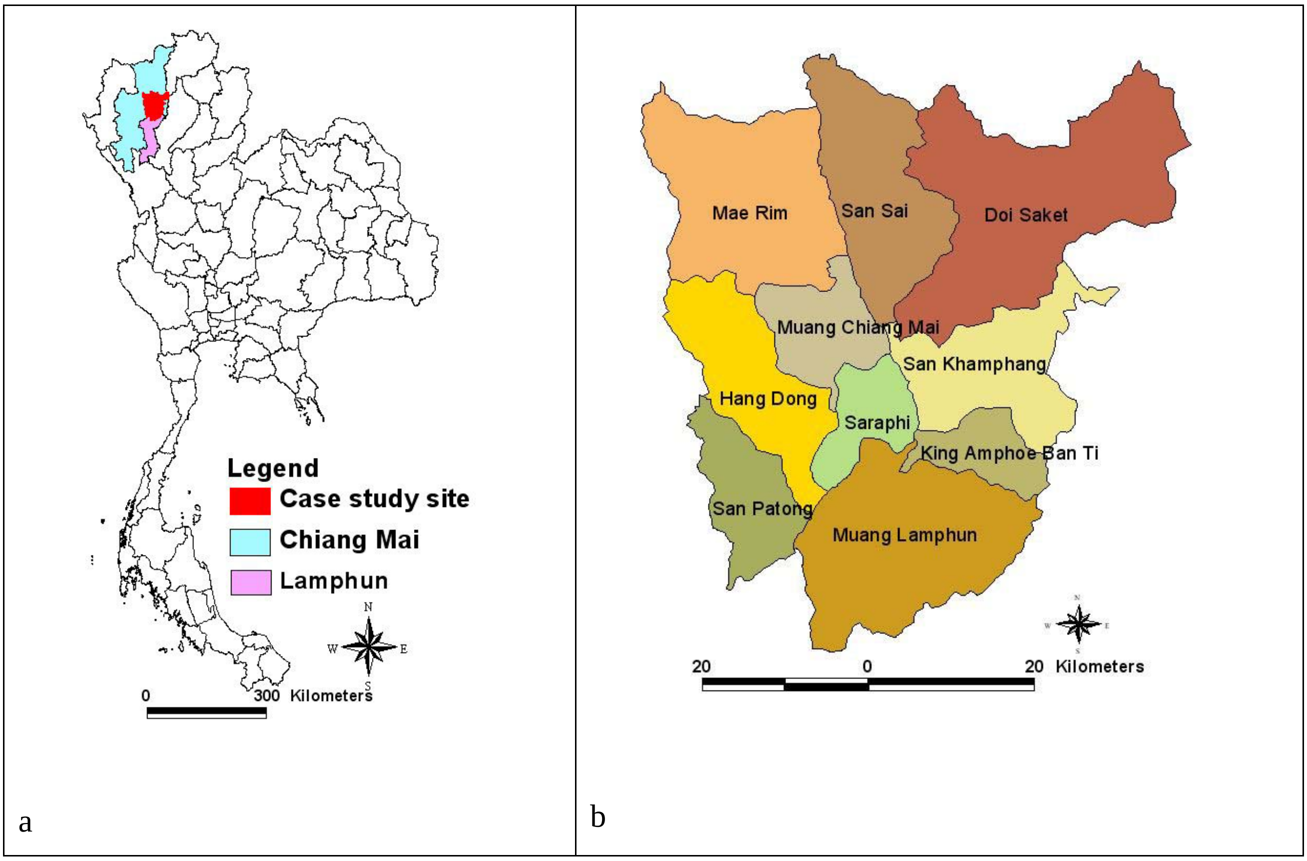


Figure 2: Urbanizing region of the Mae Nam Ping basin around Chiang Mai and Lamphun towns that is the focus of this study. (a) location of study region within Thailand. (b) Administrative boundaries used to defining the Chiang Mai region in this study.



The built environment in terms of dwellings and road infrastructure has grown very fast. The city has grown much faster and larger than changes in population statistics, even taking into account, under-registered seasonal and more permanent migration for employment.

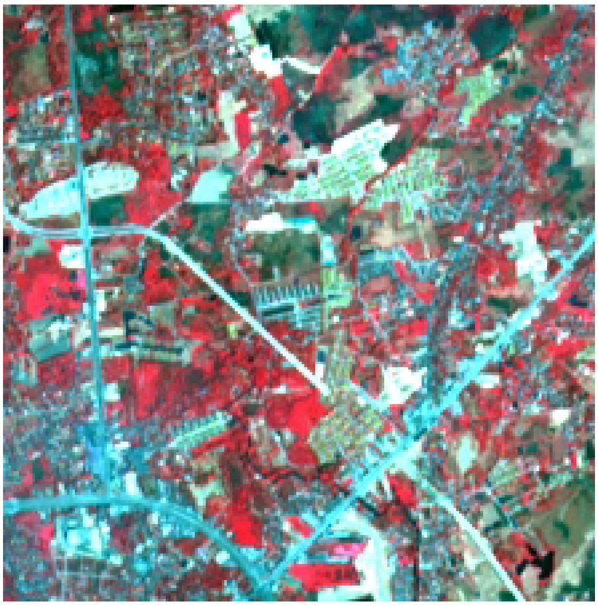
In Chiang Mai, changes in urban form are one of the most important drivers of rising energy consumption in the transport and residential sectors, as well as having unnecessarily large impacts on land cover.

The central part of Chiang Mai dates from the 13th Century. The very high density of Buddhist temples and a more recent partly walled square moat are part of the key aesthetic attractions for tourists and residents alike. It is a planned city (Sanay Yarnasarn 1985). The urbanized portion of Chiang Mai slowly emanated from, the ancient walled city. After the bridge was built across the Ping River in 1903, and Chiang Mai was connected to the national railroad in 1921, Chiang Mai continued to expand. Urban areas now make a substantial part of the land-use in the city districts of Chiang Mai and Lamphun. In the past, residences in the urban-rural periphery were organized around Buddhist temples which usually doubled as schools and part of the social welfare system, and regular markets. With increased mobility, refrigeration and secularization these spatial dependencies have declined.

The highly compact urban form, however, began to unravel in earnest with the economic boom in the 80's and 90's.

Housing estate developments have created a star-like pattern of commercial buildings along the main spoke highways heading in and out of the town with urban housing immediately behind, often in gated communities (Figure 2). Much of the development has been on irrigated agricultural land, but forests have also been cleared. Although it is hard to say exactly how much, a substantial number of these homes were second homes of Bangkok elites. The 1997 financial crisis led to almost half of the planned units being abandoned, often partly finished, with many others stuck in the bank as a result of owners being unable to repay loans.

Figure 3: Ribbon and spike development in the outskirts of Chiang Mai. ASTER 2000 image. Main urban area is towards lower-left corner.



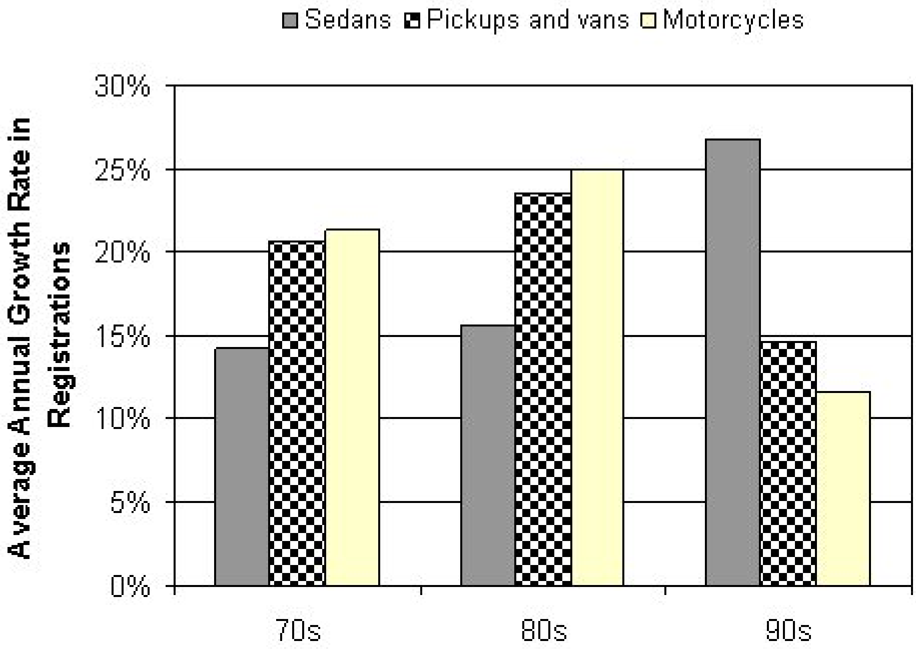
The sprawling pattern with large spaces away from the road remaining in agriculture or lying idle under land speculation is highly inefficient in that it requires large amounts of infrastructure and long travel distances. Low costs of leaving land idle and very rapid rises in costs of land help reinforce these trends (Pearson 1999; Sanay Yarnasarn 1985; Setiawan & Rahmi 2002).

Even though individual buildings and clusters can be of relatively high density these advantages are lost by poor spatial layout.

The ribbon and spike sprawl pattern of urban and commercial development in the new areas of Chiang Mai, together with growing economic prosperity, has also created a surge in personal vehicle use for going to and from work and markets. Motorcycle and passenger vehicle registrations have soared for three consecutive decades as households pass the thresholds where they can afford or expect the convenience of personal vehicles (Figure 3).

A few statistics for Chiang Mai province as a whole illustrate the depth of the changes: between 1970 and 2000 the number of both registered passenger cars and motorcycles increased more than twenty-fold while population only doubled. The number of pick-up's, minivans and light trucks increased more than forty times. Expressed differently the number of motorcycles per 1000 population went from 55 to an extra-ordinary 342. For cars the rise was from 6 to 45 and of pick-up's and vans from 11 to 75.

Figure 4: Rapid growth in vehicle registrations in Chiang Mai.



A critical feature of Chiang Mai around the turn of the century was the complete absence of public transport system and low use of non-motorized modes of transport (Figure 4). This reflects a commitment to car oriented growth and lack of public investments in pedestrians. Much of Chiang Mai outside the centre is un-walkable and un-cyclable with high-speed new ring roads without over-passes or side-walks or alternative routes. It should be noted that the high use of private vehicles is not just household passengers cars but reflects the high profile of private sector in providing fixed-route and "on-demand, but shared" multi-passenger services using modified pick-up trucks or "songthaew's", three-wheeler "tuk-tuk's" and mini-vans. Discussions about re-building a public transport system around above or below-ground light rail and buses have re-surfaced many times in the past decade and finally appear to be getting some needed high-level political support.

During 2004 the Office of Transport and Traffic Policy and Planning and Chiang Mai University drafted a new transportation master plan for Chiang Mai city, neighbouring areas and 8 surrounding provinces in northern region of Thailand(Atchareeya Saisin 2004). As part of the process two one-day public hearings were conducted in July and December 2004. One of the first steps will be to replace individual private "songthaew" taxis into a coordinated private bus system in which the original owner-drivers will be part shareholders. Another is an upgrading of rail-link between Lamphun and Chiang Mai for a commuter service.

The huge changes in number of vehicles are paralleled in both fuel consumption and road infrastructure. Growth in fuel consumption has paralleled changes in vehicle ownership.

Dual carriageways, ring-roads and under- and over-passes have reinforced the transformation into a motorcycle and car city. The failure and abandonment of a public bus system and its replacement by a very loosely coordinated private fleet of converted pick-ups with poorly maintained exhaust systems has made air quality at major intersections and around schools a growing concern. Relatively large roads with still modest traffic loads mean travel times are modest, but distances covered in daily commutes may be fairly large especially for rural-based factory and service workers (Figure 5).

Figure 5: Chiang Mai's dependence on private transport is unusually high. Comparison with cities between 50,000 and 1 million inhabitants from around the world for 1998.

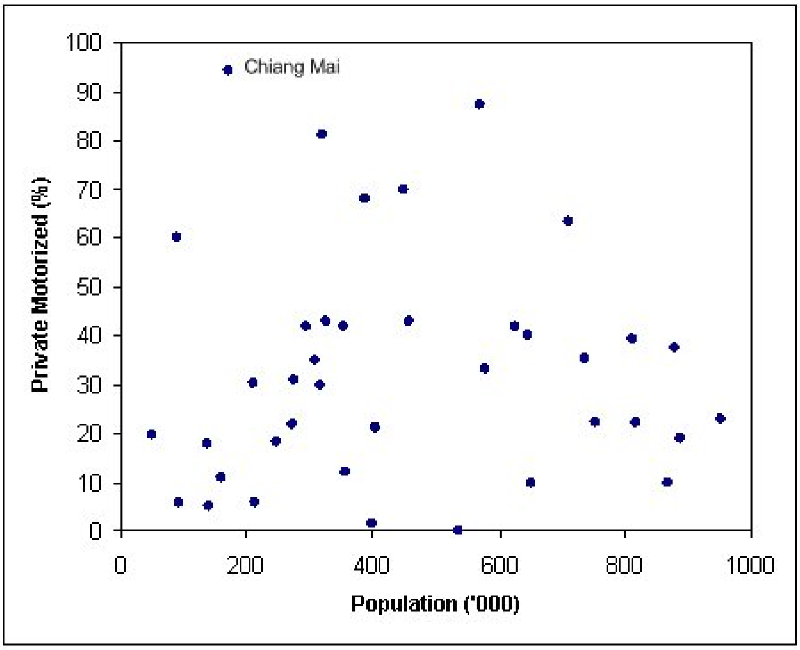
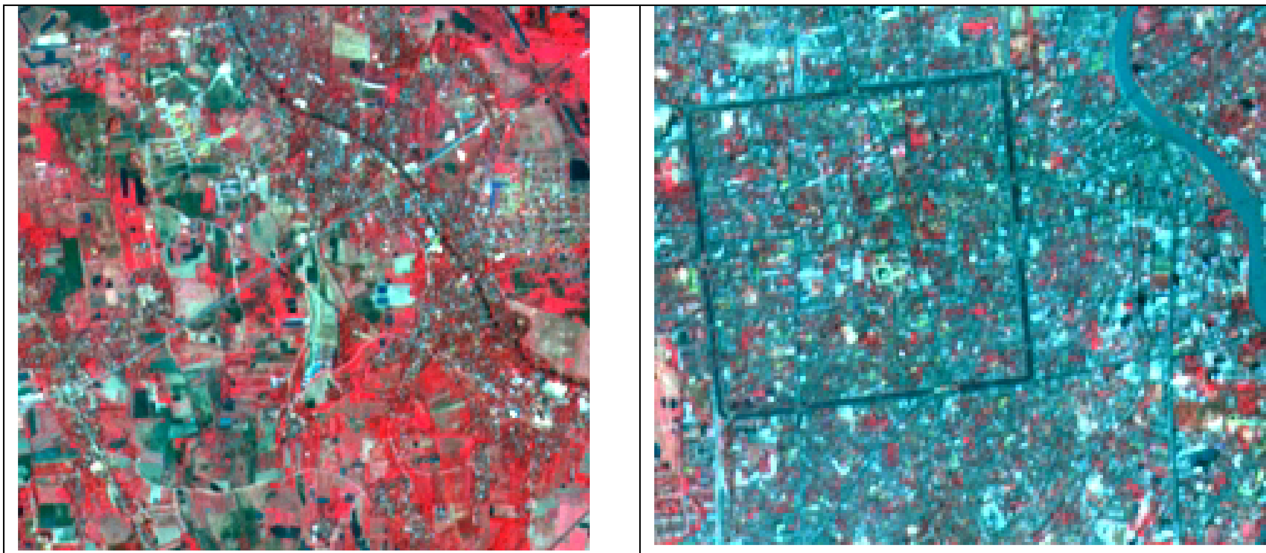


Figure 6: Contrasting urban densities and structure in Chiang Mai. a. Low-density. B. High density inner city.



A	B

The impacts on local air quality of growth in number of vehicles are amplified by poor vehicle maintenance. Spot surveys in Chiang Mai suggest conditions are even worse as monitoring and enforcement of emission regulations is usually absent. The Pollution Control Department and the Chiang Mai Air Quality Initiative Program conducted roadside inspections of motor vehicle emissions in the municipality of Chiang Mai in September 2003. They found that 73 % of in-use diesel motor vehicles had emissions exceeding the legal standards. New regulations which authorize inspectors to ban the use of such vehicles, however, are only enforced in Bangkok (Po Garden et al. 2004)

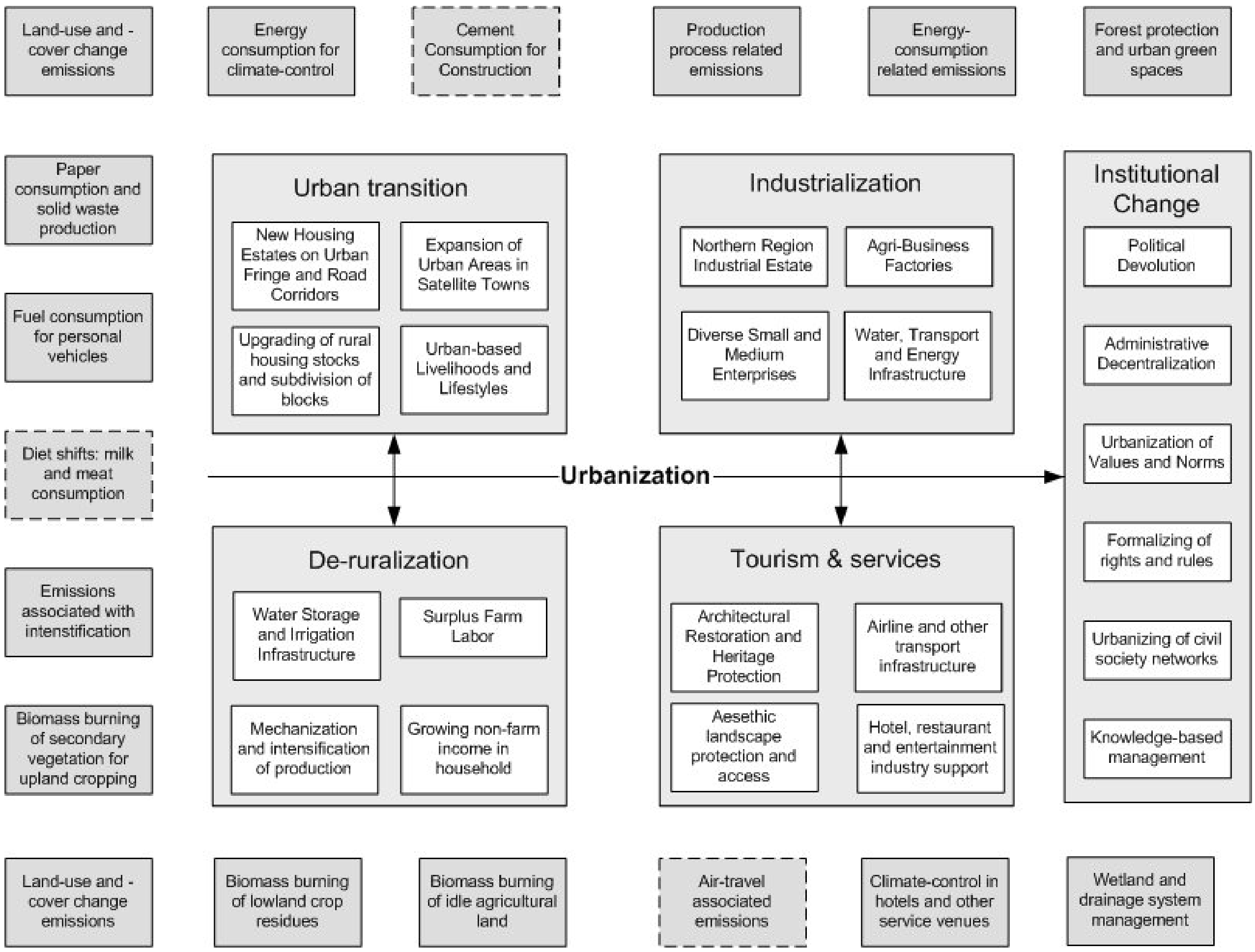
Increasing wealth of course doesn't only drive mobility but also makes possible higher levels of consumption of household goods, energy for cooling and so on. One of the difficult to answer but important questions is: what are the impacts on life-style changes as people move from agriculture or forest-based livelihoods to industrial and service sector employment in an urban setting? Unfortunately we don't have relevant household data on this beyond measures of overall income.

Rural – urban – industrial interplays

The Mae Nam Ping basin has under gone some radical shifts over time as a result of periods of agrarian transformation and urbanization (Lebel et al. 2004; Romanos & Auffrey 2002). Technological change has played an important role. For example, in construction materials from wood to concrete, the advent of air-conditioning and the rise of personal mobility with motorcycles and pick-up tricks, and modern contraception. In the last 2 decades industrial investments, tourism, manufacturing and trade have grown in importance and along with overall economic growth of the Thai state resulted in the most profound transformation of economic activities and livelihoods (Figure 7). During this period, urbanization has strongly interacted with industrialization, literally building on the foundations of agricultural expansion then intensification in the 60s and 70s (Lebel et al. 2004).

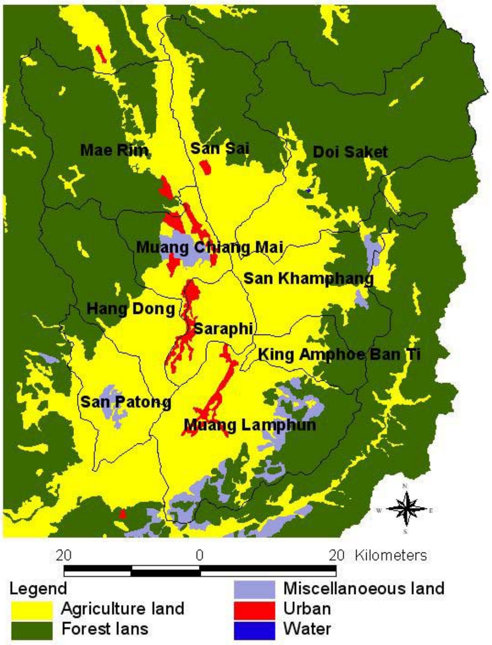
Finally, capacities and responsibilities of provincial, municipality and local administrations have expanded substantially, especially in past decade with various decentralizing reforms, although so have the challenges of coordination and monitoring from rapid urbanization.

Figure 7: Conceptual model of urbanization in the Mae Nam Ping basin around Chiang Mai and Lamphun.

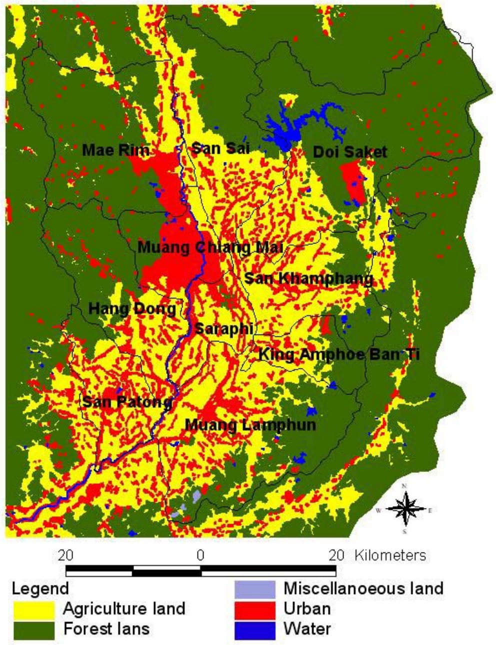


The main changes in carbon stocks arising from land-use between 1974-2000 were the conversion of forest land to agriculture, and the conversion of forest and agriculture land to urban use. These were similar in magnitude over this period. Starting from a base-line with relatively low energy consumption, changes in land-use have had, during these early stages of economic development, played role, proportionately in overall changes to carbon stocks and fluxes, but one that is obviously declining fast relative to emissions from consumption of fossil fuels.

Figure 8a: Changes in land-cover in the Mae Nam Ping basin around Chiang Mai and Lamphun cities. (a) Landcover in 1974 based on Landsat; (b) Landcover in 2000. District boundaries shown.



a. 1974



b. 2000

Urbanization driven changes in agricultural practices related to changes in availability and cost of labour over the past 20 years undoubtedly have also influence emissions. The shift to orchards in areas along the Mae Nam Ping River can be understood in terms of the lower labour requirements compared to rice and intensive vegetable cropping. Most orchard owners also have other concurrent investments and even full-time employment as civil servants, teachers and small business owners. Over the past 10 years this together with reductions in areas of methane producing rice paddies may have made land-use in the region as a whole a net sink.

Overall intensification, in terms of number of crops per year, and water management practices may have also altered methane emission regimes from paddy rice, but it is hard to assess the aggregate consequences with much confidence.

Almost nothing is known about impacts on non-cultivated green spaces, for example, land re-growing while it is under speculation for urban development, and re-emergence of community forests and plantations and home gardens within urban areas.

Traffic congestion and smoke from land fires, combined with inversion conditions, at the end of the dry season regularly result in poor urban air quality.

Air quality in Chiang Mai usually falls in the latter-half of the dry season (Jan – Apr) as a result of smoke from fires lit to clear crop residues, garden refuse and upland fields in the surrounding mountains. Waste incinerators and open cremations also contribute significant loads of particulate matter. The inversion conditions which dominate at this time of year trap air high in particulates in the basin. In addition exhaust and re-suspended dust from high-levels of vehicle traffic at the peak of the tourism season further degrade air quality. The result is seasonally poor environmental health conditions. In 2001, the Chiang Mai Public Health Office, for example, reported a staggering 78% of the Chiang Mai population was suffering from respiratory sicknesses, but these figures need to be viewed sceptically.

A careful study by a biochemist Usanee Vinitketkumneun documented high levels of PM 2.5 and correlated these with health problems. She prioritized open burnings as the most relevant source of PM 2.5 during the dry winter months when air quality is at its worst (Usanee Vinitketkumnuen et al. 2002).

The incredible interplay and intermixing of land-uses in the new areas of Chiang Mai is a reflection of the lack of control of local government over land-use. The main municipalities of Chiang Mai and Lamphun, and the sub-district Tambon Administration Organizations elsewhere rarely get beyond the challenging problem of collecting rubbish and cleaning roads.

New lifestyles and values

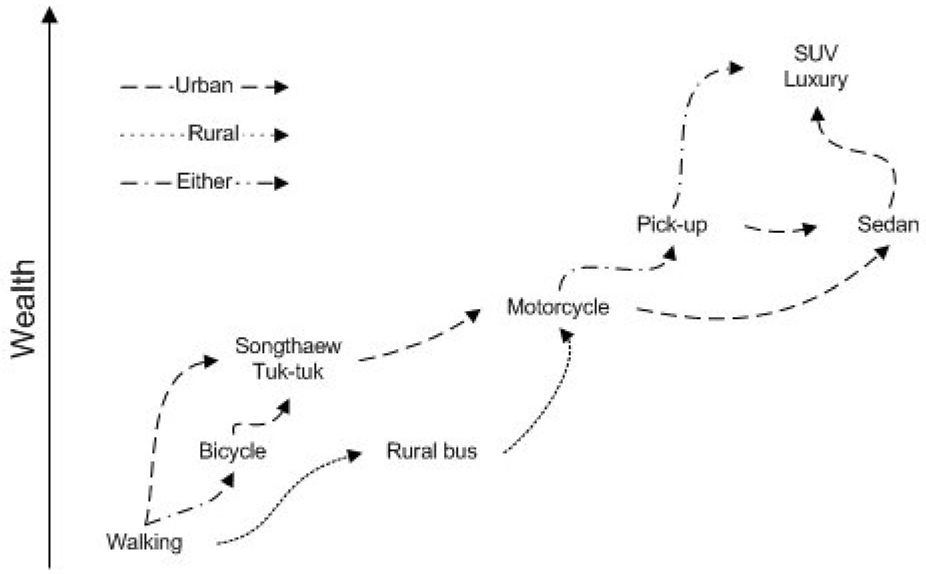
Urbanisation of the basin has also brought changes to livelihood portfolios of rural households throughout a much wider part of the region with many rural household now having at least some income from urban-based employment or informal sector activities (Rigg & Nattapoolwat 2001). The organization of production-consumption relations has also changed visibly from a base of small commercial traders in and around old market areas to many more scattered and larger factories, retail outlets and service centres.

The pathways of regional development in transport modes has followed a fairly conventional sequence but highly compressed in time (Figure 8b). The advent of low-cost light commercial diesel pick-up's has been a key technology for rural and urban areas and their interaction. Pick-up's have been an important working tool for the mostly small-scale farmers throughout the basin for transport of inputs to fields and commodities to markets. They have also been critical for small brokering firms in the cities and smaller rural towns providing flexible delivery logistics for huge range of products. Pick-up's are incredibly flexible, being used as mini-buses to transport both paying passengers as well as families and maybe later the same day produce to market. The latest urban fashion is four-wheel drive pick-up's with oversized engines and luxury interiors, that compete in every sense of the word with luxury SUV's.

The possibility of rising indirect emissions in material consumption is a key issue for analysing the consequences of urbanization (Dhakal 2004). In Chiang Mai the most visible change due to urbanisation is the expansion of concrete-based housing. The construction boom is reflected in figures for the consumption of cement.

Thailand produced 31 Mt of cement in 1994 to yield 7.2 Mt C or 2.4% share of world total emissions from cement production (Worrell et al. 2001). Emissions from cement production arise from approximately equal shares from fossil fuel energy use and the calcination process. In 1998 a year affected by the financial crisis Thailand was the 13th largest cement producer in the world with 23 Mt production (Nordqvist et al. 2002).

Figure 8b: Transition pathways for transport modes with urbanisation.



Siam Cement, a Thai multinational, was one of 10 cement producers that joined the international Cement Sustainability Initiative under the World Business Council on Sustainable Development (Nordqvist et al. 2002).

The growth of construction over the past decade has been largely outside the core older municipal areas for which there is no systematic data collection. Floor area for construction permits issued within the Chiang Mai and Lamphun municipalities fell from 1-2 million m^2 in the early 90's to almost one-tenth this level by 2000. Key transitions in housing stocks are summarized schematically in Figure 9. Changes in social structure, including family sizes and availability of additional land for rice cultivation in rural areas is an important driver of these architectural shifts in housing stocks.

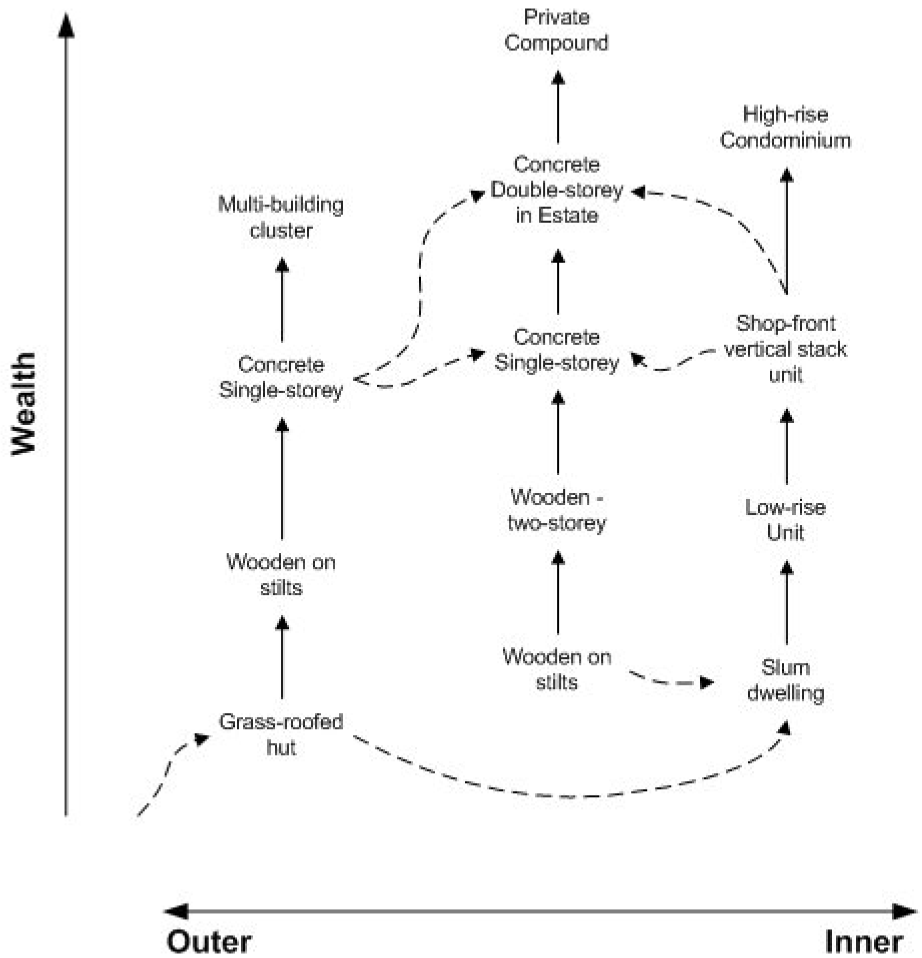
These gross structure and building material changes are paralleled by changes in internal design with shifts towards full compliment of electrical appliances with rising wealth and as move inwards shifts to electric fans then air-conditioners.

Housing styles are of course in part "created wants" through the activities of major land and housing development corporations that use home magazines, display homes and billboards to create images of success. That the buildings in the double-storey gated communities (Wilson & Rigg 2003) increasingly resemble suburban US images should not, therefore, come as a surprise.

Several trends in architecture building styles and materials are contributing to rises in energy consumption. One of the most striking features of the new urban areas of Chiang Mai is the dominance of concrete-box style constructions based on a 4 X 4 m spacing of reinforced concrete pillars. This is true both of low cost 3-5 storey multi-occupant blocks used both for residential and commercial purposes and often both together and the more expensive stand-alone homes in gated communities. Tile roofs typically lack insulation, windows are often not easy to open to create cross breezes and a lack of trees and other green areas compound problems of temperature regulation. Air-conditioning is essential in the hot wet season especially in upper floors. Poor siting, orientation, rooves with very short eaves that cannot keep hot sun in late afternoons off main wells all compound problems. Lack of street trees in new developments, especially in first 10 years, makes "comfort" dependent on fans and air-conditioning.

The irony is that many components of traditional architecture and siting were able to keep houses cooler with no extra energy consumption.

Figure 9: Main transition pathways for housing stocks. Dashed lines indicate splits or moves of households into new urban zone.



Although we have no direct break-down data on usage we expect that air-conditioning for both commercial and residential properties is one of the fastest growing components of electricity consumption over the past decade, and consequently a major contributor to growth in emissions.

In the home there has been a substantial shift away from small-scale combustion of biomass fuels to bottled natural gas for cooking. Electric stoves are still uncommon but consumption of microwaves and other electric domestic appliances is growing very fast.

Overall electricity consumption increased across the study region by on average 21% a year between 1990 and 2000. Growth rates in the districts with rapid urban expansion like San Sai or Hang Dong show some of the largest changes. The Northern Region Industrial Estate itself in 1994 was already using as much electricity as 5 of the smaller non-muang districts underlying the importance of growth in commercial uses as well.

At the national level approximately two-thirds of electricity generated comes from natural gas (64%) with lignite, fuel oil and hydropower making up the rest.

Diet changes over the past two decades have been significant and would likely have implications for emissions. For example, annual consumption of fresh milk in Chiang Mai province increased from just over thousand tons in 1993 to more than three hundred thousand in 2002, a 25-fold increase.

There is also a whole series of social institution changes that parallel the more immediately visible changes wrought in concrete as a location or household *urbanizes*. Firstly, household sizes are decreasing with much greater single occupant and small family dwellings. Secondly, we suspect but cannot adequately document large changes in social organization, for example, related to formalizing institutional arrangements for credit and safety nets as urban lifestyles bringer with it greater access to, and use of, banks and insurance companies. Thirdly, rural patterns of reciprocal labour exchange especially among relatives are replaced by non-kin employee-based relations. Fourthly, political institutions shift out of often older village headman context into bureaucratic state structures including TAO and other municipal committees. Fifthly, there is very little opportunity or support for low-cost housing projects making slum areas inevitable. Finally, many services, counter-intuitively, are becoming increasingly privatized like education and various services in gated housing communities.

Perhaps the most impressive indicator of lifestyle change is the growth in size and sheer volume of advertising billboards. Over the past two years the main “superhighway” that rings Chiang Mai on the east has been lined with monstrous advertising billboards that literally block out the sky and Doi Suthep mountain in the background with images of air-conditioned cooled comfort and bigger and better pick-ups and manicured gardens of gated communities.

Regional hub and competitiveness

A great part of rhetoric and some of the reality of infrastructure growth in the north has been explicitly towards the goal of improving the Lamphun-Chiang Mai twin cities competitiveness in the wider regional context.

A key step was the establishment and development of the Lamphun Industrial Estate in the northern region. Up until this point economic growth had been based entirely on agriculture and tourism (Glassman & Sneddon 1998). During the Sixth National Economic and Social Development Plan (1986-1991), the concept of making the Chiang Mai –Lamphun twin city a regional hub linking the economies of South West China, Myanmar, Laos to Northern Thailand became part of conventional wisdom on northern development (Tran Hung 1998).

Emissions related to energy consumption in these factories and commercial sector as a whole has become a significant contributor to overall emissions budget of the region. The industrial estates have altered urban form creating a Chiang Mai-Lamphun urban-industrial corridor and other satellite settlements of factory workers (Figure 6). Livelihoods that make “urban” lifestyles possible have undergone drastic transformations (Figure 10) that are, in part, gender-specific. Although no analysis has been done we expect that male per capita emissions would be substantially higher than female because of the latter group’s greater use of public transport.

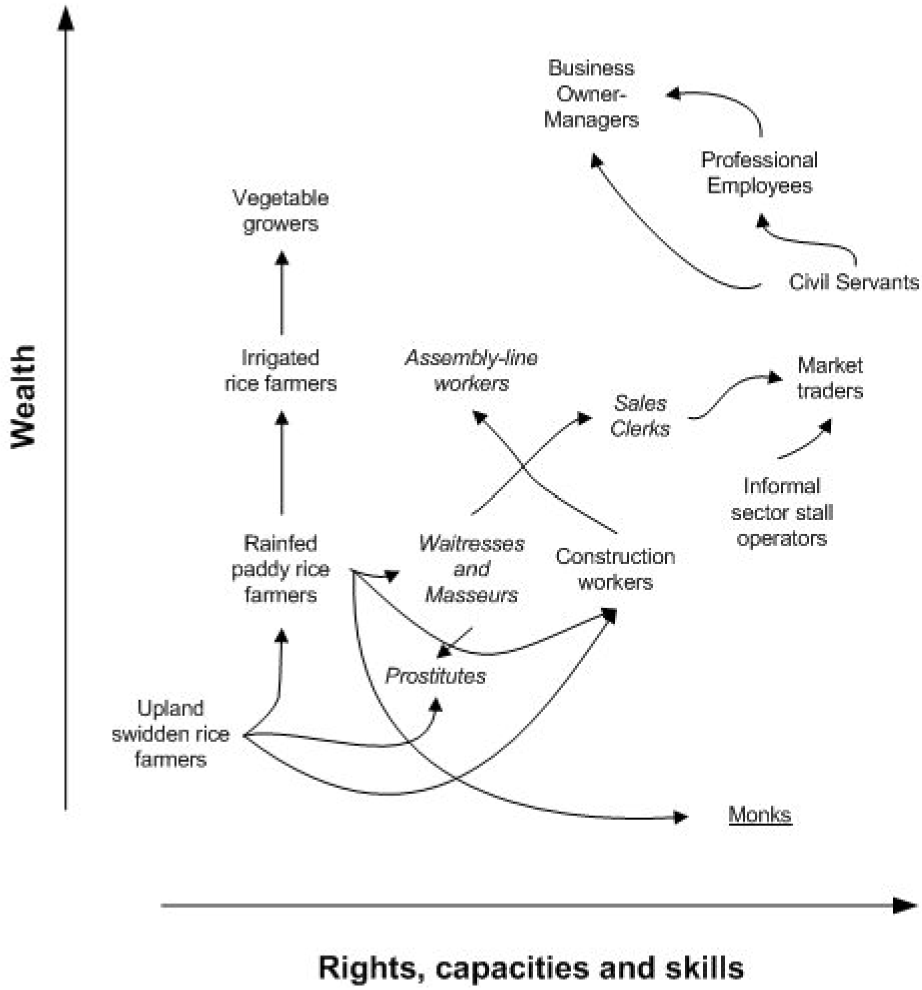
Can Chiang Mai become a successful regional hub without degrading its cultural and ecological environment that forms a critical part of it past attraction as a tourist destination?

Tourism has been a high priority since the Sixth National Economic Social Development Plan with significant investments in public infrastructure in key destinations like Chiang Mai stimulating even greater private sector investments (Chifos & Looye 2002). Since 1996 the number of annual visitors has fluctuated between 3- 3.5 million while the fraction of international visitors has risen from around 1/3 to nearly ½. Visitors stay on average just over 4 days meaning if they consumed as little energy as residents they would represent may be 5%, but reality is this is likely to be very much higher.

Tourism and associated services are significant to carbon emissions through several pathways. First there is their direct energy expanded in facilities such as hotels, guest rooms, restaurants and the entertainment industry and local transport. Second there are the emissions associated with travel, especially air travel. Third, but probably least important are the embodied emissions in facilities built for tourism and the impacts on land use, for example, through development of resorts, and indirectly on attracting labour out of agriculture into the services sector.

It could be argued that responsibility for air-travel related emissions lie with the "tourist consumers", but the fact remains that the aggregate impacts of tourism-oriented development on carbon cycle are non-trivial. A key irony is that customers reach their environmentally friendly tour destinations after long-plane rides.

Figure 10: Shifts in livelihoods: changes in dominant occupations. Women-dominated roles in italics and male-biased roles underlined.



11.3 Balances and prospects

Changes in urban spatial organization and architecture, the intensification of agriculture away from paddy rice, nucleus of a agribusiness and manufacturing industrial sector, the continuing expansion of tourism, and importantly, sweeping institutional transformations interact to define the urbanization process in the Mae Nam Ping Basin (Figure 6). These processes, in turn, have modest to larger consequence for carbon stocks and fluxes through a fairly modest number of key pathways.

Urbanization impacts on emission budgets

The consequence of these various processes on overall carbon stocks, fluxes and balances could not be estimated with much precision in this study, because of limitations of adequately dis-aggregated or relevant local data on emission factors. The only previous emission inventory in the northern region of Thailand is a very rough calculation made by Chiang Mai municipality.

They calculated 0.9 Mt of CO_2 for the year 2002 for the municipality. A few studies have looked at methane emissions from rice fields and forest conversion in the vicinity. Nevertheless, some initial calculations provide useful information about the relative magnitudes of key trends (Table 1).

Uncertainties in national emission inventories can be quite large. Errors in estimates are easily compounded rather than reduced for smaller-scale regional analysis in little-studied areas because of the lack of disaggregated data and uncertainties about appropriateness of emission factors from elsewhere. Our carbon budgets for the urbanizing region of Chiang Mai (Figure 11) are therefore rough (Table 1). We attempted to give some idea of uncertainties in estimates by cascading uncertainties in key parameters.

Table 1: Carbon emissions in Chiang Mai region. Mt of CO_2 equivalents. Numbers in parenthesis are negative (i.e. a carbon sink).

	1980	1990	2000
Transportation	0.12 - 0.25	0.42 – 0.80	0.45 – 0.96
Electricity	0.09 - 0.19	0.24 – 0.43	0.75 - 1.20
Waste	0.036 - 0.044	0.050 – 0.058	0.64 – 0.71
Land-cover	0.025 – 0.076	0.025 – 0.076	(0.014) – (0.031)
Paddy rice	0.24 – 0.59	0.25 – 0.60	0.17 – 0.42
Total	0.51 – 1.16	0.98 – 1.97	1.42 – 2.62
Per Capita	0.7 – 1.4	1.1 – 2.0	1.6 – 2.7

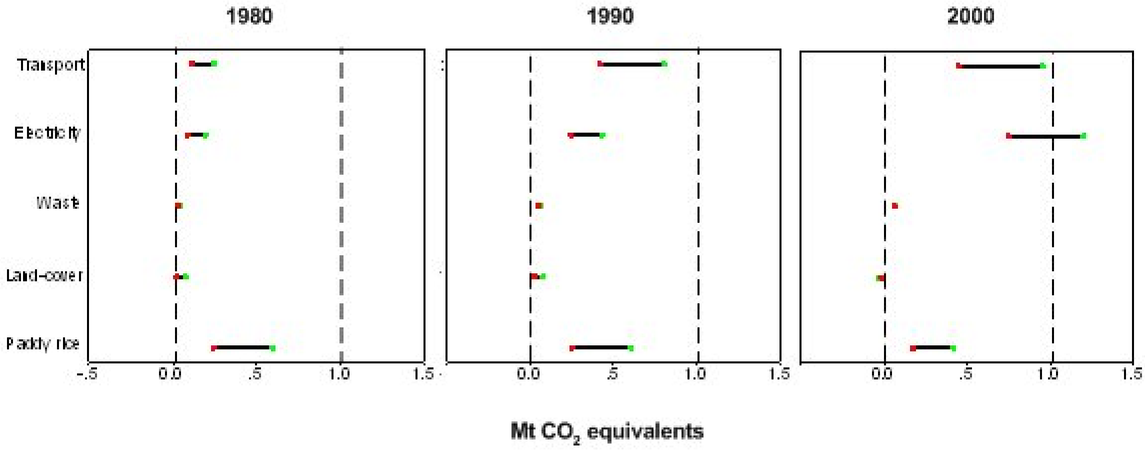
Nevertheless, there are several visible trends over the past two decades (Figure 11).

Firstly, the decline in rice-growing areas and concomitant rise in other sources means the relative contribution of methane from agriculture has declined substantially, from around half in 1980 to less than 20% in 2000. Inclusion of data for deemed emissions from livestock as a result of large increases in consumption of dairy products would not be enough to reverse this trend. Numbers of livestock within the area fluctuate substantially among years but are generally at levels half in 2001-02 of what they were in the early 90's when stock reached more than 50,000 head. Most are in SangKampang district. It is uncertain whether parts of the landscape may also be methane sinks.

Secondly, emissions associated with rising electricity consumption have grown even more strongly than growth of consumption of fossil fuels in transport sector. In 1980 electricity accounted for only 17-18% whereas by 2000 this had jumped to 46-53%. Proportionally transport sector increased only marginally from 21-23% to 32-37%.

A critical missing part of the budget is for cement. We have not yet been able to get reliable figures to estimate cement production and consumption in the Chiang Mai study area. We anticipate that the deemed emissions involved in construction would be quite large compared to other items in the table.

Figure 11: A carbon's eye view of urbanization in the Chiang Mai study region. Bars represent uncertainties in estimates (see Table 1).



Other smaller missing parts of the budget are the growth of woody biomass which since the 1988 logging ban probably means that within forest areas there may have been a net increase in carbon stocks during the 90's in the study area.

One issue we have little information about but which may of a major influence on methane emissions is the impacts of altered water flows and levels on fragmented often highly disturbed wetlands in the basin.

Finally, one other trend not obvious in the decadal budgets is the 1997-98 financial crisis which led to sharp drops between 1996 and 1998 in many factors affecting emissions. Many indicators suggest "recovery" to pre-crisis levels by 2000-2003 but with often slower rates of growth than prior to the crisis.

For Chiang Mai region there are some difficulties in interpreting per-capita emission values. Firstly as a tourism destination that also has high rural-to-urban cyclic migration and daily commuting, using residential population as a denominator (as done in Table 1) is a misleading over-estimate. A detailed analysis of tourism related emissions would be worthwhile as clearly from a global perspective managing their emissions may have a lot higher leverage than that of residents.

Urbanization scenarios

Urbanization provides many opportunities for helping achieve social justice, improved well-being and more sustainable livelihoods for the poor (Lebel 2004a). The concentration and shorter distances makes key service delivery in terms of education and health cheaper and simpler. Skills training could create new opportunities for meaningful employment in urban settings and needed increases in consumption.

The benefits of urbanization for sustainability also apply to the lifestyles of the wealthy. More compact aggregations create opportunities for more efficient and cost-effective public transport systems, and provide a taxation base for developing better public services, like schools, libraries, parks and sporting venues (Lebel 2004a). It may also make creating a sense of responsibility for place among leaders and influential individuals easier.

Regardless of your preferred starting point, how urbanization unfolds in the next one to two decades is going to be clearly important for longer term regional sustainability. For example, there is a "windows of opportunity" for decoupling energy use and emissions from urban growth through appropriate design of urban transport infrastructure that could moderate a huge rise in car dependency.

The major uncertainties in all this is how Chiang Mai fares in relation to other cities in the region with which it has to compete, the overall levels of potential investments, and foremost, the capacity of the urban-based administrations to keep control of development in the interests of the public they are supposed to serve (Lebel et al. 2004). Feedbacks from environmental changes, in particular, conditions of agricultural soils, water resources and aesthetic quality of mountain landscapes, are also important for future urban transitions. These uncertainties are captured by four scenarios (Figure 12, Table 2).

Figure 12: The urban scenarios are embedded in a larger regional socio-economic scenarios for how the landscapes may evolve.

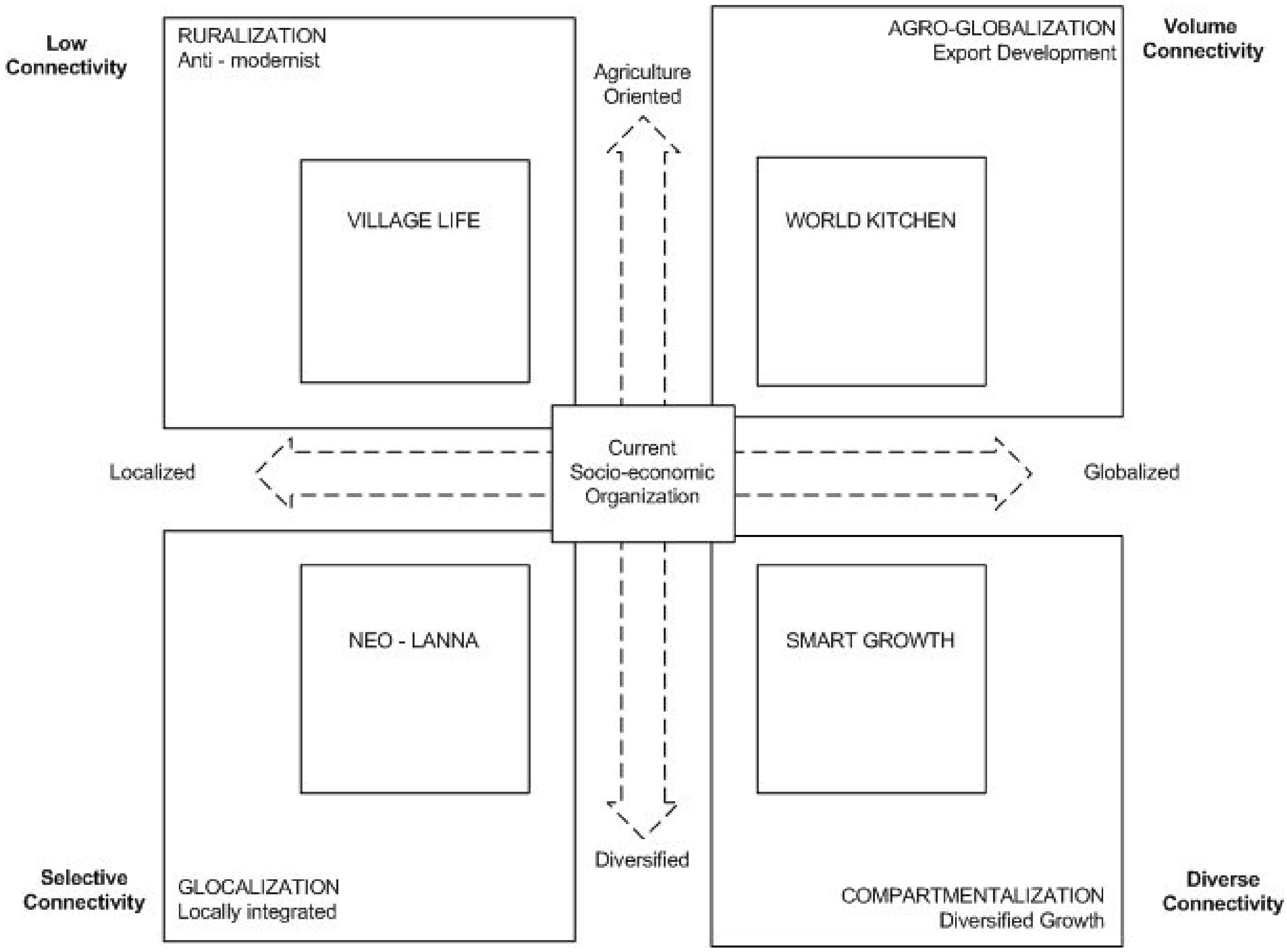


Table 2: Abbreviated story-lines of the four scenarios. (For full details see: Lebel et al. 2004)

Scenario	Story-line summary
Neo Lanna	This scenario is characterised by appeals to the past for values, styles and organizing principles, but at the same time a willingness to adopt modern technologies, and thus, selectively engage in trade and court external investments. More than any other scenario, this requires the region to maintain a significant degree of control over how urbanization and other development processes unfold within it. This is achieved socially by re-creating a "neo-lanna" identity that is beneficial for firms developing niche markets for higher-value products and services. Ecologically, the emphasis on regional values means that the quality of the environment in the basin receives a high priority, not necessarily as "wilderness" but as an aesthetic contribution to the cultural landscape. Cultural diversity is fostered to the extent it doesn't challenge the "emerging" regional identity. This is pre-fixed with "neo" because invariably it includes significant contributions from ethnic minority and Chinese culture, as well as value fostered by decades of high levels of western tourism.
Village Life	This is probably the most radical of the scenarios given current political and economic trends. It is anti-modernist and local in perspective. It is sold as pro-rural and pro-poor and labelled by its opponents as everything from "communist", "nostalgic" through to "reactionary". It sees the purpose of economic development as serving rural areas and the poor rather than the other way around. The city is seen as a place of concentrated services for rural areas, including developing the capacities of the rural poor. In practice the scenario does not unfold as radically as any group argues, but emerges as a compromise.
World Kitchen	The key idea behind this scenario is that engagement with larger scale commodity markets for food, and the technological and other inputs to produce it is a broad and dominant force of socio-economic change and land-uses. Regional economic development is pursued primarily through agricultural and agri-business industrialisation, though of course manufacturing industrial sector also expands, its land-use implications are not large, at least directly, but maybe for water and energy resources. Chiang Mai is re-oriented towards this primary production role with huge investments in agricultural, processing, and marketing research and development
Smart Growth	In comparison to the other scenarios the smart growth comes closest to purporting to balance multiple objectives of economic growth, industrialization and conservation. The main pattern being that different commercial, conservation, recreation, settlement and other activities become increasingly segregated spatially. It places a strong emphasis on spatial planning, controlling land-uses and the allocation of resources like water and quality soils. Technical expertise is highly-valued and engineering solutions are sought for any limitations to continued growth arising from environmental feedbacks. The well-managed industrial estate is the symbol of this scenario.

Carbon and air quality implications

From the perspective of climate protection, key contrasts in the scenarios are about how they affect the use of high-carbon content fuels and rates of conversion of land-surface to low-carbon stock land-uses (Table 3). For air quality several other issues need to be considered some of which may have trade-offs with greenhouse gas emissions.

Urban air quality in the *Village Life* scenario, for example, is anticipated to be seasonally poor as a result of large biomass burning emissions from fire being used as land management tool. In the *Smart Growth* and *Neo Lanna* scenarios, it is expected that air quality would improve through emission controls on vehicles and industry but that that overall CO_2 emissions from energy use would continue to rise substantially above current levels especially in Smart Growth scenario. In the *World Kitchen* scenario, emissions from intensified agriculture and livestock production as well as agri-business process and energy use would rise substantially, but it is in the transport sector for high volumes of trade that the largest emission growth would be associated. CO_2 emissions would likely be very large with largest contributions from industrial and agriculture sectors rather than residential. With little emphasis on environmental management urban air quality would also deteriorate and include significant impacts from industry in the rural-urban periphery.

Table 3: Qualitative implications of future four scenarios of development and urbanization in the Mae Nam Ping Basin for carbon emissions: 5-point comparison scale from lower to higher: O -- . + #

	Stocks and fluxes				
Scenario	Transport	Land-use - crop areas	Urban lifestyle - electricity	Tourism – deemed emissions	Industry
Village Life	O	--	O	O	O
World Kitchen	#	#	+	--	+
Neo Lanna	.	O	.	+	.
Smart Growth	+	--	+	#	#

11.4 Carbon management

In this final section of the paper we consider the prospects and options for accelerating the relative (to economic growth) rate of decarbonization through explicitly incorporating carbon management into development strategies. We also explore some of the governance issues that arise in carbon management based on our understanding of development in Chiang Mai.

Evolve better urban form and designs

The evolution of more environmentally benign urban forms could make an important contribution to improved quality of life of the poor while also helping de-couple growth in aggregate levels of emissions from gains in social development. In the case of Chiang Mai four key processes need to be influenced.

Firstly, a vicious cycle of road-building and spatial organization that is increasing dependent on private vehicle use while making public-transport systems more and more costly to implement. Low-cost public transport system should be laid out to guide future development and commuting patterns rather than just be a delayed response to congestion and long-commuting times. Privileged use of parking and lanes to multiple-occupancy, clean and efficient vehicles could reinforce incentives.

Secondly, rather than using strict and fixed zoning laws on land-uses in the Thai context it seems more feasible to make use of public investments to ensure better spatial distribution of quality local services, especially schools and key commercial infrastructure and to integrate this with public transport layout. The problem should not be reduced to one of complaints about lack of power or capacities for urban planning, management and regulation. This is too conventional a model of the role of officials and experts in urban governance. Urbanization in the Chiang Mai has unfolded as a result of a complex interplay of market incentives, practical local decisions, and historical and cultural legacies as well as the usual mix of politically-linked land speculation and construction contracts. This means there is an adaptive and flexible character that overly-planned cities cannot emulate and which makes Chiang Mai such a popular place. The result is a very fuzzy rural-urban boundary which doesn't conform to the suburban standards of landscape schools or urban management manuals. Some aspects are clearly bad for energy and land use in that ribbon development interferes both with access and water management of agricultural land while also making travel distances longer. Other aspects of having significant green spaces and traditional "village-like" structures around temples and wet markets, and places of work and local businesses, on the other hand, could be a source of urban renewal protecting both ecological services and people's lives in safer low and slow traffic environments.

Thirdly, changes in urban form should be linked to improvements in urban architecture that greatly reduce energy expenditures for climate-control in buildings. Insulation, for example, is still rarely used and units in apartment blocks almost always have own individual water heating and air-conditioning systems and so fail to take advantage of savings in efficiency. Residential area planning should make much better use of green space, wind corridors and water bodies to provide low-energy passive cooling to dwellings. Native deciduous trees can provide seasonal shade. Provision of quality shared-use areas could act as a break on rising house sizes and allow compact developments. Improvements to building design are needed both in the gated communities of the wealthy and in the low-rise low-cost housing blocks which easily become insufferably hot.

Finally, lessons from the 1997-98 financial crisis which was started and amplified by the collapse of a real estate property bubble should be heeded. State regulatory agencies need to monitor loans and macro-economic conditions so that the inevitable swings in the business cycle are not amplified into even larger costs of abandoned projects. They also need to take a realistic and scenario-informed perspective on future regional development. Several trends, especially demographic ones, for example, suggest at best very moderate growth of Chiang Mai's population through in migration, whereas current outer ring-road building spree suggests huge urban growth spurt which will likely never eventuate and thus leave more ribbon and corridor patterns of development.

Look beyond the municipal boundary

Cities are open systems subject to external shocks and driving emissions in remote locations through the consumption behavior of their citizens.

The jurisdictional areas of the current municipal boundary of Chiang Mai is way too small to be relevant to affectively govern the urbanization process. Provincial level is much more appropriate, but we note that the fates of Lamphun and Chiang Mai are closely linked. Making Chiang Mai a clean city will not also make it a sustainable one.

The best illustration of cross-scale linkages, and the need to look beyond the urban boundary in the case of Chiang Mai region, is the huge impact that tourism has on the economy and emissions.

Tourism is clearly an important part of the Chiang Mai economy and makes a significant contribution to emissions. Most of these emissions take place within urban areas of Chiang Mai affecting local air quality. Ultimately this may degrade the "tourist experience". This suggests there may be substantial incentives to keeping air quality high for tourists. The tourist sector should lead by example as it is in their shorter and longer-term commercial interests to do so. In the short term substantial improvements in energy efficiency associated with housing, eating, entertaining and moving tourists around without degrading the "quality" of tourist experiences. In the longer-term they can show by example to other commercial sectors with less immediate vested interests on how to reduce emissions and maintain local air quality. The state can also help through greater attention to the spatial organization of tourist activities in urban planning. For example, the layout of road and transport infrastructure, and zoning of areas for tourist development are important for the feasibility of sustainable public transport and pedestrian-only access strategies to reduce emissions.

Perhaps growing less important but still significant is the way urbanization impacts on upland development and the fire disturbance regimes in the surrounding mountains. Much of the air pollution in the urbanized valley originates from agricultural practices outside the built-up areas. Urbanization, market and demographic transitions may help reduce the rate of growth in emissions without specific policy interventions. They may also create opportunities to reclaim abandoned agricultural land. Conservation could increase the extent and improve security of carbon stocks held in forested parts of the landscape.

The biggest challenge of boundaries and scales, however, is directly in the political and administrative systems in which urbanization in the basin is unfolding. In the long-established governance structure in Thailand, powers and responsibilities are divided among a number of ministries and departments at the level of the central government, while lower levels of government have traditionally had rather limited powers and capacities. Rules on paper at the national level often have little meaning for local government practices, and vice-versa.

Link local air quality with climate protection

Reducing emissions to improve local air quality for health reasons can be linked to global efforts for climate protection but there are challenges and maybe some important trade-offs.

The first and largest challenge is that the issue of seasonally poor local air quality is still a relatively low priority of citizens and bureaucracy alike. Trying to add issues of less immediate local concern onto the policy agenda in this context is likely to be exceedingly difficult beyond lip-serivce. Despite a substantial amount of NGO, research and media attention (Kanyawat Sriyaraj et al. 2004; Po Garden et al. 2004; Usanee Vinitketkumnuen et al. 2002) the municipality and provincial governments have been very slow to take any real actions. It was until the second-half of 2004 that a systematic plan was drafted and deliberated. Even now, however, the links between urban air quality and biomass burning in the surrounding agricultural and forest areas is not well appreciated.

The second challenge is that Chiang Mai region's cumulative, aggregate and per-capita contribution to climate damage is small compared to that of citizens and cities in developed countries so the rationale for why its citizens should be concerned with climate protection is not straightforward. The key reasons are strategic. There may be important benefits for inter-region competitiveness of moving early on carbon management. Experience with decoupling emissions growth from social development should be beneficial in future worlds with greater competition for energy resources and higher oil prices. International environmental agreements may also provide a context that markets don't. If Annex 1 countries were put under great pressure to reduce emissions because a major or series of climatic-induced disasters were clearly attributed to climate change then having an efficient and clean regional economy already may be a great advantage. Urbanization would have to be part of such a strategy.

Strategic actions would be especially promising if the actions taken today are largely win-win, in that they don't have significant negative impacts on competitiveness or social development. Reducing reliance on automobiles is central for the multiple benefits it could provide, but requires negotiating a comprehensive vision for Chiang Mai's future that integrates transport, urban form and layout, and ultimately, values of its citizens. Efforts to improve energy efficiency including not just residential and commercial buildings or industrial processes but also in the large state sector in Chiang Mai also promise double benefits. But there may also be some divergence in air quality and climate protection. Efforts to influence fuel choice among diesel and gasoline, for example, may work against each other as diesel typically processes less CO_2 but higher particulates and NO_x.

The municipality clearly sees some strategic and symbolic value in climate protection. The level of awareness of the more diffuse but globally important issue of carbon emissions for climate protection can be gauged by actions of the municipality. Chiang Mai municipality joined the Cities for Climate Protection—Southeast Asia Campaign, of the International Council for Local Environmental Initiatives ICLEI) in 2002 (Chiang Mai Municipality 2004). As part of this they conducted emission inventories and forecasts, set emission reduction goals and introduced an action plan (Table 4). The report, however, does not include the contribution of the industrial, electric utility, agricultural sectors, as well as carbon sequestration for forest sinks.

Table 4: Key features of Chiang Mai's Action Plan for the Climate Protection Campaign

Key Milestones according to Cities for Climate Protection Campaign	Status and effectiveness of actions taken by Chiang Mai (as of June 2004)
Conduction emissions inventory and forecast	Inventory based on electricity consumption in residential and commercial sector, fuel use in transport sector, and waste management was prepared for 2002. The inventory focuses on the municipal area – so does not consider agriculture or forestry.
Set up an emissions reduction goal	Done. Unclear how.
Develop emissions reduction action plans	Draft plan based on 2002 baseline and with reduction targets for 2012 has been set (Chiang Mai Municipality 2004). Key measures proposed are (1) improving energy efficiency through better lighting and other appliances; (2) minibus-based public transport system; (3) improved recycling of waste now destined for landfill; (4) and a small contribution from urban greening. 75% of emission target is to be fulfilled from recycling of waste.
Implement emissions reduction actions	Minibus program has been approved and set to be implemented. Other transport improvement options underway but were not related to emissions reductions.
Monitor results achieved	Appears to be no commitment.

Nevertheless, the Chiang Mai municipality has taken some first steps by joining the ICLEI program. This could even be a bargaining chip in gaining greater regional control that would be reinforced if it could expand interest and responsibilities to the larger urbanizing and industrializing districts in the basin. This might be through, for example, building a consortium with district offices, civil society groups and key firms that would allow greater attention to be paid to the environmental consequences and opportunities in urbanization.

A third challenge is that many emissions are either caused by activities and decisions elsewhere or themselves occur outside the immediate boundaries of Chiang Mai as a result of consumption behavior of residents. Policies and programmes at national level that target reducing growth rates in greenhouse gas emissions may themselves do little for local air quality in urban areas and vice-versa.

Tourism in particular creates an interesting mix of challenges for linking issues. Chiang Mai could promote itself as a green and environmentally aware city with good health services and healthy environment to live and visit. If this led to sustained or increased international tourism the consequences would undoubtedly be greater energy use locally and also much higher emissions associated with air travel. Tourism can undoubtedly be used as a force to improve and maintain local air quality but it is much harder to see how it can also serve goals of reducing carbon emissions. How many trees would each visitor need to plant to balance their trip budget? How long should they stay?

Negotiate responsibilities

In any case, in the Chiang Mai context, local governments have still relatively little influence over key policy areas affecting emissions which remain largely national in focus. Betsill's review of the activities of US cities in the Cities for Climate Change Protection campaign emphasise the importance of state and national level policy changes – in part, because cities don't have control over key institutions (Betsil 2001).

Perhaps this biggest barrier to improving local air quality is that most of the major decisions about urban planning and infrastructure appear to have been made by the bureaucracy in Bangkok. This history of technocratic management at a distance is a major organizational barrier to public participation, even self-interested forms, in improving quality of urban life in Chiang Mai. The state of affairs has been so dismal that Preecha concludes that Chiang Mai municipality has been more or less dysfunctional for the past 60 years. Apart from interference and control by central government, the council has largely been made up of retired government officials and has not been very active (Preecha Jengjajern 2000).

Most research on solving urban air quality problems in Thailand has focussed on economic policy instruments, technology standards and regulations and studies of traffic and road design. Air quality is seen as a technical issue for the bureaucracy to solve. Very little attention has been paid to issue of sharing governance or responsibilities.

A good indicator of the challenges faced is that internationally funded projects seem to have driven most initiatives. The Chiang Mai Air Quality Initiative program was established in 2000 and involves partnerships between the United States of America and Thailand at the national and local levels. The United States–Asia Environmental Partnership (US-AEP) linked the Thai Pollution Control Department with the Maryland Department of Environment. A third initiative the Managing Air Quality and Health in the Urban Environment (MAQHUE) was launched in early 2002 under the Asia-Urbs Program linking Middlesex University, England, with Chiang Mai University and the Regional Environmental Office.

With the aid of international groups Chiang Mai municipality established a few air quality monitoring stations around the city. A large scoreboard sits at a prominent place in town indicating basic air quality values. Overall the Chiang Mai authorities have not communicated their intentions or activities on air pollution very well. Opportunities for public participation have been rare.

Local NGO's, academics and media from time-to-time write about the air quality problem, for example, on public health, and the issue is raised in public meetings. The Urban Development Institute Foundation has been particularly noteworthy for its efforts. There is not much evidence, however, that these latter actions by civil society are having much influence on policy.

Justice considerations suggest that the main actions to reduce emissions should be taken by the developed world (Harris 2002). This is recognizing that many of the key negotiations over international institutions related to carbon have been among nation-states. But justice considerations would also suggest that within countries the wealthiest, who often live in urban areas, should bare the largest responsibilities.

Ironically, we note that most of the wealthy parts of civil society with the political connections to be influential and mobilize resource are pre-occupied with buying second and larger cars and moving out to larger houses further way from town where the environment is still pleasantly rural or forested, and driving in to work, play and shop.

11.5 Conclusion

A carbon's eye view of urbanisation in Chiang Mai led to several surprising insights about the importance of pathways of regional development for the environmental health and climate protection more generally.

First, there is substantial promise in linking efforts to reduce greenhouse emissions to attempts to improve air quality for health reasons, but there are also significant trade-off's and non-complimentarities. Ultimately, air quality improvements and carbon management should be a part of a broader sustainable urbanization development strategy that also examines utilization and allocation of water, protection of soil resources and biodiversity. Urbanisation provides many opportunities for environmental improvement, but many of these will be lost without attention to integration of resource use, waste streams and the services provided by ecosystems.

Second, a focus on urbanization at the regional scale is much more promising then one that is too narrowly on cities. Reasons include: ease with which pollutants can be conveniently relocated beyond municipal or provincial boundaries; rapid rise in deemed emissions that often accompanies consumption-growth in cities; important contribution of rural land in urban-periphery for carbon stocks, and wetland methane and fire-related emissions.

Third, urban form should be an important consideration in trying to find ways of incorporating carbon management into regional development strategies. The spectacular "urban growth" of Chiang Mai is not because of large influx of population as changes in life style associated with increasing wealth and the constraints of poor urban layout. Automobile dependence can get established early in economic growth of region with long-term detrimental consequences and costs for efforts to improve environmental health and adopt more sustainable development strategies (Faiz 1993).

Fourth, small cities in developing countries are special, but nevertheless have some useful things to say about regional urbanisation that a focus on just the largest cities cannot reveal. Small and intermediate sized cities typically have lower densities than at least the central parts of the compact multi-rise mega-cities (Dhakal 2004) suggesting that many of the energy-saving solutions in transport and climate control proposed for these places may not be so appropriate. Moreover, the kinds of resources and institutional leverage that smaller cities have over the direction of their development are also often very different from large or capital cities. On the other hand opportunities for more integrated rural-urban linkages and nodal structures with shorter daily commutes arise.

This initial study of Chiang Mai, however, suggests there are still several major gaps in the general understanding of how urbanization influence the carbon cycle and thus could be guided as part of strategies of incorporating carbon management into development strategies. Foremost among these is developing better forward-looking indicators and measures of success for carbon management in the context of regions still under-going rapid economic growth and urban transformation in which relative increases in energy use and material consumption must be large. Per capita and per unit-GDP are crude and not well related to urbanization phenomena. There also needs to be much more careful exploration of potential institutional arrangements, including market-base systems, at the city-region level that could directly link increasing emissions from fossil fuel energy use to increasing carbon stocks in the landscape as way of maintaining sub-national carbon balances.

Finally the role of cultural change and differences and how these shape carbon-intensity of lifestyles in developing countries needs a much better understanding (Lebel 2004b). What lessons might there be for high de-carbonizing the lifestyles of wealthy consumers in developed countries from looking at how smaller and intermediate-sized Asian cities are managing their growth and maintaining a quality of life that has often escaped the mega-cities of the region.

Urbanisation because it affects (and is affected by) so many processes in development may be a critical set of leverage points in efforts to decouple social development from carbon emissions. A carbon's eye view of how urbanization is unfolding around Chiang Mai suggests there may be alternative pathways to both the automobile-dominated landscapes of North America and the winding streets of historical cities of Europe. The big question is: who should be choosing the routes of Chiang Mai's future?

11.6 Acknowledgements

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12.0 Appendix 6: Case Study Working Paper – Jakarta

Carbon and the City: Carbon Pathways and Decarbonization Opportunities in Greater Jakarta, Indonesia

By Agus P. Sari[*]

12.1 Introduction

Climate change will result in devastating impacts on livelihoods.[13] Climatic change is expected to occur as a result of the thickening of greenhouse gas "blankets" in the atmosphere due to anthropogenic emissions of these gases. Emissions of greenhouse gases, especially carbon dioxide, are mainly due to combustion of fossil fuels in the energy sector, and secondarily due to deforestation and others. While the split between carbon emissions from land use and forestry sources and from energy and industrial sources is roughly half-and-half, the energy and industrial processes represent the most rapidly-growing sources of carbon emissions. In 1994, based on the latest emissions inventory, Indonesia emitted about 200 million tons of carbon and sequestered 110 million tons of which by its forests. Out of the 90 million tons net emissions, 46 million tons and 5 million tons are in the energy and industrial sectors, respectively.[14] But between 1990 and 1994, whereas the carbon emissions in the land-use and forestry sector were relatively stagnant, those in the energy related sector grew at a rapid pace of 5 percent per year.[15] The trends of emissions currently and in the future are that, while emissions from deforestation are decreasing, those form fossil fuel combustion are increasing.

Combustion of fossil fuels will continue due to the continuing demand for energy services, especially in the industrialized and industrializing economies — the "urban" economies. Additionally, demand for energy correlates strongly with the level of income (especially in purchasing power parity terms). For example, member countries of the Organization of Economic Cooperation and Development (OECD), whose income are relatively higher and level of urbanization similarly higher than the rest of the world, have higher energy use on a per capita basis compared with those in developing countries. Urbanization levels in poor countries usually are much lower than those on the OECD countries. As a result, levels of carbon emissions in these poor countries are also much lower.

But these will change very soon. Rapid economic development in developing countries will bring increased income, but along with it increased urbanization and energy demand. According to the Word Bank, Asia faces the fastest urbanization rate in the world besides Sub-Saharan Africa, growing rapidly at 3.7 percent per year from 1990 to 2003.[16] In the meantime, large cities will grow even larger. The shape of these cities will determine their carbon emissions in the future. Once the cities are shaped, they stay that way for a very long period of time. The emissions intensity of these cities, therefore, will be "locked-in" for a very long period of time.

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[13] IPCC (Intergovernmental Panel on Climate Change), Third Assessment Report. Intergovernmental Panel on Climate Change, Geneva, 2001.

[14] Ministry of Environment of the Republic of Indonesia, First National Communications to the UNFCCC, Indonesia. Ministry of Environment, Jakarta, 1999.

[15] Ministry of Environment, National Strategy Study on CDM in Energy Sector. Ministry of Environment, Jakarta, 2002.

[16] The World Bank, World Development Indicators 2005, Wahington, DC, 2005.

Cities are designed differently in different places. As well, the ways public infrastructure is provided for in the cities are different from one place to another. The intricacies of the designs of cities and their infrastructure are so closely linked with the social, cultural, political, and institutional backdrops of the cities. These driving forces that shape the cities basically are the underlying driving forces of carbon emissions resulting from the cities. From what has happened in the past we can extrapolate what could happen in the future; the knowledge of the driving forces can bring insights to pave less carbon-intensive path of future urbanization.

This research is an attempt to assess the human and institutional dimensions of changes in carbon stocks and fluxes due to urbanization, with Jakarta and its surrounding districts (Bogor, Depok, Tangerang, and Bekasi, making up the Jabotabek area) as a case.

12.2 Research Questions and Methodology

There are two sets of questions here. The first set of questions refers to pathways, as follows.

What are the consequences of different pathways of regional development, especially urbanization and urban transformation, on carbon stocks and fluxes? Are certain patterns of urbanization and urban transformation less carbon intensive than others?

How and why different pathways arise? What are the historical underpinnings of the different pathways of regional development? What were the important historical drivers of regional development path?

What drive these different pathways at present? What is the role of internal (e.g., local politics) and external (e.g., development agenda) influences?

These three questions are to be answered in the following ways. Our hypothesis is that emissions correlate with spatial development of the city, which in turn correlates with the socio-economic and political backdrop of the city development itself. Therefore, we will have three parallel sets of data. The first set of data is the carbon stocks and fluxes in 1980, 1990, and 2000. This set of data will be an inventory of emissions from the key sources, for example, emissions from transport, industrial, commercial, and household sectors in those years. The second set of data is the spatial development of the city in those years — with some explanations of the planological reasons for such shape of the city. The third set of data is the social, economic, and political settings that provide the backdrop of the periods, especially the institutional settings that provide interplay within the process of city development.

Historical data for the carbon stocks and fluxes, which will be derived from the data on the development of key sources (and sinks, if possible) of these fluxes in 1980, 1990, and 2000, are to be obtained mainly from statistical data published regularly by the Indonesian Central Bureau of Statistics (Biro Pusat Statistik, BPS), especially those in the Jakarta Dalam Angka (Jakarta in Numbers) for 1981, 1991, and 2001. These historical data can also shed some lights on the establishment of the third set, namely the social, economic, and political settings of the city. Additional datasets are acquired from the Energy Statistics for 1980, 1990, and 2000, published regularly by the BPS and by the Department of Energy and Mineral Resources, and Transportation Statistics either by the BPS or by the Department of Transport. Satellite imagery and maps, when available, will also be acquired. The Jakarta dalam Angka datasets especially can be used to create a socio-economic storyline on the population dynamics, urbanization trends, urban economic development and industrialization, and urban settlement patterns.

The historical legacies of the city, for example its intention to become a trading port, the capital of the nation, and a (partially) industrial city, can be revealed by undertaking surveys of past and recent publication on the city history. The production and consumption dynamics of the city can be revealed partly through the Jakarta dalam Angka statistics. More information regarding the economic development / economic growth, industrial composition, and energy use can be revealed through the various statistical data to be acquired. The per capita consumption of energy, and the per capita mobility — which will drive carbon emissions — will be inferred from these datasets. The policy development of the city will also be analyzed. Its role as the capital of the nation and the most urbanized one may prove to be influential in the process of shaping the city.

Finally it will be important to map out the political economy of the city development pattern, especially when the pattern leaves out a significant portion of the population and creates some pockets of poor slums throughout the city.

The second set of questions refers to the possibility for decarbonization of city development — using the case study of Jakarta — as follows.

What future urban forms, governance, institutional and cultural arrangements might be effective in facilitating the integration of carbon management as an explicit goal in regional development?

What are some of the most important technological options (e.g., change, innovations, among others) that could influence carbon emissions, sequestrations and storage? What are the opportunities and constrains of adopting these options as part of regional development carbon management strategies?

How could the de-carbonization agenda become an integral component of regional development strategies? Where do changes come from? What kind of instruments needed? Who needs to be involved? What are the trade-offs of adopting these strategies?

These questions are basically an attempt in learning lessons from the co-evolution among changes of carbon stocks and fluxes, city shape, and social, economy, and political settings of the city development process. The lessons learned will be the basis for determining future changes in carbon stocks and fluxes based on the projected changes in the shape of the city and the socio-economic, political and even technological changes that are likely to happen. An attempt to derive a “baseline” scenario for 2020 and 2050 — which includes scenario for the social, economic, and political trends, the trends of the shape of the city, and the trends of emissions — will be carried out. A set of alternative scenarios will also be developed to see what can influence the future carbon trajectories and their carbon consequences.

These scenarios will have to be developed at the sectoral level. This will allow for deeper analysis on the potential technological innovations within the sectors. While admittedly piecemeal, these innovations may influence the changes in the stocks and especially fluxes of carbon.

The institutional aspects of city development (the “governance” aspect) will be revealed by carrying out institutional survey of policy making in the process of developing and shaping the city. This institutional analysis will be instructive in identifying the points of influences in the process through which concepts of carbon management can be infused. This information will base the analysis that forms recommendations at the end of this study to integrate carbon management in city development in Jakarta.

This paper is structured as follows. It is divided into two sections: the first is on carbon path, whereas the second is on decarbonization. In the first section, a background on city planning and development of Jakarta is laid out. Then, the human dimension of the city development is presented, followed by the institutional aspects. Finally, the carbon consequences of the city development will be presented to close the first section. The second section deals with some scenarios for the future emissions resulting from further development of Jakarta and some possible less-carbon-intensive alternative ones will also be examined.

12.3 Carbon Pathways in the City

What determines the carbon pathways in a city? The link between city development and carbon pathways are possibly one of the most complicated relationships, yet one that is less studied. There is a positive feedback between industrialization and urbanization. Industrialization and urbanization is an engine of economic growth, especially in developing countries. Much of energy and industrial emissions are associated with the urban sector. Most, if not all, industrial facilities are urban-based. While the production of electricity and fuels happens outside of major cities, they cater to the large consumption of urban consumers. In these cities, emissions are generated directly by the industrial, transport, and energy sectors, and indirectly by other sectors through their energy consumptions. The majority of the emissions are due to the (primary and electricity) energy consumption. A very small amount, such as those in the cement industry, are due to the production process itself. The consequence is that, since urban and industrial sectors are more carbon-intensive than rural sectors, emissions of carbon continue to grow as a result of industrialization and urbanization. Thus, the carbon pathways in a city are determined by how developments of the carbon-intensive sectors are carried out in that city. The diagram below shows this.

Figure 1: Carbon pathways in a city

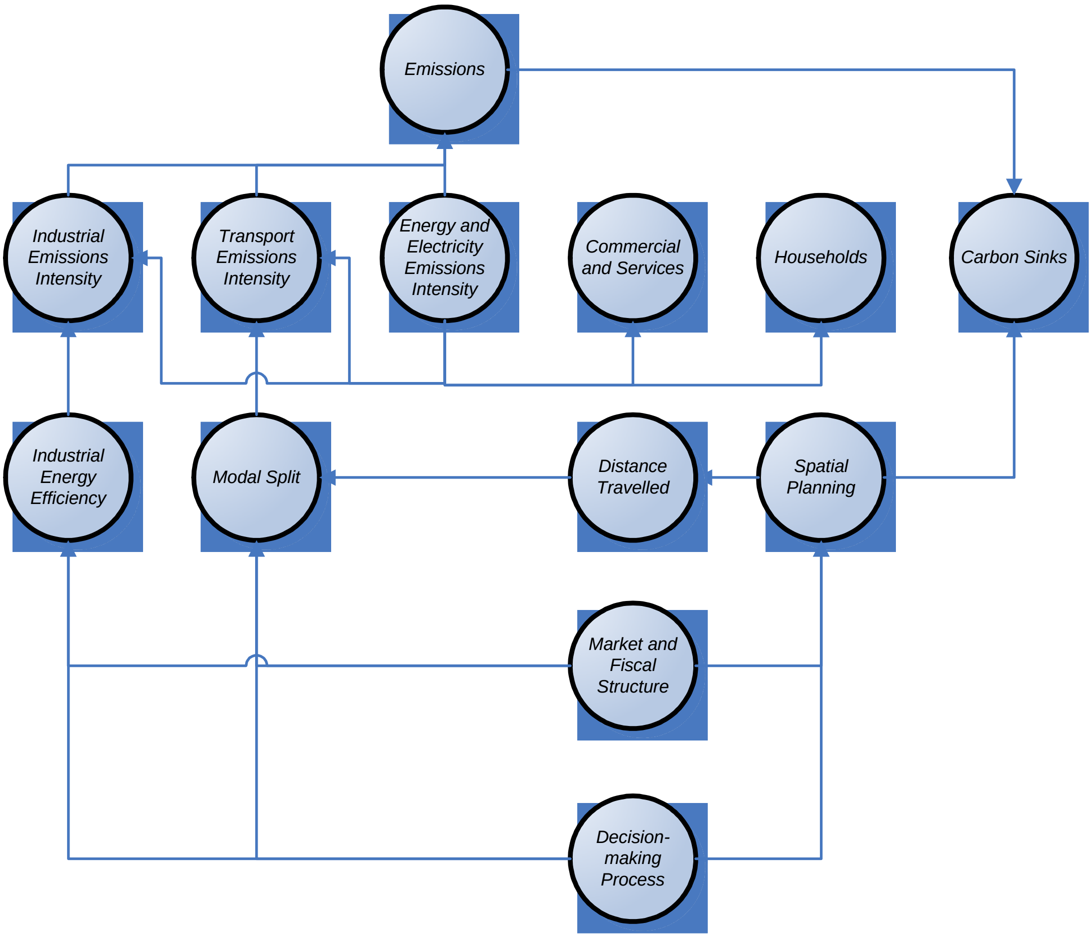


Figure 1, above, shows that emissions of carbon are generated by production of energy and electricity services needed by the industrial, transport, commercial and services, and households sectors. Emissions in the energy sector depend on a number of factors, namely the carbon intensity of the energy system due to the energy mix, the energy intensity of the economy, and the efficiency in its production and use in all of the consuming sectors, which in turns depend on the number of population and their economic activities. Energy use in the industrial sector depends on the energy intensity of the industrial sector itself — in turn is determined by the industrial policy of the country and of the city in general (whether it wants more or less energy-intensive industries or not). Carbon emissions in the transport sector are determined by the modal split between private and public vehicles, the emissions intensity of each of these modes, and the distance traveled. In turn, spatial planning will determine how the transport demand in the city will take shape. Carbon emissions from households and commercial and service sectors are largely determined by the level of income of the citizens. Moreover, city greeneries provide "sinks" to the carbon emissions. Here again, spatial planning will determine how much of the city land is covered by urban greeneries. Finally, all of these will be determined by market and decision-making process ("governance").

One key finding from this research is that the transport sector emerges to become the "carbon time bomb", being the fastest growing fossil fuel consuming sector in the city. Transport system, however, strongly depends on the shape of the city, and therefore cannot be separated from land-use planning. Another finding is that governance plays an important role in making the cities sustainably livable.

12.4 City Planning and Development

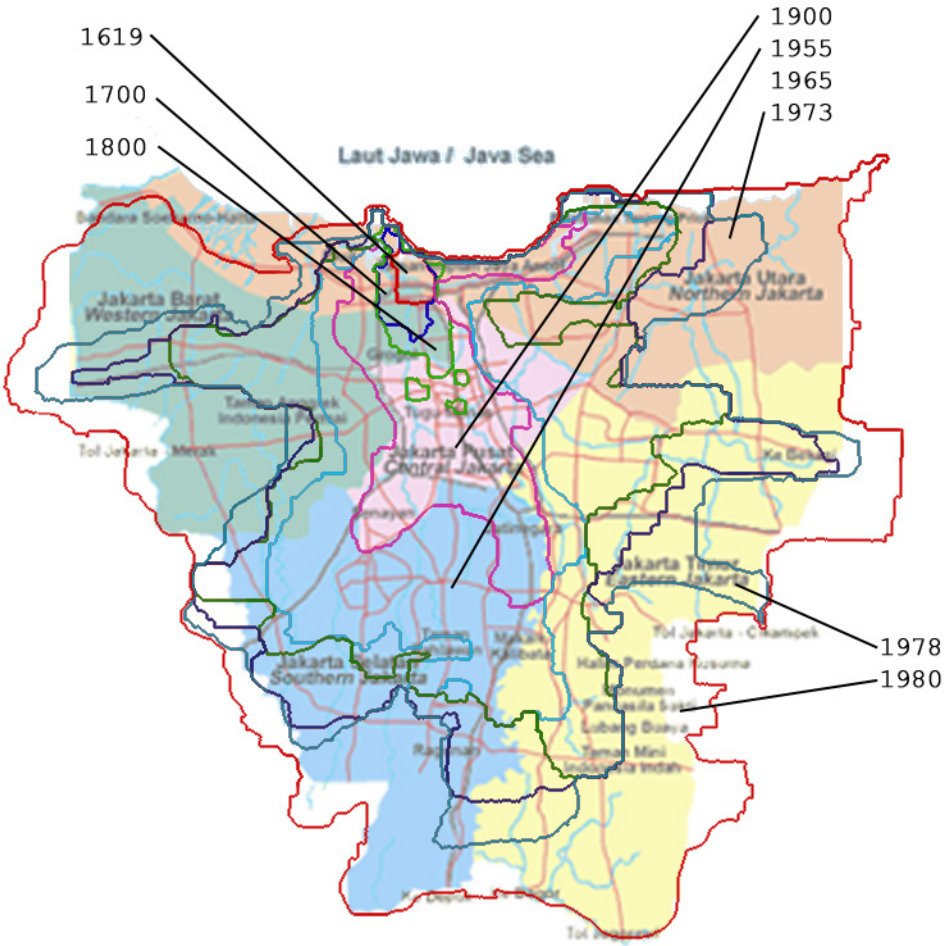
Jakarta, in the estuary of the Ciliwung River, started as Sunda Kelapa, a humble but important trading port of the Pajajaran Sultanate. In early 1500s, Governor d'Albuquerque from Portugal intended to erect a fortress in Sunda Kelapa. Falatehan, or Fatahillah, the Pajajaran Prince also known today as Prince Jayakarta, ousted the Portuguese Navy on June 22, 1527. Since then, the Sunda Kelapa trading port was renamed to be Jayakarta (means "the great victory"). In early 1600s, however, Jayakarta fell under the colonizing troops of Holland. Under the Dutch East Indies — Indonesia as a Dutch colony — Jayakarta became Batavia (or, in local pronounciation, Betawi). Independent Indonesia renamed it again as Jakarta. The victory of Fatahillah is recognized as the date of the establishment of the city, and June 22 its anniversary.

Over the centuries, the small trading port has become a melting pot of many Indonesian ethnicities, identified especially by the naming of certain areas in Jakarta that refers to their place of origins. For example, those from Banda, Ambon, and Flores in the Molluccas were settling in Kampung Banda (the Banda Compound), Kampung Ambon (the Ambon Compound), and the Manggarai area (also the name of a region in Flores), respectively; from Malaysia in Kampung Melayu (the Malay Compound); from Bali in Kampung Bali (Bali Compound), from Central Java in Kampung Jawa (the Java Compound); and those from overseas such as the Filipino Papango settling in the Papanggo area in North Jakarta; the Portuguese in the Cilincing area; and the Chinese — traditionally the traders and city-center dwellers — in the Kota area. All these ethnicities mix with the indigenous Jakartans, the Betawis, to create a unique melting-pot culture of modern Jakarta.

The development of the city is a classic model of a so-called "radial-concentric" city.[17] This model forces a radial movement of commuting. Figure 2, below, shows the development of the city since it was a colonial trading town in the early 1600s until late 1900s.

[17] Rahmah, A., Transjakarta Busway: Akankah Menjadi Tulang Punggung Sistem Transportasi di Jakarta? (Transjakarta Busway: Will It Be the Backbone of the Transportation System in Jakarta?). Pelangi, Jakarta, forthcoming.

Figure 2: The ever sprawling Jakarta



Source: Sari, A., and B. Susantono, The Blue Skies Initiative: Voluntary Actions to Reduce Urban and Global Air Pollution in Jakarta, Indonesia. Pelangi, Jakarta, 1999.

From a humble trading post, Jakarta has expanded to become a sprawling megacity. The small town center in the middle grew southward to accommodate the growing service sector and the need for housing facilities. This area is what is currently still called “Kota” (“the city”) by the native Jakartans, showing the delineation of the old city of Jakarta. The industrial revolution that commenced in England in mid-1800s triggered rapid urbanization everywhere in the world, including in the center of the Dutch East Indies and in Batavia. The expansion was accelerated, all the way southward. Independence Indonesia, since 1945, continued the development East- and Westwards, still in a radial concentric pattern.

Since the era of the Dutch colonial where then Batavia consisted of the Oud Batavia, Weltevreden, and the Buitenzorg (Bogor, the most important suburb that was linked to the city by train), Jakarta has come a long way. The independent Indonesia has seen massive development of the city striving to become an international city. Indeed, the image of a “big city” is most obvious in the main thoroughfare of the city, the Thamrin-Sudirman corridor where the first “skyscrapers” were erected. When Soekarno, the first President of Indonesia in post-colonial era, developed the capital, he immediately erected some communist-country-like monuments around the city, starting from the Monas (the colloquial name coined by the locals for the Monumen Nasional, or the National Monument). The Southern end of the city was marked by a large roundabout with the Tugu Selamat Datang (the Statue of Welcoming) in the middle of it, with

Jalan (Street) Thamrin large boulevard linking the Lapangan Merdeka (the Freedom Square, where Monas is) and the Tugu Selamat Datang. Large skyscrapers dotted the sides of the boulevard, ended with then the then tallest building in the country, the 11 storey Hotel Indonesia right on the roundabout. Until today, the roundabout is called the Bunderan HI (or HI roundabout — HI is the colloquial abbreviation for Hotel Indonesia).

On the backroads of Jalan Thamrin were where residential and smaller commercial establishments were developed, delineating the elite and the priviledged from the rest. The rich and the powerful government officials live in Menteng, East of Jalan Thamrin, expanded through Salemba where the University of Indonesia was, whereas the rest live in Tanah Abang, West of Menteng.

Later, a new area was developed in Kebayoran Baru, and a new North-South corridor, Jalan Sudirman, was built connecting the Bunderan HI in the North and the Bunderan Kebayoran in the South ends. In the middle of the corridor, an East-West corridor, Jalan Gatot Subroto, was built connecting Grogol in the West and Cawang in the East ends. A cloverleaf interchange was built connecting the two, Jembatan Semanggi (the Cloverleaf Interchange). At the time, this was an engineering marvel, especially since it was designed by Indonesian engineer, Sutami. Kebayoran Baru soon became a bustling new town for middle-class people that considered Menteng too posh but rich enough to afford better houses than in Tanah Abang. Blok M, the designated commercial center, was soon developing to become the city center of the new area even until today. The East-West corridor also spurred development in the two areas. The Bekasi area — off Cawang — on the East end of the corridor was developed even more rapidly as a residential suburb for mostly low-income people.

Table1: Spatial Development in Jakarta

	Early 1980s	Mid 1980s	Early 1990s	Mid 1990s
City center and main commercial corridors	Development of high-rises along main roads.	Over-supply of spaces in office buildings and slowing of housing development. Beginning of high-rise apartment building development.	Peaking of office building development Peaking of apartment building development. Beginning of large-scale shopping centers.	Over-supply of spaces in office buildings although some new office buildings achieved high occupancy rates. Crashing of apartment markets. Increasing number of large-scale shopping centers. Beginning of multi-purpose developments.
Buffer regions			Development of high-occupancy office buildings. Development of apartment buildings.	Continuation of the development of office buildings. Continuation of the development of high-rise apartments.
Sub-urban areas	Development of housing facilities for government officials, military officers, and the general public along the arterial corridors.	Large-scale housing and real-estate development.	Intensifying of large-scale housing and real-estate development. Highly Increasing demand for housing.	Development of "new towns" in the Bodetabek areas. Stabilizing demand for housing.

Source: Susantono, B., "Transportation and Land-Use Dynamics in Metropolitan Jakarta", in Berkeley Planning Journal 12, 1998, pp. 126-144.

The development of the two corridors and their respective areas on the four ends of the corridors gave rise to the strategic location of the Semanggi interchange. Soon, in 1980s, the immediate corridors around the Semanggi interchange were dotted with modern high-rise buildings. Jalan Rasuna Said in the Kuningan area, a new corridor connecting Menteng and Kebayoran Baru, was also rapidly developing with new buildings, mostly diplomatic ones. The area enclosed by Sudirman, Gatot Subroto, and Rasuna Said has soon been known as the "Golden Triangle", being the most valued real estate for office buildings. In the 1980s also, the immediate neighboring cities — Bogor, Tangerang, and Bekasi — were developed as housing facilities for military personnels and civil servants, and public housing along the arterial throughfares. New large-scale housing complexes, such as Bintaro Jaya in the Southwestern part of Jakarta, began to be developed.[18]

In mid 1980s, there was an oversupply of office space, especially along the Sudirman-Thamrin-Gatot Subroto-Rasuna Said corridors. Meanwhile housing development was slowing down.

[18] Susantono, B., "Transportation and Land-Use Dynamics in Metropolitan Jakarta", in Berkeley Planning Journal **12**, 1998, pp. 126-144.

Anticipating the rapidly increasing demand for housing facilities in the city center itself, high-rise apartment building began to be developed in the Golden Triangle area, whereas “satellite towns” — large-scale housing development — continued sprawling.[19]

In early 1990s, the development of downtown office and apartment buildings reached their peak. Shopping malls sprung all over the place, becoming new “downtowns” and meeting places for the city dwellers, especially since city greeneries, gardens, and parks were compromised by the new development. The changes were mostly felt in the suburbs that are supposed to buffer the urbanization flow into Jakarta. Early 1990s witnessed the development of office buildings along the ring-roads — the peripheral thoroughfares. New apartment buildings were also erected along the ring-roads.

The development in the outskirts of Jakarta were carried out until about mid 1990s. This period also witnessed the peak of office building development including those in the outskirt of the city. Meanwhile markets for apartment buildings crashed. Nevertheless, shopping malls were more numerous, while multiuse zones were introduced. The crash in real estate markets instigated a widespread economic crisis that continued until well into the 2000s.

12.5 Transport Sector — Implications of City Planning

The development of the city center of Jakarta as a commercial center alongside the development of Bogor, Depok, Tangerang, and Bekasi (“Bodetabek”) areas for settlements greatly influence the transport system pattern in Jakarta. The relatively “easy” access to and from the Bodetabek areas contributes to the rapid development of settlement areas and satellite towns. The sprawling development pattern affects the mobility volume. It has been estimated that about 30 percent of the people working in Jakarta actually live in the Bodetabek areas.[20]

In early 1980s, arterial roads began to be utilized. Meanwhile, the North-South corridor was widened. Traffic pressures were already felt in main thoroughfares. Tolled highways were developed with the one linking Jakarta (in Cawang, East Jakarta), Bogor, and Ciawi (the Jagorawi highway). Commuting (electric) railway began operating also in the early 1980s. In mid-1980s, two North-South arterial corridors were widened, but failed to ease the traffic pressures. The Jakarta-Merak highway to the West was commenced, while the Jakarta-Bogor commuting railway was upgraded into a dual-track railway.[21]

In early 1990s, the East-West corridor was commenced including the Eastward highway to Cikampek, while “fly-overs” in several clogged segments of the arterial corridors helped ease the traffic pressures. Some railroads in the suburban areas were renovated. In mid-1990s, East-West downtown tolled highways began to be operational. Supporting toll roads that goes Southward was also commencing. But traffic remained in the downtown areas and expanded into the main arterial roads linking Jakarta with its suburbs. Table 2, below, summarizes the development of the transport infrastructure in Jakarta.

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[19] Susantono, B., 1998. See footnote 18.

[20] Rahmah, A., et al., 2001. See footnote 36.

[21] Susantono, B., 1998. See footnote 18.

Table 2: Development of the Transport System in Jakarta

	Early 1980s	Mid 1980s	Early 1990s	Mid 1990s
Intercity tolled highway	Commencement of Southward highway to Bogor and Ciawi (Jagorawi)	Commencement of Westward highway to Merak	Commencement of Eastward highway to Cikampek	Expansion of highways Westward and Eastward.
Intra-city tolled highway and regular roads	Commencement of arterial corridors and widening of Center-South arterial corridors	Widening of two Center-South arterial corridors	Widening of East-West arterial corridors	Commencement of supporting Southward highway
Traffic jams	Medium jams in main throughfares	Traffic jams in main arterial corridors	"Fly-over" development eases traffic jams in main intersections	Extended into downtown area, in the suburbs, and the arterial corridors.
Rail-based transport	Commencement of Jakarta-Bogor commuting trains	Commencement of double-track for Jakarta-Bogor commuting trains	Renovation of some trainstops in the suburbs	Commencement of elevated rails in downtown Jakarta Commencement of new cars

Source: Susantono, B., "Transportation and Land-Use Dynamics in Metropolitan Jakarta", in Berkeley Planning Journal 12, 1998, pp. 126-144.

Indeed, road-based city development has created skyrocketing demand for mobility that has grown considerably more rapidly than the city itself grows. Between 1985 and 1993, the number of commuters increased four-folds from 68,000 to 280,000, with yearly average growth of about 22 percent (Figure 3). Without any significant mitigative measures, the need for car-based mobility will increase to become 56 percent of trips in 2010, up from about 50 percent in 1995.[22]

[22] Sari, A., and B. Susantono, The Blue Skies Initiative: Voluntary Actions to Reduce Urban and Global Air Pollution in Jakarta, Indonesia. Pelangi, Jakarta, 1999.

Figure 3: Commuting pattern in the Jabotabek area

Source : Rustiadi, E., B.H. Trisasongko, D.R. Panuju, D. Siddiq, Janudianto and R. Maulida, LUCC and Planning Studies in Jabotabek Region. Center for Regional Systems Analysis, Planning and Development (CRESPENT), Bogor Agricultural University (IPB), Bogor, 2004.

The skyrocketing demand for mobility also demanded almost impossible amount of infrastructure investments, even though the quantity and quality of roads in Jakarta remained behind other comparable cities. With 0.5 meters of roads per person in mid 1990s, Jakarta was behind Bangkok with 0.6 meters per person, or Kuala Lumpur with 1.5 meters per person. Main cities in Europe and the US had about 2.4 meters and 2.5 meters per person.[23]

Unfortunately, extensive development of roads has not caught up with the rapid increase of the number of vehicles, resulting in massive traffic jams everywhere. Between 1989 and 1994, the total length of roads in Jakarta increased at 6 percent per year, but the number of vehicles increased at 9 percent per year, excluding motor-cycles which number increased even more rapidly. This is filling a bottomless pit.

Public transport could have accommodated suburban and intra-urban mobility needs, but its provision in Jakarta is far from adequate. The powerlessness of the city regulators against the "mafia-like" management of public transport exacerbated the problems. For example, some

[23] Sari, A., and B. Susantono, 1999. See footnote 22.

routes that should have been served with existing operators were not served well, while no other operators could serve the routes. Data from the Office of the Traffic and Road Transport, Provincial Government of Jakarta, points to the following routes that were not served: nine air-conditioned limited-bus routes, 23 non-air-conditioned limited-bus routes, and 57 regular bus routes that were not served. About 180 air-conditioned buses, 330 limited-buses, and 855 regular buses could have served those routes.[24]

The development of rail-based transport has been even worse. Currently, about 90 percent of mobility needs are fulfilled by road-based transport system; only 10 percent by rail-based one. Especially in rush hours (6:30 am – 8:00 am and 4:30 pm – 8:15 pm), the conditions of commuter trains in Jakarta is even worse. With about 250 percent load factor, it is inevitable to see commuters sitting on top of the trains.[25]

Meanwhile, non-motorized transport modes such as the "becaks" (peddycabs) have been banned through Provincial Regulation No. 11/1988 due to the perception that it is too traditional for a "modern" city such as Jakarta, and that it causes traffic jams, despite the facts that peddycabs exist and are operational in more modern cities such as Singapore and San Francisco. In 2000, the becak drivers in Jakarta brought the Provincial Regulation to court in a class action, and they won. In 2001, the Provincial Government of Jakarta challenged the court decision, and won, leading to a collossal Rp 2.4 billion ($240,000) becak clean-up operation. The becak driver brought the case to the Supreme Court in 2003, but lost the case. Since then, becak has been illegal in Jakarta.[26]

Consequently, largely private car-based transport sector will constitute a major source of carbon emissions. It is already the largest fuel-consuming sector. It is also the most rapidly growing energy-consuming sector in the country. Only because the liquid fuel used in the transport sector is harder to replace, its carbon emissions are the second largest after the carbon-intensive, coal power plants-dominated, energy sector.

Emissions pathways in the transport sector are slightly more complicated. As in the energy sector, it depends on the carbon intensity of the fuel. But unlike in the energy sector, the options for fuel switching in the transport sector are more limited. Then, the fuel efficiency of the vehicles will determine the fuel consumption. What vehicles that populate the transport system in turns depend on the modal-split between the use of public and private vehicles, the intensity of the non-motorized modes, and the distance traveled. Here, land-use and spatial planning of cities play a very important role in determining the demand for mobility.

Indeed, the climate time-bomb in urbanization in developing countries is in the transport sector. And transport sector development is a consequence of city planning — or lack thereof. Dependency on private cars and on fossil fuels, once created, cannot easily be changed, because it involves massive transport and land-use infrastructure investments. Once they are invested, it is prohibitively expensive to un-invest or replace with other kinds. The city of Los Angeles in the US is a good example. Once this sprawling car-dependent city is shaped presently, it is prohibitively expensive to turn it into something like compact and pedestrian- and bicycle-friendly city like Amsterdam. While Los Angeles may be an extreme case, many cities in developing countries including Jakarta have used it as a "model". Roads and highways have been

[24] Dinas Lalu Lintas dan Angkutan Jalan (Office of Traffic and Road Transport), Kebijakan Masa Depan Pengelolaan Angkutan Umum di DKI Jakarta dalam rangka Perlindungan terhadap Lingkungan dan Peningkatan Pelayanan terhadap Masyarakat (The Future Policy of the Management of Public Transport in Jakarta towards Environmental Protection and Improvement of Service to the Community). Provincial Government of Jakarta, Jakarta, 2001.

[25] As stated by a panelist in a Panel Discussion on "the Development of Urban Rail-Based Transport and Efforts to Increase Services", by the Indonesian Transportation Society and the National Development Planning Board, September 30, 1998.

[26] Rahmah, A., Sari, A.P., Soejachmoen, M.H., and Susantono, B., Loe Loe Gue Gue: (Mind Your Own Business:). Pelangi, Jakarta, 2001.

developed much further than public transport and railway systems. Fuel infrastructure has also been developed to become gasoline-dependent.

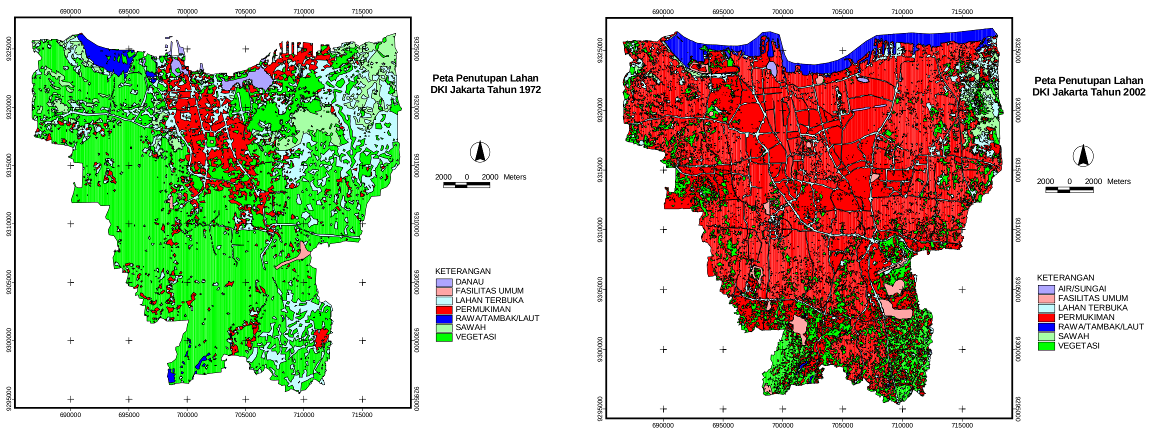
In the beginning of 2004, the city of Jakarta has introduced the TransJakarta Busway, an exclusive lane bus system along the south-north corridor of Jakarta. While the system has been opposed by many private cars users, a survey conducted 6 months after its operation showed that around 14 percent of its passengers were using private cars before. The number has been increasing especially during rush hours.[27]

12.6 The Vanishing Greeneries

Due to massive physical development, Jakarta has lost much of its greeneries. Between 1992 and 2001 alone, built up areas increased from 103,846 hectares (ha) to 173,208 ha, which is a 66 percent increase. This caused 3,958 ha of paddy fields converted (from 148,184 ha to 144,225 ha). Figure 4, below, shows an even more massive change of land-use in Jakarta.[28]

The changes — from greeneries such as paddy fields and open spaces — result in reduced capacity of Jakarta to sequester carbon released by its economic activities.

Figure 4: Land-use change in Jakarta



1972 2002

Source: Rustiadi, E., B.H. Trisasongko, D.R. Panuju, D. Siddiq, Janudianto and R. Maulida, LUCC and Planning Studies in Jabotabek Region. Center for Regional Systems Analysis, Planning and Development (CRESPENT), Bogor Agricultural University (IPB), Bogor, 2004.

12.7 The Human Dimension

"A city is a theater of social action, and everything else — arts, politics, education, commerce — only serve to make the social drama … more richly significant", says Lewis Mumford (1895 – 1990).[29] Kevin Lynch agrees by saying that "cities are an arena of conflict", where the resultant of these conflicts will color the shape of the city itself.[30]

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[27] http://trans.jakarta.go.id/informasi/news_view.php?nid=87

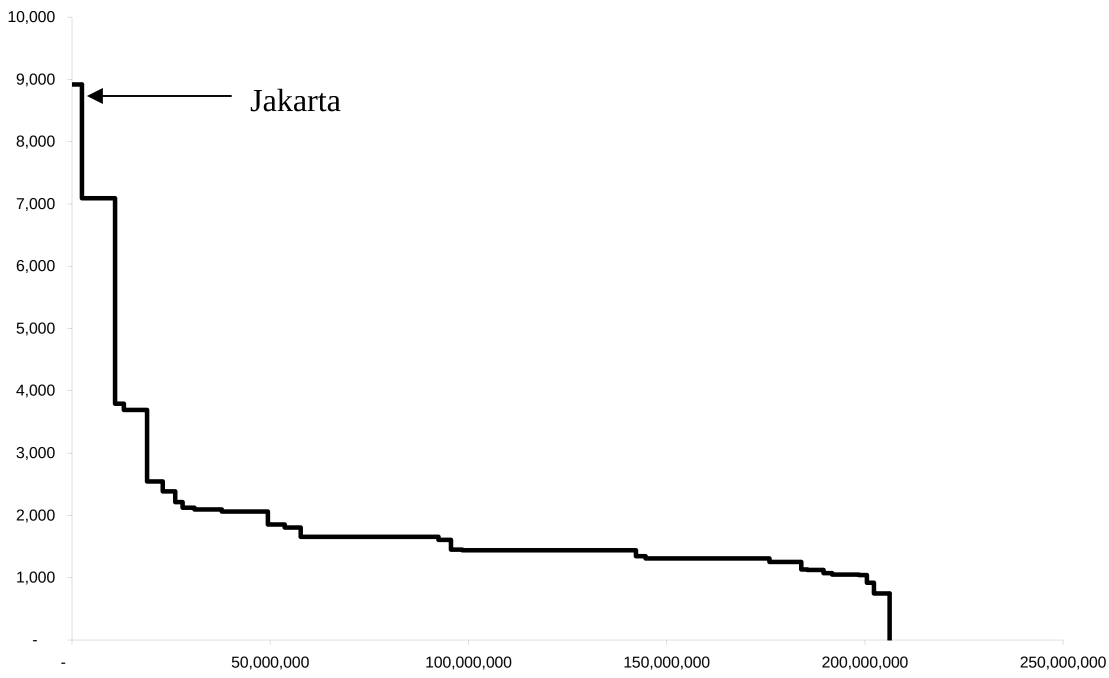
[28] Rustiadi, E., B.H. Trisasongko, D.R. Panuju, D. Siddiq, Janudianto and R. Maulida, LUCC and Planning Studies in Jabotabek Region. Center for Regional Systems Analysis, Planning and Development (CRESPENT), Bogor Agricultural University (IPB), Bogor, 2004.

[29] Mumford, L., The City in History: Its Origins, Its Transformations, and Its Prospects. Harcourt Brace, New York, 1961.

[30] Lynch, K., A Good City Form. The MIT Press, Cambridge, 1990.

The social arena of conflicts plays well in Jakarta. The modern day Jakarta boasts smooth boulevards and highways, tall skyscrapers, shiny new cars, and smart yuppies in them that show no sign of a "developing country". Indeed, Jakarta is the richest "province" in Indonesia. Among the five richest provinces, measured through per-capita income, not only is Jakarta the richest, but also the only one that has no natural resources. If incomes from natural resources were taken out of these provinces, the gap between Jakarta and the rest of Indonesia would become even wider — even more so if those natural resource-based incomes were accounted for in Jakarta instead of in the provinces of origin. Figure 5, below, shows the per capita income level in Jakarta compared with other provinces.

Figure 5: Distribution of income in Indonesia



Source of data: Biro Pusat Statistik (Central Bureau of Statistics) online database (www.bps.go.id, as of October 2003)

Per capita income in Jakarta in 2000 was about Rp 22.5 million. This was doubled from about Rp 11.7 million in 1997. In 1990, it was only Rp 1.5 million. Service sector continued to be the largest sector in Jakarta, comprising of trade, hotels, and restaurants (23.2 percent); finance, rents, and business services (22.8 percent); and other services (10 percent), totaling 56 percent of the total income in 2000. Industrial sector followed with 23 percent in 2000.[31,32,33]

Right after Indonesian independence, the number of people who called Jakarta their home grew considerably at a 6 percent per year pace between 1949 and 1990.[34] In the last two decades, from 6.5 million in 1980, the number of population increased to 7.6 million in 2000, a rapid rate of about 0.9 percent per year between 1980 and 1990, and about 0.7 percent per year between 1990

[31] BPS, Jakarta Dalam Angka 1981 (Jakarta Statistical Yearbook 1981). Central Bureau of Statistics, Jakarta, 1981.

[32] BPS, Jakarta Dalam Angka 1991 (Jakarta Statistical Yearbook 1991). Central Bureau of Statistics, Jakarta, 1991.

[33] BPS, Jakarta Dalam Angka 2001 (Jakarta Statistical Yearbook 2001). Central Bureau of Statistics, Jakarta, 2002.

[34] BPS, 1981. See footnote 16.

and 2000.[35] If these figures were combined with those for the surrounding municipalities of Bogor, Tangerang, and Bekasi that make up the Greater Jakarta region (the "Jabotabek", later becomes the "Jabodetabek" region when Depok had also been included), the growth rate is even more staggering. From 12 million in 1980, the number population in the Jabotabek area increased to 21 million in 2000, an average increase of 2.9 percent (3.6 percent between 1980 and 1990 and 2.1 percent between 1990 and 2000). These figures were higher than the average growth rate nationally of less than 2 percent per year.[36] Take a look at Table 3, below.

Table 3: Population in Jakarta and Jabotabek

Regions	1971	1980	1990	2000
Central Jakarta	1.3	1.2	1	0.9
Jakarta	4.5	6.5	7.1	7.6
Jabotabek	8.3	11.9	17.0	20.9

Note: figures are in million people.

Source: Jakarta dalam Angka 1981, 1991 and 2001; Rahmah, et.all., 2001 (see footnote 20)

What is interesting from the figures in Table 3, above, is the spatial demographical dynamics of the city. While the population in the city showed a modest growth of about 0.8 percent per year, that in the municipality of Central Jakarta showed a decreasing trend. Population growth in the surrounding municipalities of Bogor, Tangerang, and Bekasi, on the other hand, showed a more staggering rate of 2.9 percent per year between 1980 and 2000 (3.6 percent between 1980 and 1990; and 2.1 percent between 1990 and 2000).[37] This spatial dynamics show a classic problem in urban population dynamics especially in Asian developing countries where the city center is losing its attractiveness as a place to live due to various problems including the price of real estate, accessibility, and crime that leads to the booming growth of the suburban areas.

As a result of a rather *ad hoc* development, a "dual-faced" Jakarta emerged: the formal and the informal ones. The formal ones are neatly developed whereas the informal ones are only developed organically — some of which turned to become slums amid posh skyscrapers neighborhood. A very comprehensive study in Indonesia shows that about 85 percent new settlements in Jakarta were supplied by informal development.[38]

12.8 The Institutional Dimension

The shaping and reshaping of Jakarta cannot be detached from the evolution of the way the city is governed. In turn, it cannot be separated from the way Indonesia is governed, as Jakarta is the capital of the country. The "city" of Jakarta actually consists of five municipalities: North, East, West, South, and Central Jakarta, and one district of the thousand islands in the Jakarta Bay. These five municipalities and one district make up the Special Capital Region of Jakarta, headed by a Governor. The "Greater Jakarta" (Jabotabek) consists of Jakarta and the surrounding regencies of Bogor, Depok, Tangerang, and Bekasi. Up to 2000, the surrounding regencies were

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[35] BPS, 2001. See footnote 18.

[36] Rahmah, A., et all, 2001. See footnote 14.

[37] Rahmah, A., et all, 2001. See footnote 20.

[38] Dowall, D., and M. Leaf, The Price of Land for Housing in Jakarta: An Analysis of the Effects of Location, Urban Infrastructure, and Tenure on Residential Plot Prices. Institute of Urban and Regional Development, Berkeley, 1990.

part of the province of West Jawa, but since 2000, the province was divided into the Provinces of West Jawa and Banten, and the regency of Tangerang is currently a part of the new Province of Banten. As also known as DKI (Daerah Khusus Ibukota, the Capital Special Region), Jakarta is not only a city that obtains the status of a "province" — a common treatment of the capital of any country — but also centers of business, investment, international gateway, tourism destination, social and political movements, and other functions.[39]

City and spatial planning has dynamic aspects with the development actors within it. The most important implication is that there is a need for constant adjustments in the field and its consistency with the original plan. In reality, however, the Land Use Master Plan of Jakarta failed to respond to the rapid changes of development in the field. While zoning permit is theoretically supposed to be a tool to control land use, in reality corrupt practices have rendered it ineffective. A 1993 study under the Jabotabek Management Development Project shows that there are many developers that are not in compliance with the existing land use allocation.[40] Another study even points out that large-scale developers usually influence the changes of land use.[41] Indeed, corruption, collusion, and nepotism have subverted the city development from its intended plan.[42]

The story of Jakarta development cannot be separated from one person: H. Ali Sadikin, a retired Marine General who, although appointed by Soekarno in 1966, became the first governor in the New Order era under Suharto for 11 years until 1977. For his services, he was given the most prestigious award by President Megawati Soekarnoputri in 2003. Although there were three Mayors and two Governors succeeding him, he was the undisputable strongman behind the city development. A strong, disciplined Governor, he ruled the city with strict regulations and, at times, controversial decisions. For example, he legalized gambling and prostitution in several locations in the city, but taxed them dearly and used the revenues to further develop the city. This way, the city revenue was raised from only Rp 66 million to about Rp 40 billion. But with this revenue, Bang Ali ("Brother" Ali, as people call him) also developed many public services buildings such as the Taman Ismail Marzuki Arts Center, the Brojonegoro Youth Center, the Usmar Ismail Cinematography Center, the Ancol Amusement Park, and the likes, as well as smooth roads and other urban infrastructure.[43] In 1977 his term ended with him resigning following a dispute with then President Suharto over governance.

Unfortunately, his successors were not nearly as popular as him; some of them were even rather unpopular. City governance has become much less transparent. Instead of being accessible to the public, the Master Plan of the city has only been made available to the highest bidders. Non-transparent city planning led to involuntary resettlements of the urban poor who happen to occupy public areas. But non-transparent city planning also led to massive profits to well-connected land speculators.[44]

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[39] Mokoginta, L.F., Jakarta Untuk Rakyat (Jakarta for the People). Pustaka Sinar Harapan and Sattwika, Jakarta, 1999.

[40] Directorate General Cipta Karya, Jabotabek Management Development Project: Land Management Review. Department of Public Works, Jakarta, 1993.

[41] Ferguson and Hoffman, 1992.

[42] Server, O.B., "Corruption: A Major Problem for Urban Management: Some Evidence from Indonesia", in Habitat International 20, pp. 23-41.

[43] http://www.tokohindonesia.com/ensiklopedi/a/ali-sadikin/index.shtml

[44] Rahmah, A., et al., 2001. See footnote 20.

12.9 The Carbon Consequences of City Development

Current Emissions

Electricity Sector

In Indonesia in general and in the Jabotabek (Jakarta, Bogor, Depok, Tangerang, Bekasi) region in particular, energy and electricity sectors are the largest sources of carbon emissions. This is due to the use of coal as the primary fuel for electricity production. Electricity in the islands of Java and Bali, where Jakarta is located, is produced by multiple sources of electricity generation with various uses of fuels, all of which are interconnected with massive island-wide grid system. Table 4, below, shows the shift in energy mix in the Jawa-Bali interconnection between 1980 and 2000.

Table 4: Jawa – Bali Energy Mix in Electricity Generation

	1980			1990			2000		
	TJ	GWh	share	TJ	GWh	share	TJ	GWh	share
Solid	-	-	0%	35,348	9,819	35%	91,164	25,323	38%
Liquid	19,126	5,313	80%	39,154	10,876	39%	38,450	10,681	16%
Gaseous	-	-	0%	3,490	969	3%	73,541	20,428	31%
Hydro & other renewables	4,843	1,345	20%	22,438	6,233	22%	35,772	9,937	15%
Total	23,970	6,658	100%	100,430	27,897	100%	238,926	66,368	100%

Source: http://www.djlpe.go.id/Link%20Kiri/ISI%20Statistik%20ketenagalistrikan%202003.pdf

Table 4, above, shows that liquid fuels (mostly diesel fuel) served as the sole source of energy in 1980s. Due to the energy diversification policy (so that the country can export more than it consumes domestically, especially in the era of "oil boom"), the use of solid fuels (mostly coal) was increasingly dominant, and remained so until 2000. Gaseous fuels (mostly natural gas) started being used in 1990 with a tiny 3 percent, but were increasingly important in 2000. Indeed, there was no increased use of liquid fuels at all from 1990 and 2000.

Since solid fuels (coal) increasingly dominated the energy mix in Indonesia, the carbon intensity of the electricity system was also increased. To calculate the emissions resulting from the energy use, the Intergovernmental Panel on Climate Change (IPCC) has offered a set of emissions factors for various kinds of fossil fuels, as in Table 5, below.

Table 5: Emissions Factors of Fossil Fuels

	kg-CO_2 / kWh	KT-CO_2 / TJ
Solid	0.940	0.263
Liquid	0.798	0.223
Gaseous	0.581	0.163

Source: IPCC.

With the emissions factors above, emissions of the electricity system in Jawa-Bali as well as its carbon intensity can be calculated, as summarized in Table 6, below.

Table 6: Carbon Dioxide Emissions from the Jawa-Bali System in Indonesia

	1980	1990	2000
Solid	-	9,230	23,804
Liquid	4,240	8,679	8,523
Gaseous	-	563	11,869
Hydro & other renewables	-	-	-
Total	4,240	18,472	44,196
Carbon intensity (KT/GWh)	0.64	0.66	0.67

Note: All units in Gigagrams (Gg), which is equivalent with Kilotons (KT), except noted otherwise. Source: IPCC emission factor and own calculation

During the last three decades, Jakarta consumed about 24-28 percent of the electricity produced nationally. Table 7, below, shows the rapid increase of electricity consumption in Jakarta from 1980 to 2000, at about 11 percent per year (about 15 percent per year between 1980 and 1990 and about 7 percent between 1990 and 2000).

Table 7: Electricity consumption in Jakarta

	1980	1990	2000
Electricity consumption (GWh)	1,997	7,811	15,928
Carbon intensity (KT/GWh)	0.64	0.66	0.67
Carbon emissions (KT CO_2)	1,272	5,172	10,607

Source: own calculation

Transport Sector

Transport sector in Indonesia has mainly been fuelled by two kinds of fuels, namely gasoline (premium and diesel) and natural gas (in the form of compressed natural gas, CNG). Natural gas has only been used for a short while during the 1990s. The lack of CNG fueling station, due to its high cost and lack of gas distribution pipeline, was the main reason of natural gas losing its popularity among the public. At present, the government is trying to reintroduce the use of natural gas as an alternative to gasoline. Table 8, below, shows that until 2000 fuel for transport was dominated by oil and its usage doubled during the last decade alone.

Table 8: Energy consumption in transportation sector

	1980	1990	2000
Oil	55,760	56,650	118,006
Natural gas	-	24	-
Total	55,760	56,674	118,006

Note: All units in TJ. Source: author's calculation

The emissions resulting from transport sector has always been significant in total carbon dioxide emissions in Jakarta, as shown in Table 9, below. Emissions in 2000 were more than twice those from electricity sector. Even in 1980, transportation emission has reached tenfold compare to electricity sector.

Table 9: Carbon Dioxide Emissions from Transport Sector in Jakarta

	1980	1990	2000
Oil	11,834	12,633	26,315
Natural gas	-	4	-
Total	11,834	12,637	26,315

Note: All units in Gigagrams (Gg), which is equivalent with Kilotons (KT), except noted otherwise. Source: author's calculation

In summary, emissions in Jakarta grew rapidly as table 10, below, depicts.

Table 10: Historical Carbon Dioxide Emissions in Jakarta

	1980	1990	2000
Electricity	1,272	5,172	10,607
Transport	11,834	12,637	26,315
Total	13,106	17,809	36,922

Note: All units in Gigagrams (Gg), which is equivalent with Kilotons (KT), except noted otherwise. Source: author's calculation

Table 10, above, shows that emissions in Jakarta have constantly been increasing rapidly. Those from the transport sector have dominated the emissions, with about two-third of emissions in 2000.

Urban Greeneries

Jakarta expands an area of 655 square kilometers (km^2). In the 1970s, more than 80 percent of it was covered with greens — mostly modest forests, fruit trees, grass, and agriculture. In the 2000s, however, only about 10 percent of it was covered with greeneries (see Figure 4, above). The loss of greeneries contributes to the carbon cycle by way of reduced sequestration capacity. Table 11, below, shows the changes in the expanse of the greeneries overtime in Jakarta.

Table 11: Changes of greeneries and sequestration capacity in Jakarta

	1970	1980	1990	2000
Greeneries (Ha)	52,456	36,064	16,393	6,557
Sequestration capacity (KT) per year	53,470	36,761	16,709	6,684

Source: author's calculation

Table 11, above, show the rapidly diminishing greeneries in Jakarta, from about 52,456 ha, it decreased to a mere 6,557 ha. It is expected that greeneries in Jakarta can sequester about 278 tons of carbon per hectare (ha), or about 1.019 tons of carbon dioxide per hectare. This means that Jakarta had lost about a bit less than 47,000 KT per year sequestration capacity in the 30 years period. This is the same amount of carbon dioxide as the total emissions from the city in 2000.

12.10 Future Emissions

What will the future emissions look like in Jakarta? What are the options to modify it towards decarbonization trajectories? These will be the key umbrella questions in the second part of this paper.

Indeed, if nothing is done to mitigate the trend, the emissions trajectory will follow what has been shown by the trend from 1980s to 2000s. The increasing number of population and income — thus more economic activities — will be the most significant reasons for the increase in the emissions.

By 2000, the number of population in Jakarta was about 7.6 million. In Jabotabek, this was 20.9 million. In the last two decades, the number of population in Jakarta grew at about 0.7 percent, whereas that in the Jabotabek area at about 2.9 percent. However, the annual growth rate for population in both regions is decreasing. This means that by 2020 and 2050, the number of population in Jakarta may reach 8.4 million and 9.7 million, respectively. In the same period, the number of population in the Jabotabek area will reach 25.1 million and 27.3 million, respectively. Table 12, below, shows the population growth trends until 2050.

Table 12: Population Trends in Jakarta until 2050

	1980	1990	2000	2010	2020	2030	2040	2050
Jakarta	6.5	7.1	7.6	8.0	8.4	8.8	9.2	9.7
AAGR (%)		0.9	0.7	0.5	0.4	0.3	0.3	0.2
Central Jakarta	1.2	1.0	0.9	0.8	0.8	0.8	0.8	0.8
AAGR (%)		-1.8	-1.0	-0.6	-0.4	-0.2	-0.1	-0.1
Jabotabek	11.9	17.0	20.9	23.4	25.1	26.2	26.8	27.3
AAGR (%)		3.6	2.1	1.3	0.8	0.5	0.3	0.2

Note: figures are in million people. AAGR is average annual growth rate, in percent.

Source: Jakarta dalam Angka 1981, 1991, 2001 and author's calculation

Along with the population growth, income also rises. In 2000, regional income in Jakarta is about US$ 17 billion. With growth rate of about 5 percent per year, income in Jakarta will rise to about Rp 473 trillion (about $50 billion) in 2020, and Rp 789 trillion ($83 billion) in 2050. This means that per person, income will rise to about US$ 6,000 in 2020 and US$ 8,600 in 2050. This population growth and wealth creation will be followed by increased economic activities that, in turn, will increase energy use.

The total electricity consumption in Jakarta will increase rather rapidly at 7 percent per year, from about 57 Petajoules (PJ) in 2000 to 207 PJ in 2020. Milder increase will happen during the period of 2020 to 2050 amounted to 854 PJ in 2050. Other energy considered in this study is those being used in transport sector. The demand of energy in transport sector in Jakarta will increase at 6 percent a year in the period of 2000 to 2020, from about 118 PJ in 2000 to 353 PJ in 2020. During the period of 2020 to 2050, the increase is expected to be milder at 5 percent a year, to become 1,437 PJ.

Using the IPCC emissions factors, the total CO_2 emission in Jakarta is predicted to rise from 37 MT-CO_2 in 2000 to 119 MT-CO_2 and 492 MT, in 2020 and 2050 respectively. Table 13 below shows the prediction for Jakarta in 2020 and 2050.

Table 13: Decomposition of Emissions

		2000	2020	2050
Population	Million	7.6	8.4	9.7
Income	US$ billion	17	50	83
Income per capita	US$ thousand	2.3	6	8.6
Energy intensity of economy	J/US$	10	11	28
Emissions intensity of energy	T-CO_2/MJ	211	213	215
Emissions per capita	T-CO_2/person	5	14	51
Total emissions	MT-CO_2	37	119	492

Source: author's calculations

Table 13, above, shows that, if the trajectory is not bent, emissions will increase from 37 MT in 2000 to 119 MT in 2020 and 492 MT in 2050. From 5 tons (T) per person in 2000, every citizen in Jakarta will release about 14 T in 2020 and 51 T in 2050. Even though the emissions intensity of the energy system is expected to decrease overtime, it is more than offset by the expected increase in the energy intensity of the economy.

Options for Decarbonization

In this paper, options for decarbonization are identified by running a series of alternative scenarios. Besides the business-as-usual scenario, there are two more scenarios in each electricity and transport sectors. In the electricity sector, intervention is to be made by adding the portion of renewable sources to the electricity system (the Renewable Only Scenario) and a combination of renewable sources and efficiency (the Renewable and Efficiency Scenario). In the transport sector, intervention is to be made by adding the portion of clean fuels, namely natural gas and biomass-based renewable fuels in the fuel mix (the Clean Fuel Scenario), and the shift from private vehicles to public transport (the Modal Shift Scenario). It is assumed in each of these scenarios that greeneries remain as small a portion as in 2000, if not worse.

Intervention in the Electricity Sector

There are two scenarios in the electricity sector. The first scenario, the "Renewable Scenario", is to have a 15 percent of renewable energy share in the energy mix for electricity generation. The second scenario, the Renewable and Efficiency Scenario, is based on the first scenario with the addition of energy efficiency. Assuming that no significant investment will be applied for the energy efficient appliances, efficiency in 2020 and 2050 is expected to improve by 15 and 20 percent, respectively. These figures are taken arbitrarily, but considered plausible based on various anecdotal cases and when the efficiency policy can be fully implemented.[45]

Total energy consumption in the electricity sector is predicted to be 207 PJ in 2020 in the business-as-usual case, and 854 PJ in 2050, if no actions to reduce them are to be taken. With efficiency (as part of Renewable and Efficiency Scenario) total energy consumption in electricity sector in 2020 and 2050 are then predicted to be 176 PJ and 683 PJ respectively.

The implications of the above measures on future emissions are significant. The emissions in 2020 for Renewable Scenario will be 36 MT, while the emission in 2050 will be 155 MT. By implementing the Renewable and Efficiency Scenario, the future emissions will be 31 MT and 124 MT, respectively. Both scenarios show significant reduction of future emissions compared to the business-as-usual one. Emissions reduction from the Renewable Only Scenario will be 10 percent and 9 percent in 2020 and 2050 compared with their business-as-usual ones, while the Renewable and Efficiency Scenario will reduce the future emissions by 24 percent and 27 percent, respectively. These are significant amount of reduction — about halving emissions from what would occur otherwise. Table 14 below shows the energy consumption and CO2 emission for all scenarios.

Table 14: Future Emissions Scenarios in Jakarta

	1980	1990	2000	2020	2050
Renewable Only Scenario					
Energy consumption (TJ)	7,191	28,120	57,342	207,380	853,605
Emissions (KT CO_2)	1,272	5,172	10,607	36,499	155,237
Renewable and Efficiency Scenario					
Energy consumption (TJ)	7,191	28,120	57,342	176,273	682,884
Emissions (KT CO_2)	1,272	5,172	10,607	31,024	124,190

Source: author's calculation

<u>Intervention in the Transport Sector</u>

Similar to the electricity sector, two interventions are also applied to the transportation sector. The first scenario, the Clean Fuel Scenario, is to have 10 percent natural gas in supplying the transportation sector and 5 percent from renewable energy resources such as biofuel in 2020, and 20 percent from natural gas and 10 percent from renewable sources in 2050.[46] This will not lead to any change in energy consumption, as the total energy consumption will be the same.

The second scenario, the Modal Shift Scenario, is to assume modal-shift in the transport sector. The implementation of busway as a network to cover the whole city, supported by a safe and comfortable non-motorized infrastructure, is expected to reduce energy consumption in transport sector by 10 percent in 2020 and 20 percent in 2050. Following the conservation scenario, the intensity decreases by one percent per year from 2000, thus, if we assume that modal shift can contribute about 0.5 percent per year between 2000 and 2020, and then will decrease to 0.2

[45] Department of Energy and Mineral Resources (DEMR), <u>Kebijakan Pengembangan Energi Terbarukan dan Konservasi Energi</u> (Policy for the Development of Renewable Energy and Conservation). Department of Energy and Mineral Resources, Jakarta, 2003.

[46] DEMR, <u>Indonesia's Energy Outlook 2010</u>. Department of Energy and Mineral Resources, 2002.

percent from 2000 to 2050.[47] This will lead to reduced energy use of 318 PJ and 1,150 PJ in 2020 and 2050 compared to 354 PJ and 1,438 PJ, respectively.

Both scenarios will lead to reduction of future emissions. Clean Fuel Scenario will emit 73 MT in 2020 and 271 MT in 2050. Modal Shift Scenario will lead to 65 MT and 211 MT in 2020 and 2050, respectively. The reduction of future emissions compared to those in the business-as-usual scenario in 2020 and 2050 will be 8 percent and 15 percent for Clean Fuel Scenario, and 17 percent and 34 percent for Modal Shift Scenario, respectively. These are also significant emission reduction potential. The trajectories of business-as-usual and two intervention scenarios are depicted in Table 15 below.

Table 15: Future Emissions Scenarios in Jakarta

	1980	1990	2000	2020	2050
Clean Fuel Scenario					
Energy Consumption (TJ)	55,760	56,674	118,006	353,550	1,437,510
Emissison (KT CO_2)	11,834	12,637	26,315	72,778	271,258
Modal Shift Scenario					
Energy Consumption (TJ)	55,760	56,674	118,006	318,195	1,150,008
Emissison (KT CO_2)	11,834	12,637	26,315	65,106	210,595

Source: author's calculation

Combining the interventions in both sectors, total energy consumption for Jakarta in 2000, 2020, and 2050 as well as the carbon dioxide emissions are shown in Table 16 below.

Table 16: Trends of Energy Consumption and Carbon Dioxide Emissions in Jakarta

	2000	2020	2050
Business as usual			
Energy use	175	561	2,291
Emissions of carbon dioxide	37	119	492
Renewable only and clean fuel			
Energy use	175	561	2,291
Emissions	37	109	426
Renewable, efficiency, clean fuel, and modal shift			
Energy use	175	494	1,833
Emissions	37	96	335

Note: Energy use is in PJ. Emissions are in KT.

[47] See DEMR, footnote 46.

The projected trajectories of carbon emissions in Jakarta as depicted in Table 16, above, are not implausible. Yet, they show a significant contribution to the increasing atmospheric accumulation of carbon in the atmosphere due to unsustainable city planning and development. There are some possibilities to further decouple economic development from carbon, however. The following shows a list of possible options for decarbonization.

- ✓ Urban redevelopment. While Jakarta shows skyscrapers along its major corridors, there are low-density development with poor provision of basic infrastructure in its backroads. Increased density will increase resource efficiency per person. Increased density will also reduce the need for land, and in turn will allow more green spaces that in turn can increase the capacity to sequester carbon. The introduction of mixed use zoning — housing, commercial, and office space in one complex — in addition to increased density will reduce the need for mobility, as it allows more people to live near where they work. It also reduces the availability and, to some extent, affordability of housing facilities in the city. In turn, urban redevelopment may bring the people back to live in the city centers instead of in the suburb — it may reverse the common trend of downtown “holes” (as is an evidence also in Jakarta) as in many cities that people no longer live in downtown areas.
- ✓ Energy efficiency. Increased energy efficiency will reduce the energy intensity of the city’s economy, and in turn will be able to reduce emissions resulting from energy production and use. It has been known that no- and low-cost efficiency measures in commercial and household sectors can reduce energy use up to 20 percent, whereas more investment in more costly efficiency measures can reach up to 40 percent.[48]
- ✓ Utilization of Less Carbon-Intensive and Renewable Sources. Shifting from carbon-intensive sources such as coal to less carbon-intensive ones such as natural gas, or better yet to renewable sources that releases no carbon emissions, can help reduce the carbon intensity of the energy system in Jakarta. But since electricity system in Jakarta is part of the Java-Bali interconnection system, then the decision to this effect needs to be made beyond the scope of the provincial government. Decision to utilize renewable sources in non-electricity sources, such as the utilization of natural gas to replace gasoline for transportation, or biofuel to replace a part of — say, five percent of — diesel or gasoline can be made locally. The biofuel technology is ripe, and there are already some companies that have produced biodiesel.
- ✓ Public and mass transport system. Indeed, shifting the modality of transport from private to public transport system — buses, railways — can reduce the need for fuels in the transport sector rather significantly. In the first six months of the operation of the busway system, about 7 percent (of about 100,000 people surveyed) of the busway passengers claimed to have shifted from using private cars to using busway as their daily commuting means.[49]
- ✓ Increased greeneries. Greeneries and open spaces help sequester carbon. The denser the greeneries — such as urban forests — the more sequestration capacity they have.

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[48] Personal communication with Rizka Elyza, Energy Researcher of Pelangi, who with Nasrullah Salim currently carries out energy efficiency improvement projects for hotels in Jakarta.

[49] INTRANS (Indonesian Network for Sustainable Transport), Survey of Busway Passengers. INTRANS, Jakarta, 2004.

12.11 The Institutional Dimension of Decarbonization

How can we ensure that the institutional arrangements for the options of decarbonization in Jakarta fit the problems? Indeed, while identifying policy options for decarbonization in Jakarta may already be very helpful, it still leaves one of the most important issues unanswered: the institutional dimension.

Table 17, below, shows the scale aspect of the institutional dimension. Some of the policy options require decisions at the central government level, whereas some others require only municipal (or, in the Jakarta level, provincial) level decisions. It is important that the dynamics of institutions, including the interplay among them at all levels and across levels are fully understood when one looks for the materialization of the policy options, above.

Table 17: Institutional aspects of policy options for decarbonization in Jakarta

	C	M	Impacts
Utilization of Renewable Sources of Energy	✓		Renewable, efficiency, clean fuel
Energy efficiency	✓	✓	Efficiency in electricity
Urban redevelopment	✓	✓	Modal shift
Public and mass transport system		✓	Modal shift
Expansion of greeneries		✓	Added sequestration

Note: C is decision by central government, whereas M is decision by municipal (or provincial) government.

Table 17, above, shows that decisions on the utilization of renewable sources of energy — both for electricity and for transport — can only be taken at the central government level. This is due to the fact that policy for the utilization of energy remains in the hands of the Ministry of Energy and Mineral Resources, and that most of the energy and electricity sources are located outside of the city.

Similarly, most policies that influence the extent of energy use efficiency are set at the central level. Besides deciding on energy policies, energy prices are also decided largely at the national level. The Governor of Jakarta and the Mayors of the municipalities in Jakarta have no say in the energy policy decision. But the Governor and the Mayor may be able to take on some measures that lead to increased efficiency. For example, they can set energy standards for buildings in the city at certain level of efficiency, or the public use of energy.

Urban redevelopment can be undertaken almost entirely at the municipal level, but still requires central government's "blessing". This is due largely to the fact that Jakarta is in a special status for being the Capital of the country. Urban planning and urban development is likely to require involvement of the central government, notably the Ministry of Settlement, Infrastructure, and Spatial Development.

Public transport development is almost entirely in the hands of the provincial and municipal governments. As an example, the decision to develop the "busway" system in Jakarta was entirely the decision made by the Governor of Jakarta. Similarly, expansion of green spaces and addition of woody spaces in the city is also in the hands of the provincial and mayoral governments.

12.12 Conclusion

There are a number of conclusions that can be drawn from the analysis in this paper, those that are drawn from the case of Jakarta but are applicable to any city. First, urbanization and urban transformation as a result of certain regional development pathways lead to different impacts to carbon stocks and fluxes. Transport sector appears to be the "time bomb" for the future emissions of carbon. But transport is largely a result of city development and land-use decisions. Smaller and more compact, cities; cities that allow pedestrianism; and cities that have better public transport facilities will result in better carbon outlook than expansive and sprawling cities; cities that are largely car-based, and cities with poor public transport — such as Jakarta — has worse carbon outlook.

City planning is not only a physical development, but a process that includes decision making, culture of governance, and level of participation of its citizens. As a result, decisions are either biased towards "the elites" or "the commons". For example, corrupt city governance will lead to decisions made in secrecy and are biased towards the elites. Transparent and democratic city governance will likely lead to more populist decisions. Most possibly, elitist decisions are more carbon intensive than populist ones. While economic trajectory contributes to the regional development trajectory, it is governance trajectory that was the most important driver. Local politics influence the outcome of the governance "trajectory".

Can cities choose to decarbonize in the future? Yes, but only when the city is governed participatorily, transparently, and with its citizens that have fulfilled their basic needs and possess strong environmental awareness. In sum, a city with high "social capital". Of course, development of cleaner and renewable energy, and energy use that are more efficient can help, but to do so requires decisions on both city and national levels, and they go back to the issue of governance once again.

13.0 Appendix 7: Case Study Working Paper – New Delhi

Integrating Carbon Management into the Development Strategies of New Delhi, India

13.1 Introduction

Delhi is the capital city of India having the status of a state of India and therefore, is being administered both by a state government and federal government. This interesting mix of governance, at times by political parties with different ideologies brings in new aspects in the overall development pathways of this capital city. This is also a place, which is under intense scrutiny of the Supreme Court of India especially on environmental issues and a number of policy directives by its intervention have changed the direction and/or pace of development pathways in recent past. In transport sector, a number of drastic policy interventions like introduction of lead-free petrol, replacement of entire diesel operated public bus fleet with CNG operated bus fleet, introduction of low sulfur diesel, introduction of metro rail etc. have already been implemented in Delhi in the last few years.

An assessment of some of the development processes taking place in Delhi is being carried out by estimating the stocks and fluxes of carbon. In order to do so, attributes of regional development in terms of demographic and socio-economic data for the period of 1990-2000 have been collected[50,51,52,53,54]. Although the targeted species of carbon in the present scope of work has been confined to carbondioxide, methane and black carbon but we have developed sectoral emission inventories of other trace species too for the sake of getting a complete picture. As embodied (or deemed) emission has the significant share in the city's stock and fluxes of carbon and other trace species, these have also been calculated for various sectors like carbon dioxide emissions from production of electricity, cement and steel & methane emission from milk production. For the preparation of inventory estimates, IPCC-1996 methodologies[55] have been used with default emission factors as well as indigenous emission factors depending upon the availability.

13.2 Historical Perspective

Delhi, the capital of India and the third largest city in India, lies at an altitude of between 215 and 305 meters and covers an area of 1,485 square kilometers. Situated on the Yamuna River (a tributary of the Ganges River), Delhi is bordered on the east by the state of Uttar Pradesh and on the north, west, and south by the state of Haryana. After India gained independence in 1947, Delhi became the capital of India. Subsequently Delhi was made a Union Territory on November 1, 1956. With the 69th Constitutional amendment, Delhi got a Legislative Assembly when the National Capital Territory Act was enacted in 1991.

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[50] National Capital Region Directory, Published by National Capital Region Planning Board, New Delhi-110003 (July 2000)

[51] Delhi 1999: A Fact Sheet. Published by National Capital Region Planning Board, New Delhi-110003

[52] www.ddadelhi.com (draft Delhi Master Plan 2021)

[53] www.delhiplanning.nic.in

[54] Census of India 1991 and 2001

[55] International Panel on Climate Change 1996 (IPCC 1996): The Science of Climate Change. Houghton JT, Meira Filho LG, Callander BA, Harris N, Kattenberg A & Maskel K (eds) Cambridge University Press, Cambridge.

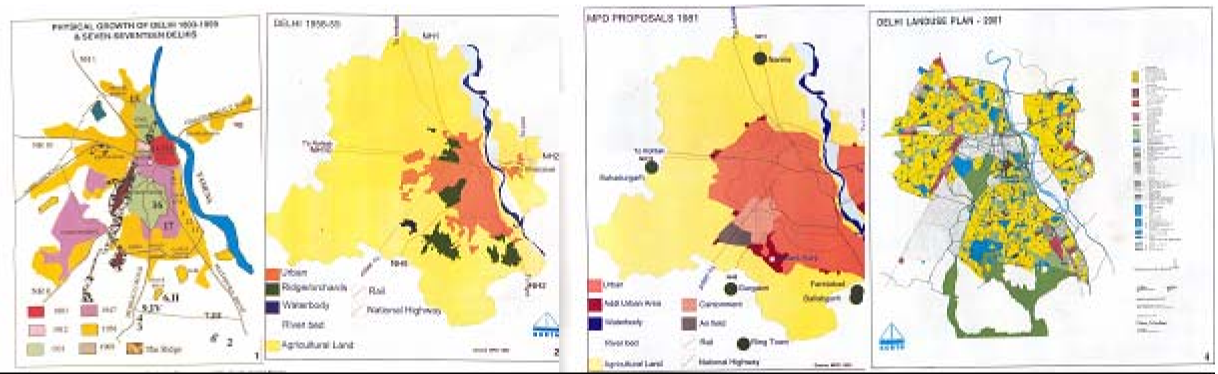
Delhi has a long history of evolution dating back to 10th century B.C. and has always remained a preferred choice for capital for ancient kingdoms also. Since 10th century B.C., the capital has been established in Delhi almost 17 times at various locations within an area covering six by twelve miles within present Delhi. The chronological order of Delhi's development until India's independence is given in the following Table-1 along with the name of the place where these capital cities have been established within Delhi and the name of emperors (founders) who established these capitals:

Table 1: Chronological order of development of Delhi[2]

Order	Date	Name of Settlement	Founders	Present Possible Site
1	900 BC	Indraprastha	Yodhistra	Purana Quilla
2	1020 AD	Suraj Kund	Anang Pal	Near the road linking Mathura Road and Mehrauli Road by same name
3	1052	Lal Kot	Prthvi Raj Chauhan	Near Qutab Site
4	1180	Quilla Rai Pithora	Prthvi Raj Chauhan	
5	1288	Kilokheri	Muiz-ud-din Kaiquabad	
6	1301	Siri	Alauddin Khilji (1295-1315)	Near Hauz Khas
7	1321-1323	Tughlaqabad	Gayasuddin Tughlaq (1321-1325)	On the link road connecting Mathura Road amd Meharauli road near Qutab Minar
8	1325	Adilabad	Mohammad Tughlaq (1325-1351)	Near Tughlakabad
9	1327	Jahanpanah	Mohammad Tughlaq	Between Siri and Raipithora
10	1354	Ferozabad	Feroz Shah Tughlaq (1351-1388)	Near Feroz Shah Kotla Stadium
11	1415	Khirabad	Khirakhan	(No Trace)
12	1425	Mubarakabad	Mubarak Shah	(No Trace)
13	1530	Dinpanah and Sher Garh	Humayun (1530, 1538, 1555-1556) Left incomplete; completed by Sher Shah Suri (1538-1545)	Purana Quila
14	1638	Shahjahanabad	Shahjahan (1628-1658)	Old Delhi (Walled City)
15	1912	Delhi	British Capital	North of Walled city Shahjahanbad; Old (Civil Lines) Secretariat
16	1931	New Delhi	British Capital (Designed by Lutyns and Baker)	Central Vista , Connaught Place and near about area
17	August 15, 1947	New Delhi	Capital of free India	Delhi Urban Area

Figure-1 shows the historical development of Delhi (Source: Delhi 1999: A Fact Sheet, NCRPB, New Delhi). The panel-A in Figure-1 shows the approximate locations of 17 ancient capital places (identified by number as per the listing given above). The Panel B, C and D in Figure-1 show the state of change of land-use patterns in Delhi during 1958-59, 1981 and 2001 respectively showing the massive urbanization taking place during last fifty years or so of post-independence years.

Figure 1: Changing Land Use Pattern in Delhi



A: 1803-1959 B: 1958-59 C: 1981 D:2001

Figure 1: Changing Land Use Pattern in Delhi

Since 1937, the urban development in Delhi has been looked after by the ‘Delhi Improvement Trust’ (DIT), which continued till the mid-fifties. However, after that, the Delhi Development Authority (DDA) and Town Planning Organization (TPO) were created in 1955, which were assigned the responsibilities of urban development in Delhi.

In the post independence era, Delhi’s urbanized area was recorded to be around 17,287 hectares in 1958-59 constituting 11.7% of the total area of Delhi Union territory[2]. The urban population at that time was estimated to be around 2 million. Since then there is a phenomenal growth in urbanization and industrial transformation in Delhi. As per the 1999 estimates, the built-up areas in Delhi have already increased to about 75,000 hectares which is more than 50% of the total National Capital Territory (NCT) area with population touching about 12 million. Table 2 provides details of the increase in urban areas in Delhi from 1958-59 to 1999.

Table 2: Increase in urbanized areas in Delhi

Year	Urbanized Area	Remarks
1958-59	42,700 acres (17287.45 hectares)	11.7% of the total area of Delhi Union Territory holding approximately 0.2 million urban population
1981	48,777 hectares	
1999	75,000 hectares	50% of the total area of National Capital Territory of India

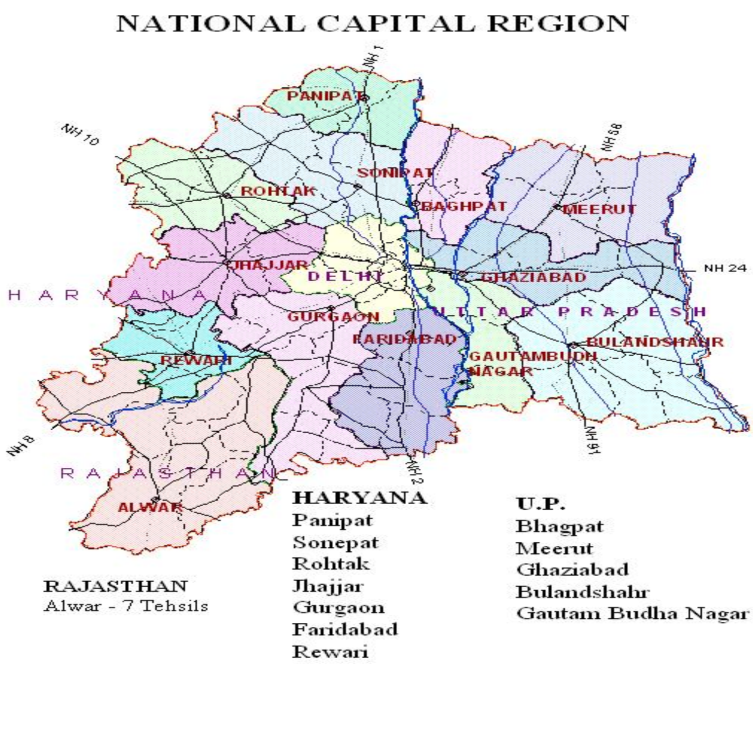
There are several reasons for this immense growth of urbanization in Delhi. Migration has been the main reason for the increasing population of Delhi[3]. Being a capital city, Delhi provides enormous opportunity for economic growth. For example, the per capita income of Delhi of Rupees 19,779 at current prices of 1995-96 has the distinction of being the highest in the country compared to all India per capita income of Rupees 9,321.

National Capital Region (NCR):

Due to more opportunities in Delhi, rapid urbanization has also taken place in the surrounding areas of Delhi. Several towns around Delhi like NOIDA, Ghaziabad, Gurgoan, Faridabad etc. have witnessed rapid urbanization although the pace of urbanization is different in different towns in different time horizons due to local factors. This is because of the fact that these towns falls under other Indian states and, therefore, are being governed by respective state governments whose policies affect the overall developmental pathways. To coordinate the developmental process, Delhi and surrounding townships have been declared as National Capital Region (NCR) to promote implementation of uniform policies.

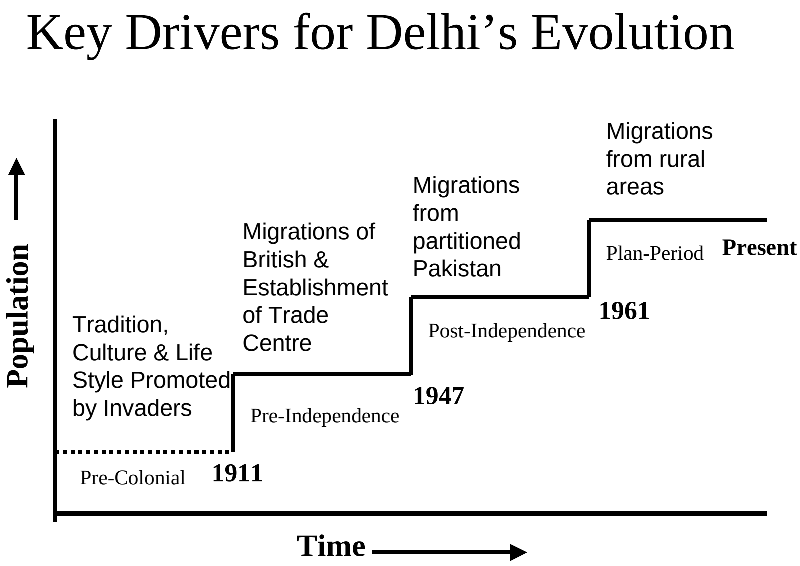
The Total area of NCR is 30,242 km^2, which is shared by National Capital Region Territory of Delhi (NCTD; 14,83 km^2), Uttar Pradesh (10,853 km^2), Haryana (13,343 km^2) and Rajasthan (4,493 km^2). NCR (Figure 2) has 12 ring towns (within a radius of 30 km of Delhi) and 8 satellite towns (around 45 km from Delhi). The present policy has been of developing NCR without National urbanization policy and without promoting development of other metropolitan regions. This has resulted in the influx of migrant population from other parts to the country to settle in NCR.

Figure 2: NCR Towns



The evolution of Delhi can be linked to circumstantial development and time and could be classified as historic, induced and spontaneous56. Historic is based on cultural and religious beliefs, e.g. Shahjahanabad (built in 1638) and traditional community based villages. Induced developments were a result of urban pressures, policies or plan-making mechanisms, e.g., migration from portioned Pakistan and migration due to jobs in central government or PSUs. Spontaneous development constitutes informal residential areas - considered illegal by city managers. Additionally, development in Delhi is linked to four different periods as shown in figure 2a. These periods are pre-colonial (before 1911), pre-independence (1911-1947), post independence (1947-1961) and Master Plan period (1961-present). During each of these periods migration to Delhi has been circumstantial. Pre-colonial period as already stated was based on traditions, cultures and religious lifestyles promoted by invaders. Pre-independence was related to migration of the British and development of trade. Post -independence was based on migration from partitioned West Pakistan. Master Plan Period refers to temporary migration from rural areas in search of employment. Presently, it has become an alternative, central place for international trade as well as a seat of power.

Figure 2a: Drivers or growth of urbanization in Delhi



It is evident that presently, growth in Delhi has been totally due to the following reasons: (1) Material growth of city; (2) Metro cities serve as centres for international trade and development providing facilities and know-how necessary for these international transfers of goods and services (3) Provides cost and efficiency advantage to business activities; (4) Provides for a large market; (5) Provides for infrastructure like international airport, telecommunications, health and education facilities

[56] **http://www.gisdevelopment.net/application/natural_hazards/overview/nho0014c.htm**

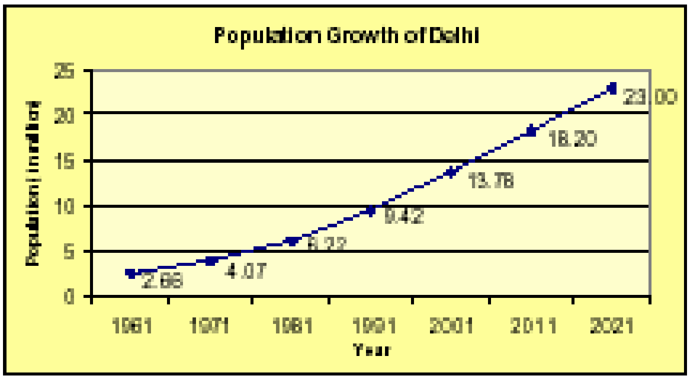
13.3 Climate

The region has a tropical steppe climate. The general prevalence of continental air leads to relatively dry conditions with extremely hot summers. Monthly mean temperatures range from 14.3^{0}C in January (minimum 3^{0}C) to 34.5^{0}C in June (maximum 47^{0}C). The annual mean temperature is 25.3^{0}C. The main seasonal climatic influence is the monsoon, typically from June to October. The mean annual rainfall is 71.5 mm. Maximum rainfall occurs in July (211 mm). The heavy rains of the monsoon act as a "scrubber". Usually northwesterly winds prevail, however, in June and July southeasterly predominates. Wind speeds are typically higher in the summer and monsoon periods; in winter, calms are frequent (about 20 per cent of the time).

13.4 Demographic changes and scenario

Population in Delhi has grown at a rapid pace in the past few decades. Six decades ago New Delhi was planned as the capital of British India, to cater to a population of 70,000, but the total urban population of Delhi now exceeds 13 million. The population increase in the past few decades is shown in figure 3 which also show that the projected population for 2021 is about 23 million.

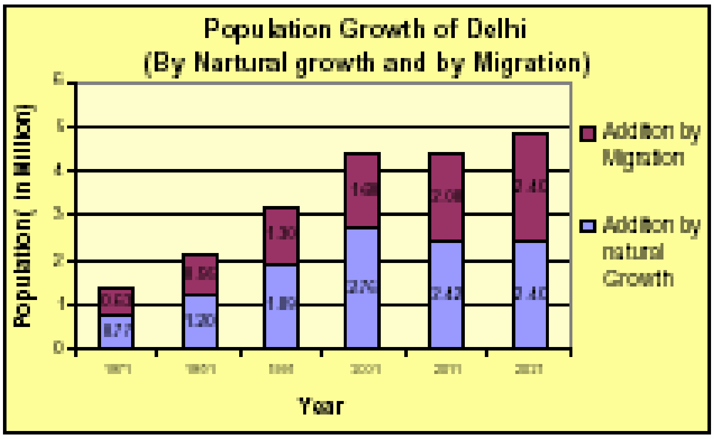
Figure 3: Population growth in Delhi



(Source: Census of India)

Migration – both international and internal - plays a major role in the growth of population of NCT Delhi. Migrants constitute about two-fifth of Delhi's population (38%; Figure 4).

Figure 4: Contribution of migration to the population growth in Delhi



Source: Delhi Development Authority

Amongst the migrants, the majority of the population belongs to the states of NCR (67.9%). The state of Uttar Pradesh alone contributes nearly half of the migrants (49.9%). The share of NCR states is 11.82% of Haryana and 6.17% of Rajasthan. Most of the population is migrating for employment purposes. To a certain extent, the number of migrants determines Delhi's nature of economic activity as 56% of workers are migrants. In addition to this, there are a large number of daily or commuter migrants (floating population). The major reasons for these commuters' visits to Delhi everyday are for employment and movement of goods and services. Table-3 shows that in the future also, the share of migration will remain significant (about 50%) in the overall projected increase in Delhi's population57.

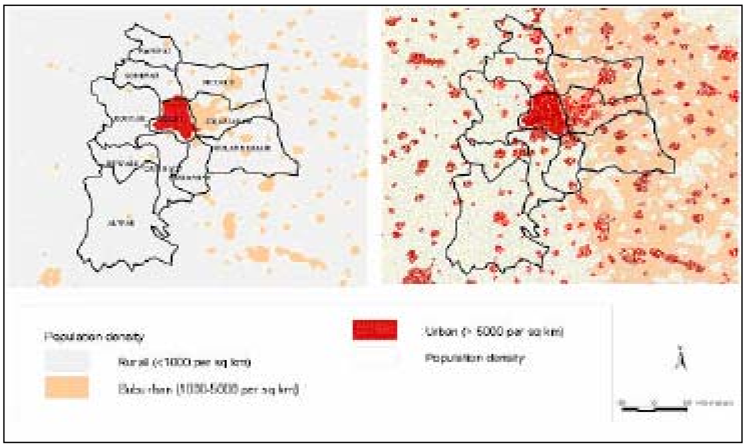
Table 3: Share of natural growth and in-migration in the projected population growth in Delhi

Year	Addition by Natural Growth	Increase by Migration	Net Increase (in million)
1981	1.20 (55.8%)	0.95 (44.2%)	2.15 (100%)
1991	1.89 (59.2%)	1.30 (40.8%)	3.20 (100%)
2001	2.76 (63.3%)	1.60 (36.7%)	4.36 (100%)
2011	2.42 (54.8%)	2.00 (45.2%)	4.42 (100%)
2021	2.40 (50%)	2.40 (50%)	4.80 (100%)

[57] Census of India and projection by MPD- 2021

As a result of the influx of population to Delhi the following pattern of population density has been observed in the past few decades (figure 5)[58].

Figure 5: Changes in population density in Delhi



However, this change in population density is not uniform all over the Delhi. For example, a comparison of population densities in different parts (districts) of Delhi shows that the north-east part has shown a large increase in population density in the census 2001 compared to census 1991 while in other parts of Delhi, this large increase is not witnessed (Figure 6). Thus this intra-city difference shows a 'population hotspot' that will have an impact on other development drivers also. Dupont and Mitra59 (1995) have suggested that the pattern of growth in Delhi has been 'centrifugal' between 1981 and 1991. The classical model of population density gradient characterized by high-density urban core and a sharp decrease towards the periphery has largely survived in Delhi till 1991. The original social causes for this model have been described by Dupont60 (2003) as 'protection, prestige & proximity'. However, since 1991 Delhi is witnessing a change in urbanization as the population densities are falling in the walled city due to out-migration of population to peripheral townships coming up as a product of town planning offering better civic and aesthetic facilities. But there are also pockets in Delhi where population densities have increased during the post-1991 period because of new settlements of migratory labor.

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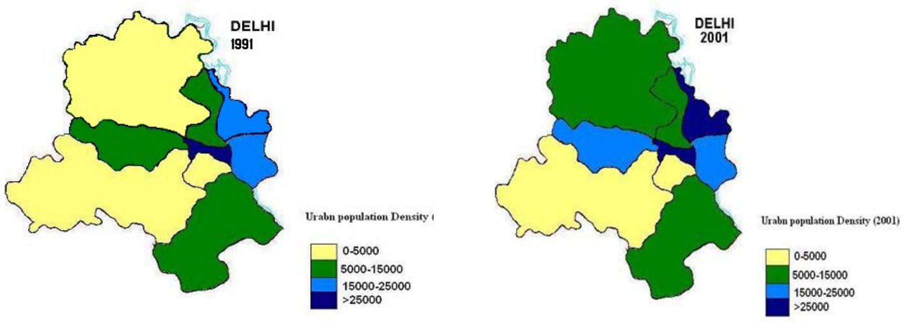
[58] Guneet Kaur, Revival of Satellite and Ring Cities, 40th ISoCaRP Congress 2004

[59] Dupont V and Mitra A, (1995) Population distribution, growth and socio-economic spatial patterns in Delhi. Findings from the 1991 census data. Demography India, vol. 24 (1 and 2) pp 101-32.Development and

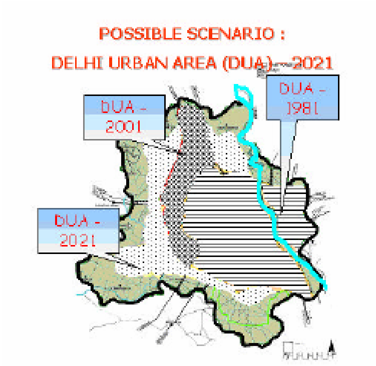
[60] Dupont V (2003) Urban development and population redistribution in the Delhi: implications for categorizing population. In: T. Champion, G. Hugo (eds.) New Forms of Urbanization: Beyond Urban-Rural Dichotomy. Aldershot, Ashgate, pp 170-190.

Figure 6: Changes in Intra-city Population Density in Delhi during 1991 to 2001 Period



Because of this immense pressure of urbanization, the present share of 50% of the urban area in the total area of Delhi's (NCT) is expected to increase significantly in future posing serious stress on its infra-structure and conservation of Delhi's natural resources. The possible future scenario of Delhi's urban share is given following figure 7:

Figure 7: Possible scenario of Delhi's urban area



(Source: Delhi Development Authority, Office of MPD 2021)

13.5 Socio-economic changes

In the following tables 4-6 and figures 8-9, some of the key parameters like literacy rate in India & Delhi 1961- 2001 period, poverty line in Delhi & India, Per Capita Income in Rupees (Delhi and all India value), growth of employment in Delhi, and functional shift in employment sectors are given for Delhi. The comparison of these socio-economic features between Delhi and rest of India shows that Delhi's citizens have a much better life to lead than compared to the rest of India. The literacy rate is higher, per-capita income is higher and also the number of persons living below the poverty line in Delhi is much lower than the all India average.

Table 4: Literacy Rate (percentage) in India & Delhi 1961- 2001

Census Year	INDIA			DELHI		
	Person	Male	Female	Person	Male	Female
1961	28.3	40.4	15.35	61.95	70.37	50.87
1971	34.45	45.96	21.97	65.08	72.55	55.56
1981	43.57	56.38	29.76	71.94	79.28	62.6
1991	52.21	64.13	39.29	75.29	82.01	66.99
2001	65.38	75.85	54.16	81.82	87.37	75

Table 5: Poverty line in Delhi &India (number of Persons in million)

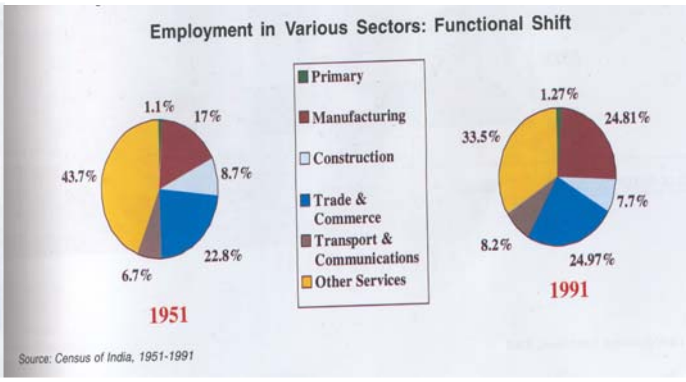
Year	Rural	Urban	Combined
Poverty line in Delhi			
1983	0.044	1.795	1.839
Percentage	7.66	27.89	26.22
1987-88	0.01	1.015	1.025
Percentage	1.29	13.56	12.41
1993-94	0.019	1.532	1.551
Percentage	1.9	16.03	14.69
1999-2000	0.07	11.42	11.49
Percentage	0.4	9.42	8.23
Poverty Line in All India			
1993-94	244.031	76.337	320.268
Percentage	37.27	32.36	35.87
1999-2000	193.243	67.007	260.25
Percentage	27.09	23.62	26.1

Table 6: Per Capita Income in Rupees (Delhi and all India value)

Year	DELHI (Current Prices)	ALL INDIA (Current Prices)	DELHI (Constant Prices)	ALL INDIA (Constant Prices)
1993-94	18021	7690	18021	7690
1994-95	21420	8857	19437	8070
1995-96	22364	10149	18998	8489
1996-97	25719	11564	20771	9007
1997-98	30537	12707	23221	9242
1998-99	33870	14395	24133	9647
1999-00	36515	15562	24327	10067
2000-01	38864	16487	24450	10254

Delhi has provided better opportunity for employment, which is catalyzing the unprecedented increase in urbanization. The employment opportunities are continuously growing and there is a slight shift in the employment opportunities in various sectors. The 1991 data has revealed that manufacturing and trade have increased their proportion in 1991 compared to 1951 but the service sector continues to dominate in providing employment in Delhi although its share has come down from about 44% in 1951 to about 33% in 1991.

Figure 8: Growth of employment in Delhi   Figure 9: Functional shift in various sectors of employment in Delhi



13.6 Air quality in Delhi

The ambient air quality in Delhi has been monitored by the Central Pollution Control Board (CPCB). The long-term record shows (see following table 7) that out of the criterion pollutants of SO_2, NO_2 and SPM, the SPM most of the time found to be above the prescribed national standard's limits.

Table 7: Air quality in Delhi (units in $\mu g/m^3$)

Year	SO_2 Residential	SO_2 Industrial	NO_2 Residential	NO_2 Industrial	SPM Residential	SPM Industrial
1990	7.3	16	22	24	317	381
1991	13	15	28	25	300	349
1992	16	24	30	32	351	431
1993	16	24	33	34	358	402
1994	17	26	33	34	385	362
1995	17	24	33	37	409	403
1996	16	21	32	35	369	420
1997	15	20	31	37	345	314
1998	16	20	29	35	345	363
1999	17	21	27	34	349	361
2000	17	19	31	36	370	433

Note: All values are annual average of monthly values (source CPCB)

The measured values show (see following figures 10a to 10c) that the SO_2 and RSPM concentrations are now showing decreasing trends in Delhi's ambient air but the NO_2 concentrations are going up (all values in µg/m^3; Source- Rajagopalan, BAQ 2004).Figure 10a: Delhi-SO_2

Figure 10a: Delhi-SO_2

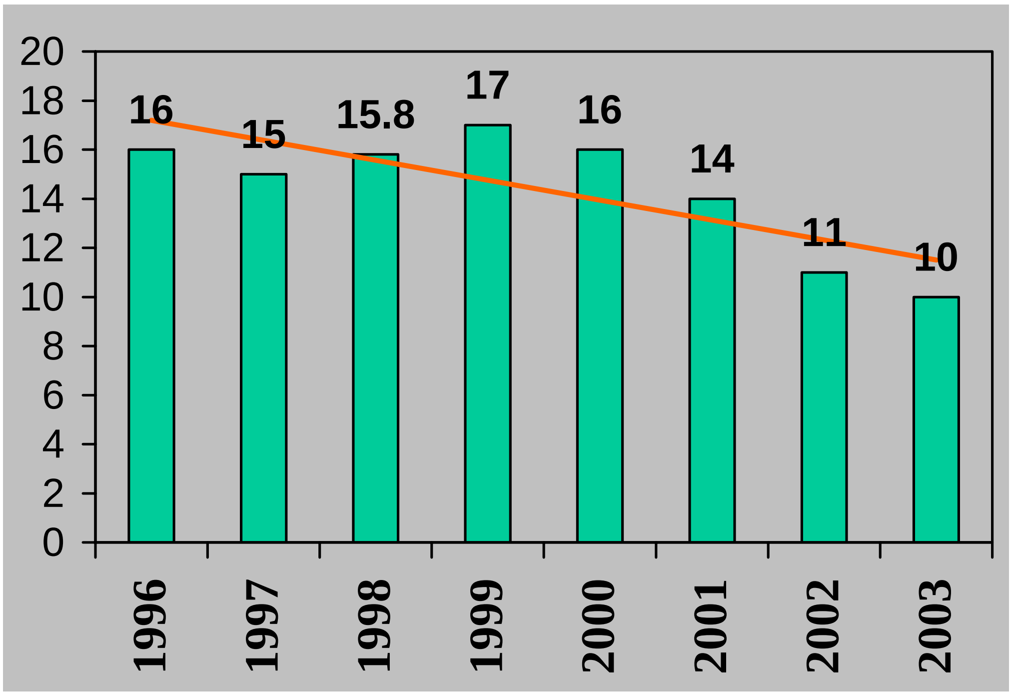


Figure 10b: Delhi-NO_2

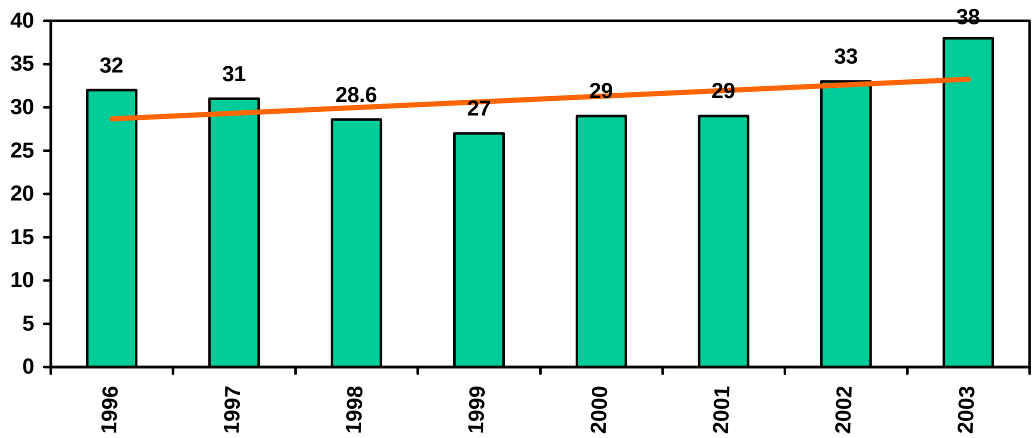
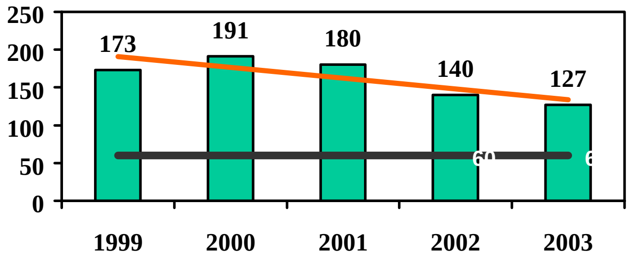


Figure 10c: Delhi-RSPM



However, we have observed intra-city differences in the ambient air quality also in different years as shown in following figures 11a & 11b for the ambient SPM and SO_2 concentrations in different parts of Delhi respectively. However, the intra-city differences do not show change in ambient air quality during 1991-2000 periods.

Figure 11a: Trends in Intra-city differences in SPM concentration ($\mu g/m^3$) in industrial & residential areas in Delhi during 1991-2000 (source-CPCB)

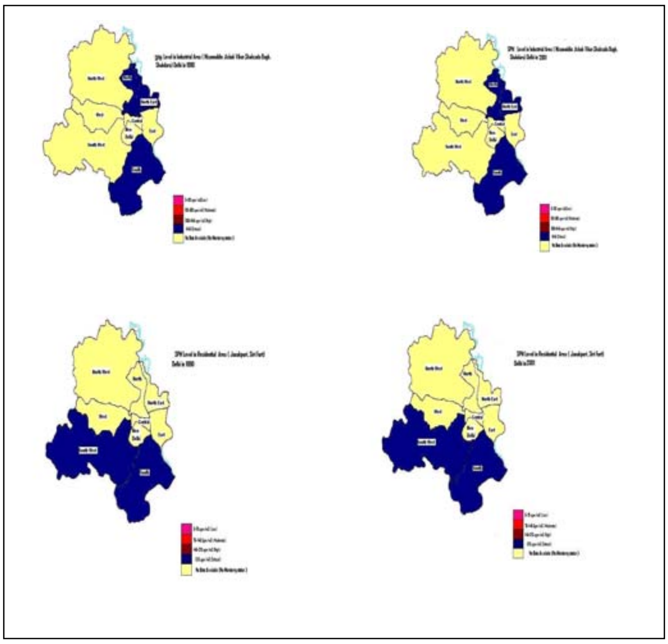
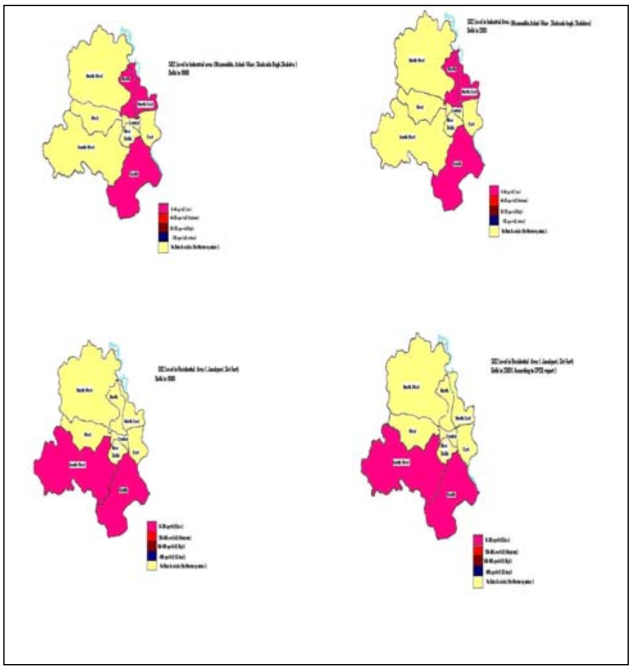


Figure 11b: Trends in Intra-city differences in SO_2 concentration ($\mu g/m^3$) in industrial & residential areas in Delhi during 1991-2000 (source-CPCB)



13.7 Inventory of Emissions from Different Sectors in Delhi

For the development of emission inventories from different sectors in Delhi, we have taken into account both 'direct' as well as 'embodied' sources which are shown in table 8 which also contains the name of trace species emitted by respective sectors. For the embodied emissions, we have estimated emissions from cement & steel consumption in the city which is produced elsewhere. Similarly, we have also estimated emission of CH_4 from Livestock using the quantity of milk consumed within the city in excess of local production.

Table 8: Significance of specific sectors for direct and embodied (indirect) emissions from mega-cities

	CO_2	CH_4	N_2O	NO_x	CO	SO_2	Particulates	Black Carbon
Energy & Transformation Industries	×			×	×	×	×	×
Transportation	×			×				×
Biomass Burning	×	×	×	×	×		×	×
Industrial Process								
Cement								
Steel								
Agriculture								
Enteric Fermentation								

Rice Cultivation								
Agricultural Soil			X					
Agricultural Residues burning		X	X	X	X		X	X
Land use And Forestry	X							
Waste		X						

Embodied emission

In our study, we have attempted to calculate embodied emissions in the material & energy that flows in the mega-city. The calculations give idea of the magnitude of emissions associated with the development and maintenance of a mega-city thus giving an idea of the sustainability of development pathways. A whole variety of data have been collected for different sectors; some of these sectors like steel, cement, power, agriculture etc. have major contributions in the embodied emissions from the mega-city. For the calculation of inventory values, in most of the cases, IPCC 1996 methodologies have been followed with default values or country specific emission factors depending upon their availability.

Emission from energy sector

In mega cities the emissions of greenhouse gases (GHGs) and other trace species depend on the developmental activities like transportation, industrialization, building construction etc. Direct & indirect (embodied) sources in specific sectors are responsible for these emissions. Energy sector plays key role in economic as well as emission scenario. The sources of energy in mega cities normally consist of coal, gasoline, diesel, kerosene & bio-fuels. The bio-fuel mainly includes wood, cow-dung cakes and agriculture residues. All these contribute to the increase in emissions of suspended particulate matter (SPM), carbon dioxide, sulfur dioxide, nitrogen oxides & other trace species.

Fuel consumption

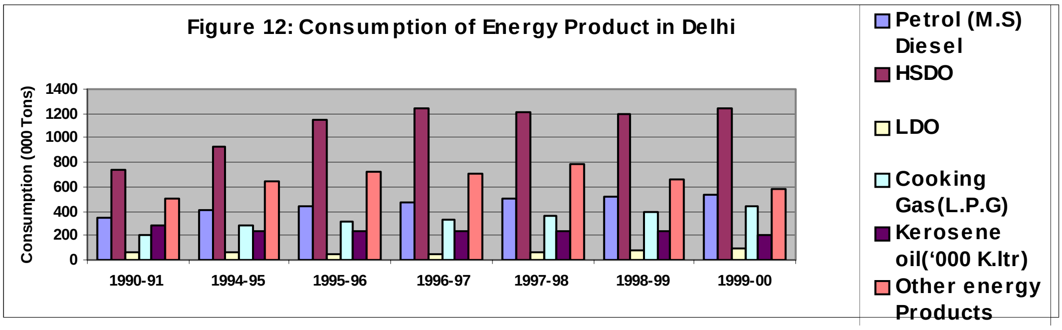
In the energy sector, fuel combustion is a major global source of CO_2 emissions. The consumption of petroleum products (viz. Gasoline, Diesel, Coal, LPG etc.) in industry, transportation, residential & commercial sectors during 1980-81 to 1999-2000 period is shown in following table 9 and figure 12. The consumption of diesel is quite high compared to gasoline consumption in Delhi.

Table 9: Consumption of energy product (in thousand tons) in Delhi

Categories	1980-81	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00
Petrol(MS) diesel	133	344	356	363	375	408	436	476	497	517	535
HSDO	377	732	747	810	840	929	1153	1242	1213	1190	1237
LDO	28	66	61	41	67	64	45	49	68	73	101
Cooking gas (LPG)	47	205	221	239	259	277	309	332	365	390	448
Kerosene oil (000 K Ltr)	na	289	231	237	238	240	240	243	243	233	206
Other Energy product	467	502				647	723	712	785	659	579

The above table shows that the consumption of petroleum products has substantially increased from the period 1980-81 to 1999-00. The consumption of petrol (gasoline) has increased four times from 133, 000 tons in 1980-81 to 535,000 tons in 1999-00, HSDO (high speed diesel) has increased from 377, 000 tons in 1980-81 to 1237,000 tons in 1999-00 , the consumption of LDO has increased from 28,000 tons to 101,000 tones from year 1980-81 to 1999-00. During this period, the consumption of LPG has increased from 47,000 tons to 448,000 tons which is nine times the 1980-81 value but is considered as a clean fuel.

Figure 12: Consumption of Energy Product in Delhi



For the preparation of the inventory, IPCC default emission factors have been used except for CO, NO_X & HC. Using the consumption of gasoline & diesel in transport sector in Delhi, emissions of different trace species including GHGs & particulate matter have been estimated. For the estimation of CO, HC, Particulate matter, and NO_x from diesel & gasoline, emission factors prescribed by Indian Institute of Petroleum, Dehradun, India (Mitra 1992) have been utilized which are given in table 10 below.

Table 10: Default Emission Factors from Transport Sector

Parameters	Emission Factor for Gasoline (kg/tonne)	Emission Factor for Diesel (kg/tonne)
CO	2.4*	2.7*
NOx	10.3	11
HC	14.5	2.6
Particulates	2	2.4
* =kg/litre		

Source: Global Change, Scientific Report ,Number -4 , Aug 1992(Page -20,Table - 2.12)

It has been estimated that the CO_2 emissions (figure 13, table 11) from gasoline consumption has increased from 408.79 Gg in 1980-81 to 1057.32 Gg in 1990-91 & has further increased to 1644.37 Gg in 1999-00. While from diesel consumption, CO_2 emissions have increased from 1197.81 Gg in 1980-81 to 3930.21 Gg in 1999-00; from LPG consumption, CO_2 emission has increased from 139.53 Gg in 1980-81 to 1330.01 Gg in 1999-00.

Figure 13: Emission of CO2 from Energy Production in Delhi

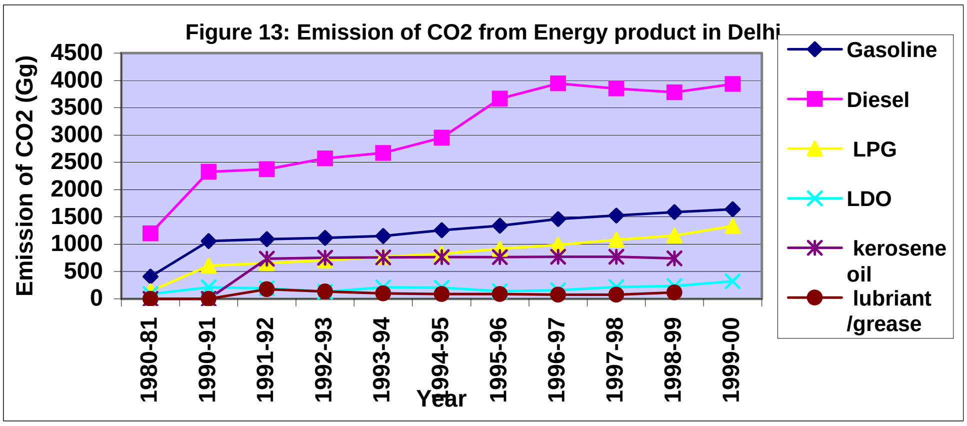


Table 11: Emission of CO2 from petroleum product in Delhi

Year	Gasoline (Gg)	Diesel (Gg)	LPG (Gg)	LDO (Gg)	Superior kerosene oil (Gg)	Aviation turbine fuel (Gg)	Lubriant /grease (Gg)
1980-81	408.7879	1197.81	139.532	88.962	NA	NA	NA
1990-91	1057.316	2325.72	608.597	209.696	NA	NA	NA
1991-92	1094.199	2373.38	656.097	193.81	735.475	1196.24	175.068
1992-93	1115.714	2573.54	709.535	130.266	754.578	1193.08	134.219
1993-94	1152.598	2668.86	768.91	212.873	757.762	1470.84	99.205
1994-95	1254.026	2951.63	822.348	203.342	764.13	1814.87	87.5338
1995-96	1340.087	3663.33	917.349	142.975	764.13	2029.5	87.5338
1996-97	1463.031	3946.07	985.63	155.684	773.681	2048.44	78.7804

1997-98	1527.576	3853.96	1083.6	216.051	773.681	1871.69	78.7804
1998-99	1589.048	3780.89	1157.82	231.937	741.842	1748.59	116.712
1999-00	1644.373	3930.22	1330.01	320.899	NA	NA	NA

The black carbon estimation from fossil fuel consumption in Delhi (as given in following table 12) shows that the coal consumption in thermal power plants are the major source of black carbon in atmosphere but diesel also contributes significant amount of black carbon. There is an increasing trend of black carbon emissions from 1995-96 to 1999-00 period but in the subsequent period, both coal and diesel might have less contributions because of the implementation of policies like conversion of diesel buses into CNG bus-fleet in city's transport and replacement of coal-based generating units with gas-based generating units.

Table 12: Black carbon Emission from Petroleum Products

Year	Black carbon emission from Coal (tons)	Black carbon emission from gasoline (Kg)*	Black carbon emission from diesel (tons)*	Black carbon emission from kerosene (Kg)*
1995-96	1836-2240	26.16	807	7
1996-97	1702-2076	28.56	869	7
1997-98	1759-2146	29.82	849	7
1998-99	1547-1887	31.02	833	7
1999-00	1743-2126	32.1	866	7

*Based on lower range of black carbon emission factor

The emission estimates of pollutants like NOx, HC, particulate matter, CO from total gasoline consumption in Delhi (table 13) shows that NOx emission has increased from 1.37 to 3.5 Gg from year 1980-81 to 5.51 Gg in 1999-00; HC from 1.93 Gg in 1980-81 to 4.99 Gg in 1990-91 & to 7.76 Gg in 1999-00. The emissions of particulate matter have increased from 0.266 Gg in 1980-81 to 0.688 Gg in 1990-91 & to 1.07 Gg in 999-00. The CO emissions show an increase from 319.2 Gg 1980-81 to 825.6 Gg in 1990-91 & to 1284 Gg in 1999-00.

Table 13: Emission from gasoline consumption

Year	CO2 emission (Gg)Y1	NOx emission (Gg)Y2	HC emission (Gg)Y2	Particulates emission (Gg)Y2	CO emission (Gg)Y1
1980-81	408.7879	1.3699	1.9285	0.266	319.2
1990-91	1057.316	3.5432	4.988	0.688	825.6
1991-92	1094.199	3.6668	5.162	0.712	854.4
1992-93	1115.714	3.7389	5.2635	0.726	871.2
1993-94	1152.598	3.8625	5.4375	0.75	900
1994-95	1254.026	4.2024	5.916	0.816	979.2

1995-96	1340.087	4.4908	6.322	0.872	1046.4
1996-97	1463.031	4.9028	6.902	0.952	1142.4
1997-98	1527.576	5.1191	7.2065	0.994	1192.8
1998-99	1589.048	5.3251	7.4965	1.034	1240.8
1999-00	1644.373	5.5105	7.7575	1.07	1284

The emissions of pollutants like CO_2, NOx, HC, particulate matter and CO from total diesel consumption in Delhi (table 14) has increased from 1197.81 Gg in 1980-81 to 2325.72 in 1990-91 for CO_2; from 4.15 to 8.05 Gg for NOx; from 0.98 to 1.90 Gg for HC; from 0.90 to 1.76 Gg for particulate matter and from 1,017.9 to 1976.4 Gg for CO in this time period. During 1991-92 to 1999-00 period, the emission estimates show an increase from 2325.72 to 3,930.21 (Gg); from 8.05 to 13.6 Gg, from 1.9 to 3.21 Gg; from 1.76 to 2.97 Gg; from 976.4 to 3,339.9 Gg for CO_2, NOx HC, particulate matter & CO respectively.

Table 14: Emission from diesel consumption (Gg)

Year	CO2 emission	NOx emission	HC emission	Particulates emission	CO emission
1980-81	1197.81	4.147	0.9802	0.9048	1017.9
1990-91	2325.722	8.052	1.9032	1.7568	1976.4
1991-92	2373.38	8.217	1.9422	1.7928	2016.9
1992-93	2573.545	8.91	2.106	1.944	2187
1993-94	2668.861	9.24	2.184	2.016	2268
1994-95	2951.633	10.219	2.4154	2.2296	2508.3
1995-96	3663.33	12.683	2.9978	2.7672	3113.1
1996-97	3946.067	13.662	3.2292	2.9808	3353.4
1997-98	3853.962	13.343	3.1538	2.9112	3275.1
1998-99	3780.887	13.09	3.094	2.856	3213
1999-00	3930.216	13.607	3.2162	2.9688	3339.9

Emission estimates from transport sector

Delhi is predominantly dependent on road transport. Transport sector is the major energy consuming sector. It has been estimated that motor vehicles contribute to about 64% of pollution in Delhi while other sources (e.g. domestic 8% , industrial 12%, power plant 16%) are of much less significance compared to vehicles.

As on March 2001, 3.456 million motor vehicles were registered in Delhi. The Census 2001 reported Delhi's population as 13.78 million. This implies 251 vehicles per 1,000 population in March 2001 as compared to 192 vehicles in March 1991. There has been an increase of about 90% in overall growth of registered vehicles during 1991-2001 at an average annual compound growth rate of about 6.7%. Motor vehicle population and its growth rate (registration) from 1990-91 can be seen in tables 15 and 16 and figure 14. The percentage distribution of categories of motor vehicles in Delhi shows that there has been a rapid proliferation in the number of cars/jeeps during the decade, while there has been a decline in the relative share of motorcycle & scooters, auto rickshaws [three-wheeler vehicle], taxis and goods vehicles indicating a shift towards higher income. The number of cars/jeeps has increased from 21.9% in 1991 to 26.6% of the total vehicles in 2001.

Table 15: Number of registered motor vehicle in Delhi

Category	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04
Car & jeeps	398479	440166	477783	522264	575762	633802	705923	765470	818962	869820	920723	968894	1154638	1267700
Motorcycle &Scooters	1220640	1317180	1403050	1492201	1617732	1741260	1876053	1991710	2011876	2184581	2230534	2265955	2449580	2650393
Auto Rickshaws	63005	67128	70459	72102	74981	79011	80210	80210	86985	86985	86985	86985	44164	74906
Taxies	10157	10694	11365	11846	12547	13765	15015	16654	17136	17762	18362	20628	12359	16053
Buses	18858	20201	23221	24211	26202	27889	29572	32333	35254	37733	41483	47578	52550	38886
Goods Vehicles	101828	107629	111277	116379	125071	133918	140922	146668	150243	156157	158492	161650	77224	135671
Total	1812967	1962998	2097155	2239003	2432295	2629645	2847695	3033045	3210456	3353038	3456579	3551690	3790515	4183609

Figure 14: Number of Registered Vehicles in Delhi

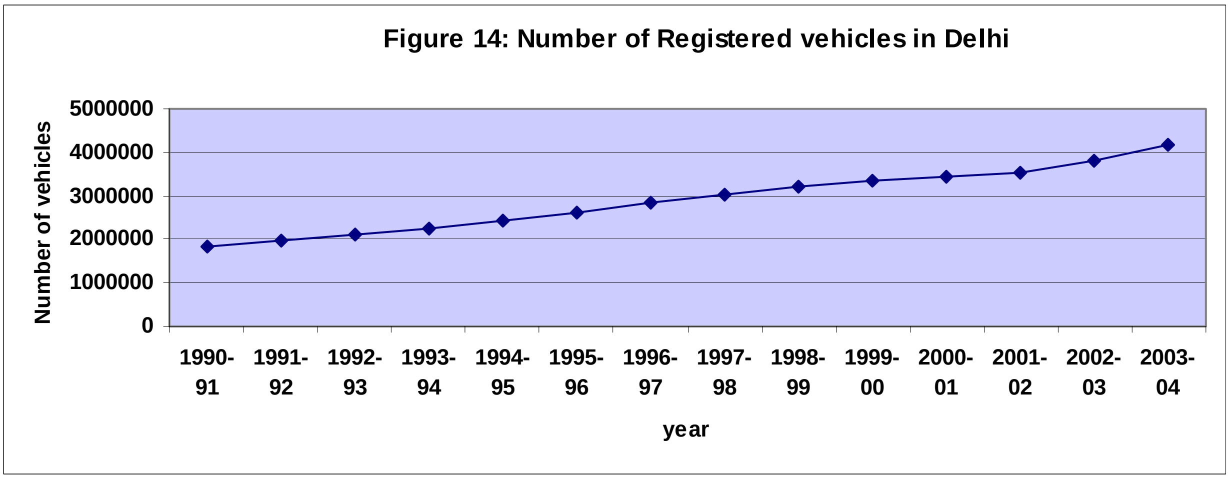


Table 16: Annual growth rate of motor vehicles (in percentage)

	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01
Car & jeeps	15.45	10.46	8.55	9.3	10.24	10.08	11.38	8.44	6.98	6.21	5.85
Motor Cycle &Scooters	9.65	7.9	6.52	6.35	8.41	7.64	7.74	6.16	5.53	3.93	2.1
Auto Rickshaws	6.9	6.54	4.96	2.33	3.99	5.37	1.52	0	8.45	0	0
Taxies	5.22	5.29	6.27	4.23	5.92	9.71	9.08	10.92	2.89	3.65	3.38
Buses	5.68	7.12	14.95	4.26	8.22	6.44	6.03	9.34	9.03	7.03	9.94
Goods Vehicles	9.75	5.7	3.39	4.58	7.47	7.07	5.23	4.08	2.44	3.94	1.5
Total	10.71	8.28	6.83	6.76	8.63	8.11	8.29	6.51	5.85	4.44	3.09

There is an uncertainty in the actual number of vehicles plying on Delhi's roads. A large number of vehicles registered in Delhi can be seen plying on NCR town roads and vice-versa. Vehicles registered outside Delhi but plying on Delhi roads are of two categories (a) plying on Delhi roads while crossing Delhi territory to reach a destination outside Delhi; and, (b) now shifted to Delhi on temporary or permanent basis. Therefore actual numbers of vehicles plying on Delhi's road are still uncertain however, Transport Department in Delhi is making efforts to estimate the actual number of vehicles in Delhi by taking into account vehicles that have outlived their life due to any account, transferred to and from other States, etc.

Using the emission factors for emissions of different pollutants from various types of vehicles (as an example given in following table 17) plying on Delhi's roads, emission estimates for different pollutants have been made.

Table 17: Emission Factor Used to Calculate Emission of Pollutants for Transport sector

Diesel	Emission Factors(t Pollutants /Tj)			
	CO2	NOx	CO	VOC
LCV	74	2.42	1.15	1.23
HCV	74	5	3.89	0.97
Gasoline	Emission Factors(t Pollutants /Tj)			
	CO2	NOx	CO	VOC
MC/SC	69.2	0.05	13.33	6.6
Cars	69.2	0.45	3.92	0.77

Emission Factor Source: Global Change, Scientific Report, Number 11, May 1998(Page -25, table-2.9a & 2.9b)

The emission estimates of various pollutants from different types of vehicles in Delhi are given in following figures 15a to 15d:

Figure 15a: CO_2 Emission from Petroleum Production in Motorcycle/Scooter, Cars, HCV, LCV

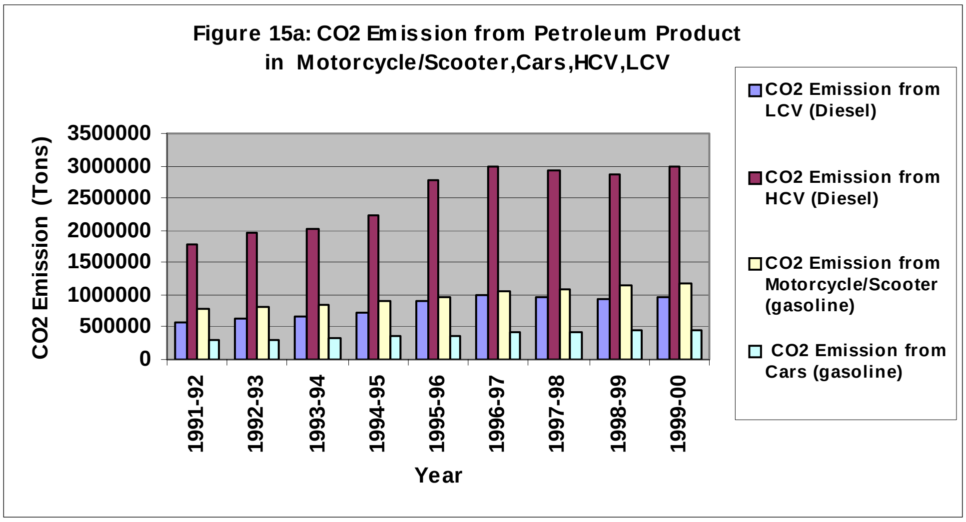


Figure 15b: NOx Emission from Petroleum Product in Motorcycle/ Scooter, Cars, HCV, LCV

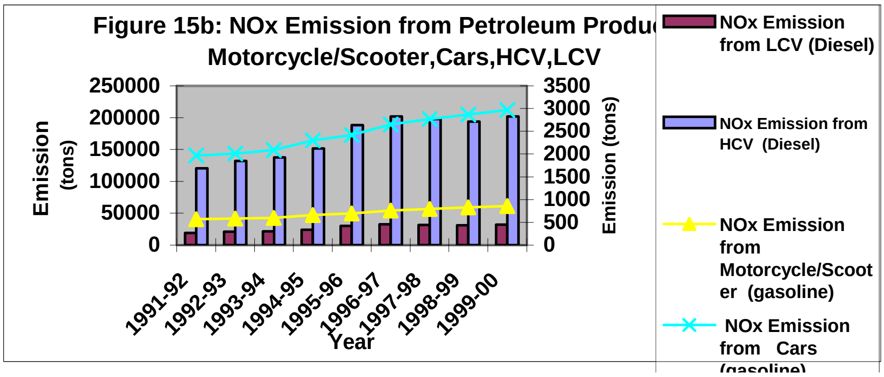


Figure 15c: CO Emission from Petroleum Product in Motorcycle/ Scooter, Cars, HCV, LCV

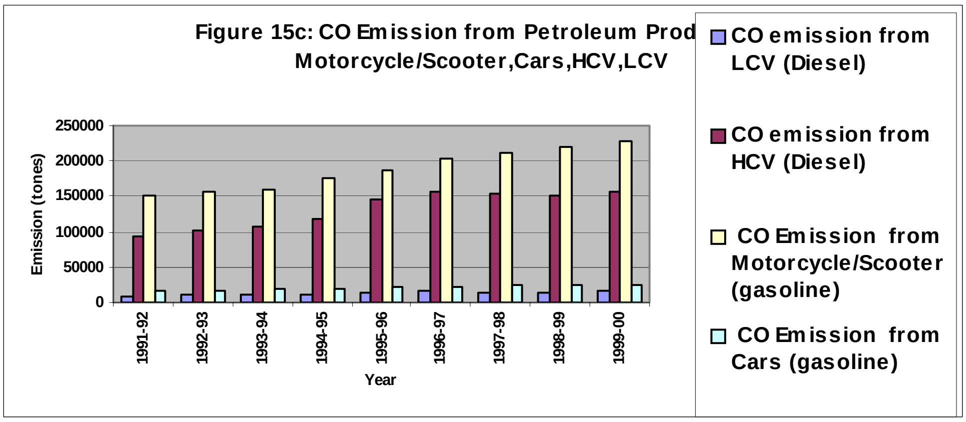
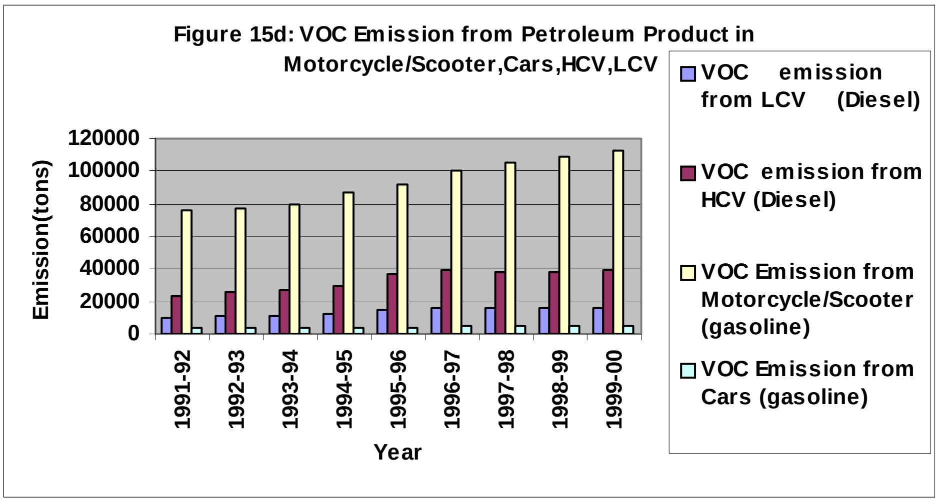


Figure 15d: VOC Emission from Petroleum Product in Motorcycle/ Scooter, Cars, HCV, LCV



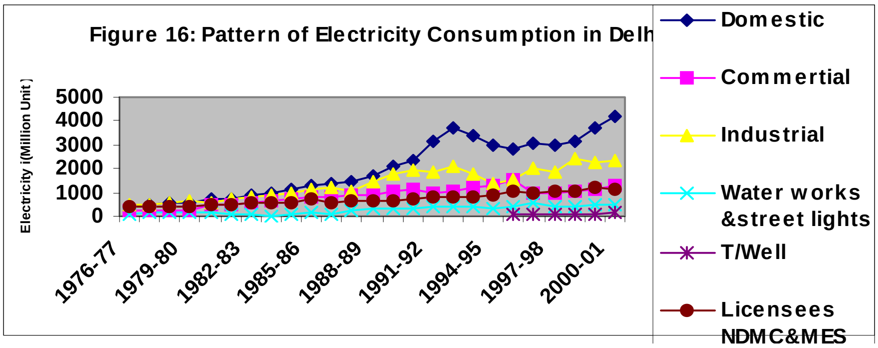
The emission of CO_2, NOx, CO, VOC from diesel consumption by LCV has increased from year 1991-92 to 1999-00 from 583,568.4 to 977,958.1 Gg, 19,084.3 to 31981.9 Gg, 9,068.97 to 15198 Gg, 9,699.85 to 16255.25 Gg respectively. The emissions of CO_2, NOx, CO, VOC from diesel consumption by HCV has increased from year 1991-92 to 1999-00 from 1,779,563 to 2,988,383 Gg, 120,241 to 201,918 Gg, 93,547.3 to157,092 Gg, 23326.71 to 39172.05 Gg.

Emission from thermal power plant

Thermal power plants are prominent contributors to air pollution. Consumption of coal to generate electricity in Delhi is the direct source of CO_2 emissions while electricity purchased from surrounding towns & cities (national grids) is used to calculate indirect (embodied) CO_2 emissions. There are three coal-based thermal power plants in Delhi, namely Rajghat, I.P and Badarpur Power Plants, which have a total generation capacity of 1087 MW and were responsible for as much as about 10% of the air pollution load in 2001 while these three Thermal Power Plants in NCT of Delhi contributed about 16% of the total air pollution in 1991 (DPCC 2003). All the three power plants have installed electrostatic precipitators in all their units to control particulate matter emission.

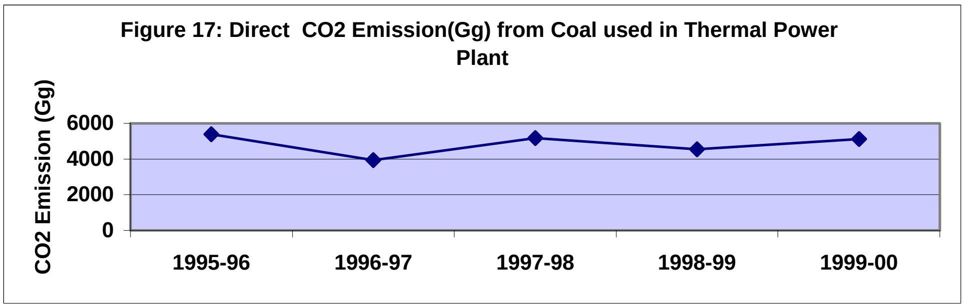
The pattern of electricity consumption in Delhi is given in figure 16, which clearly reflects the growing need of electricity in the domestic sector in the last few years since 1990, the time of greater opening of the Indian economy.

Figure 16: Pattern of Electricity Consumption in Delhi



The estimated emissions from coal consumption in electricity production in Delhi (direct emissions) are shown in figure 17:

Figure 17: Direct CO_2 emission (Gg) from coal-fired thermal power plant



The total emissions, both from direct and indirect electricity production is summarized in the following table 18 which shows that emissions from indirect electricity consumption are increasing and emissions from electricity production in Delhi are decreasing.

Table 18: Emission (Direct & Indirect) from coal used in Thermal Power Plants for electricity consumption used in Delhi

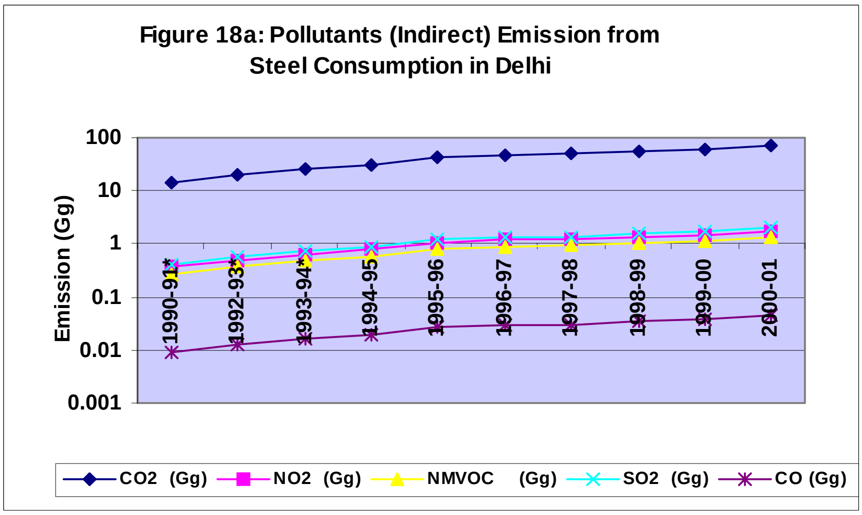
	Direct Emission (Kg)					Indirect Emission (Gg)				
Year	CO2(Gg)	SO2	NO	SPM	Cs	CO2	SO2	NO	Cs	SPM
1994-95						7333.87	45.9293	57.0412	0.4445	16.297
1995-96	5392.9	13.7144	17.0324	4.8664	0.13272	8402.83	52.6238	65.3553	0.5093	18.673
1996-97	3946.1	12.5612	15.6002	4.4572	0.12156	9231.55	57.8138	71.801	0.5595	20.515
1997-98	5167.2	12.3938	15.3923	4.3978	0.11994	10665.2	66.7921	82.9515	0.6464	23.7
1998-99	4544.5	11.5568	14.3528	4.1008	0.11184	11302.4	70.783	87.9079	0.685	25.117
1999-00	5119.9	13.02	16.17	4.62	0.126					

The coal consumption in thermal power plants has decreased as now most of them are operated by natural Gas or electricity purchased from the national grid. Direct CO_2 emission has reduced from 4,814.43 Gg in 1995-96 to 4,570.67 Gg in 1999-00 while indirect CO_2 emission has increased from 7,333.87 Gg in 1994-95 to 1,1302.44 Gg in 1998-99, SO_2 emission from 45.92Gg in 1994-95 to 70.78 Gg in 1998-99, NO emission from 57.04 Gg in 1994-95 to 67.90 Gg in 1998-99, Cs (soot carbon) emission from 0.44 Gg in 1994-95 to 0.68 Gg in 1998-99, SPM emission from 16.29 Gg in 1994-95 to 25.11 Gg in 1998-99.

Emissions from Industry Sector

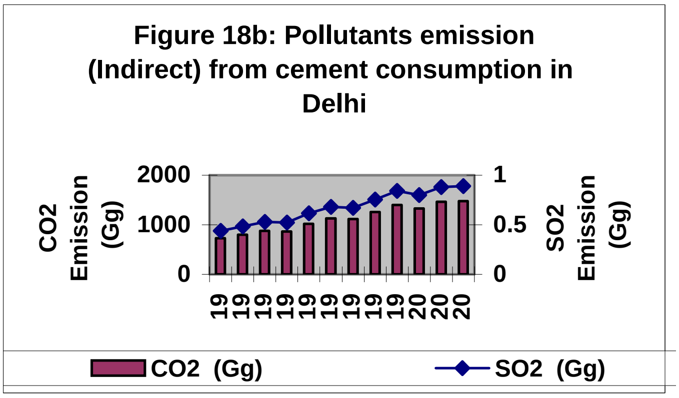
The major industries has been shifted to nearby places to improve air quality of Delhi but increasing urbanization has resulted in increased consumption of the building construction materials mainly cement & steel which have been accounted for their emissions as embodied sources. The emission estimates are given in following figures 18a and 18b for steel and cement consumptions in Delhi:

Figure 18a: Pollutants (indirect) Emission from Steel Consumption in Delhi



The indirect emission of CO_2 & SO_2 from cement consumption from year 1993-94 to 2002-2003 has increased from 877.36 Gg to 1,480.54 Gg & 0.528 Gg to 0.891 Gg respectively. It has been estimated that NO_2 emitted from steel consumption is 0.78 Gg in 1994-95 and 1.76 Gg in 2000-01, NMVOC 0.58 Gg in 1994-95 and 1.32 Gg in 2000-01, SO_2 0.87 Gg in 1994-95 and 1.98 Gg in 2000-01, CO 0.019 Gg in 1994-95 and 0.044 Gg in 2000-01.

Figure 18b: Pollutants (indirect) Emission from Steel Consumption in Delhi



Emission from Agriculture sector

Agriculture sector is an important sector for methane emission into the atmosphere. In India, the CO_2 equivalent emissions from agriculture & waste sector are 34% and 7% respectively. The agriculture sector includes emissions from paddy fields, animals, burning of agriculture residues etc. Rapid urbanization and the growth of trade and industry have reduced the significance of the agriculture sector in Delhi. Agriculture and allied activities contributed about 1.71% to the Gross State Domestic Product of Delhi at current prices (1998-99). The share of agriculture and allied activities has declined sharply from 4% in 1993-94 to 1.71% in 1998-99 (Source: Delhi Govt. Portal). Only 2.61% of the total work force in Delhi was engaged in agriculture and allied activities in 1991. This is in sharp contrast to the rest of the Indian economy where more than 60% of the total work force is engaged in agriculture and related activities. Agricultural activities contribute directly to the emission of GHGs through different process – for example:

- CH_4 emission from domestic livestock (enteric fermentation)
- CH_4 emission from rice cultivation
- N_2O emissions from agricultural soils

Ruminant animals are the major source of methane emission and in the context of cities like Delhi, contribute significantly as embodied source because most of the milk is produced outside the city areas. The total livestock (Dairy & non dairy) population in Delhi is used to calculate direct methane emission from this sector. Indirect emission is calculated on the basis of milk consumed in the city supplied from surrounding towns & cities.

Anaerobic process of rice-cultivated fields is the major source of methane emission, for direct emission, cultivated area with in the city is used.

CH_4 emissions from enteric fermentation in domestic livestock

Methane is produced in herbivores as a by-product of enteric fermentation, a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules for absorption into the bloodstream. Both ruminant animals (e.g., cattle, sheep) and some non-ruminant animals (e.g., pigs, horses) produce CH4, although ruminants are the largest source since they are able to digest cellulose, a type of carbohydrate, due to the presence of specific microorganisms in their digestive tracts. The amount of CH_4 that is released depends on the type, age, and weight of the animal, the quality and quantity of the feed, and the energy expenditure of the animal.

The direct and indirect methane emission estimates are shown in following figures 19a and 19b. It is clearly evident that embodied methane emission has the major share in this category compared to direct emissions. The indirect emission of CH_4 from livestock population from year 1996-97 to 1999-00 has increased from 85.04 to 101.86 Gg.

Figure 19a: Direct CH4 emission from livestock population in Delhi

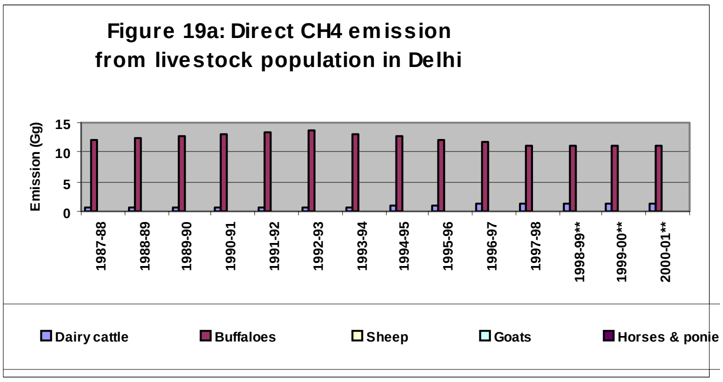
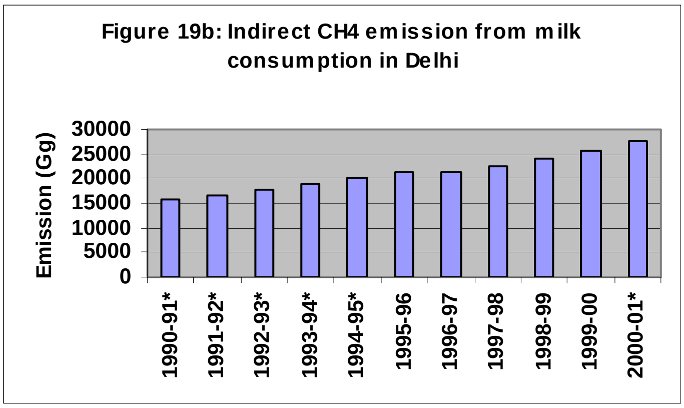


Figure 19b: Direct CH4 emission from milk consumption in Delhi

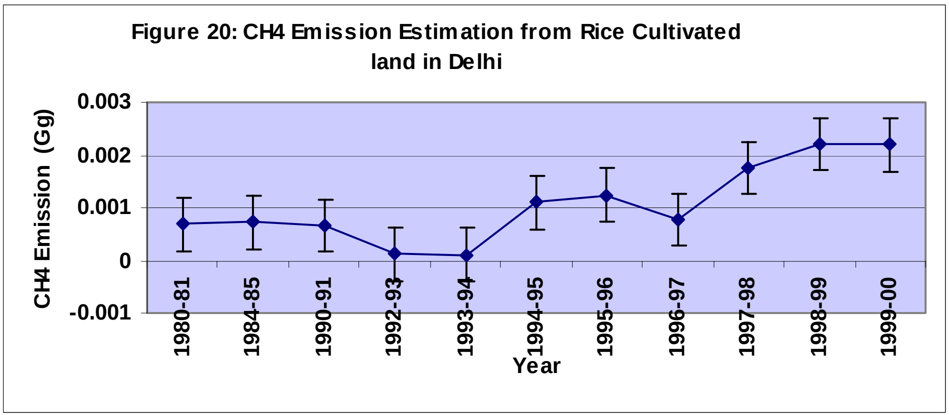


CH_4 emissions from rice cultivation

Anaerobic decomposition of organic materials in flooded rice fields produces methane, which escapes to the atmosphere primarily by transport through rice plants. The amount emitted is believed to be a function of rice species, number and duration of harvests, soil type and temperature, irrigation practices, and fertilizer use. The seasonally integrated CH_4 flux depends upon the input of organic carbon, water regimes, time and duration of drainage, soil type etc.

However since there is very little land available for rice cultivation in Delhi, the direct emissions from this source (see following figure 20) is very low.

Figure 20: CH4 Emission Estimation from Rice Cultivation land in Delhi



N_2O emissions from agricultural soils

Emissions of N2O from agricultural soils are primarily due to the microbial processes of nitrification and denitrification in the soil. Primarily the N2O emissions take place from agricultural fields due to application of nitrogenous fertilizers. The amount of nitrogenous fertilizers consumed in Delhi is given in table 19:

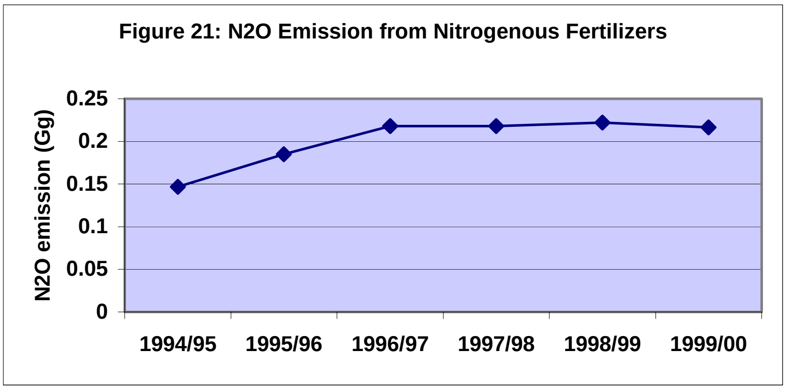
Table 19: Consumption of fertilizers in Delhi (Metric tonnes)

A-Fertilizer (Metric tons)	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00
Nitrogenous	13039	16420	19347	19370	19742	19219
Phosphatic	1703	2238	4287	4207	1349	4835
Potassic	24	16	68	184	361	281
Total	14766	18674	23702	23761	15452	24335
Sludge manure	14830	13278	10302	6618	4607	-

Source: Delhi Statistical Hand Book - 2000, Dte. of Eco. and Stat., Govt. of NCT of Delhi.

Using these statistics, N_2O emissions estimated are given in figure 21:

Figure 21: N2O Emission from Nitrogenous Fertilizer



Emission from land use & forestry sector

The area covered by forests in Delhi was 10,528 hectares at the end of March 2001. This is 7.14% of Delhi's total area of 147,488 hectares. According to the latest report of Forest Survey of India, released in 2000, the forest cover of Delhi has increased from 26 km^2 in 1997 to 88 km^2 in 2000, to maintain the ecological balance and check environmental pollution, the development plans of Delhi have given high priority to afforestation programmes.

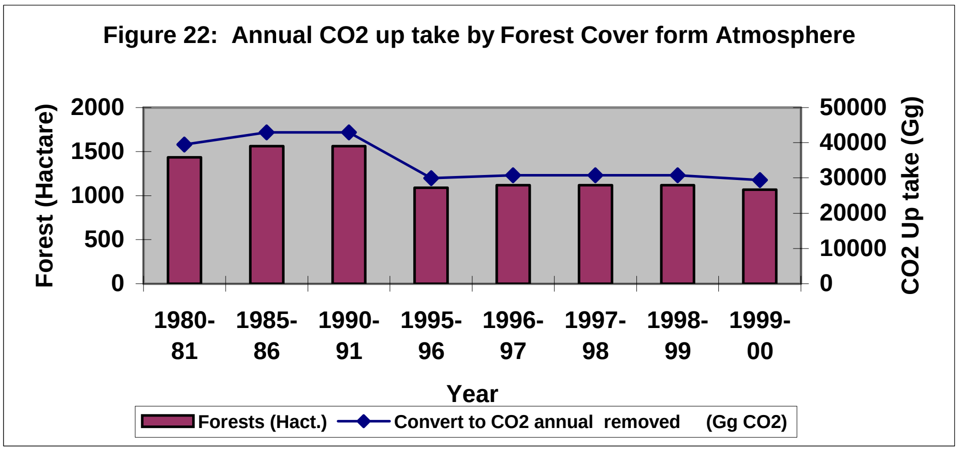
As per village records, the total cropped area was 60,885 hectares (41.28%) in 1999-2000. The remainder was being used either for non-agricultural purposes or remained as forest, fallow land, uncultivable land, etc. The total cropped area has decreased from 62,966 hectares in 1995-96 to 48,917 hectares in 1996-97. However, total cropped area has increased to 60,885 hectares in 1999-2000 showing a growth of 24.46% as compared to 1996-97 area. In percentage terms, the total cropped area, which was 42.69% of the total available area in 1995-96, dropped to 31.17% in 1996-97 and reached 41.28% in 1999-2000.

The details of the forest cover, plantation and distribution of trees for the period 1980-81 to 1999-2000 are given in table 20 and the corresponding CO_2 removal is shown in figure 22.

Table 20: Land use pattern in Delhi

Land use pattern (Area in Hect.)	1980-81	1985-86	1990-91	1995-96	1996-97	1996-97	1997-98	1998-99	1999-00
Total Area available as per village record	147488	147488	147488	147488	147488	147488	147488	147488	147488
Forests	1434	1562	1561	1089	1119	1119	1119	1119	1078
Area not available for cultivation	52077	71330	71842	82994	83482	83482	72994	72994	72994
Other uncultivated land excluding fallow land	2719	5456	12864	8190	11317	11317	10720	10720	10720
Fallow-land	32707	12816	12864	8200	10995	10995	7346	7428	7428
Net area sown	58551	56324	48357	45356	40575	40575	41701	41495	41385
Total cropped area	87599	81377	76239	62966	48917	48917	57079	60231	60885
Source: Delhi Statistical Hand Book - 1998, Dte. of Eco. and Stat., Govt. of NCT of Delhi.									

Figure 22: Annual CO2 uptake by Forest Cover from Atmosphere

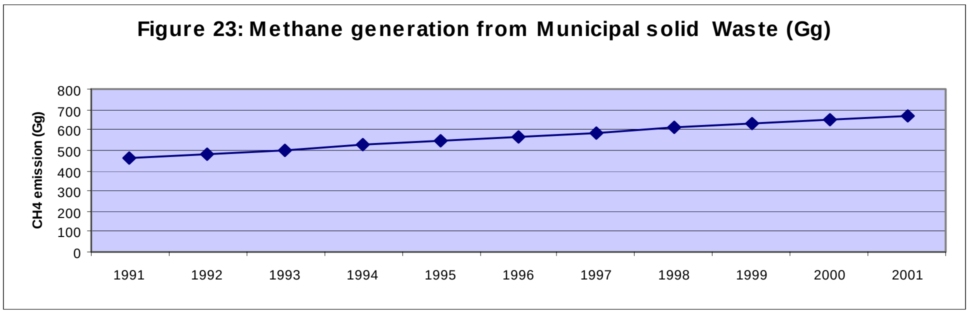


Emission from waste sector

The carbon dumped in to the landfills is potential source of methane emission into the atmosphere. Over 80% of the total municipal solid wastes (MSW) collected from the urban centers of the world are dumped either in the landfills or in open dumps. However in India, it is estimated that more than 90% of the MSW is disposed off on the land without taking any specific precautions. The deposited waste is rarely covered & compacted and the depth is generally less than five meters. The organic content & the moisture are higher in Indian MSW as compared to the developed countries and the higher atmospheric temperature result in higher degradation. Therefore, anaerobic conditions develop in the lower layer of landfills in spite of the absence of soil cover & lesser depths.

Based on all these facts and using IPCC default emission factors, the methane emissions from MSW in Delhi has been estimated which is given in following figure 23.

Figure 23: Methane generation from Municipal Solid Waste (Gg)

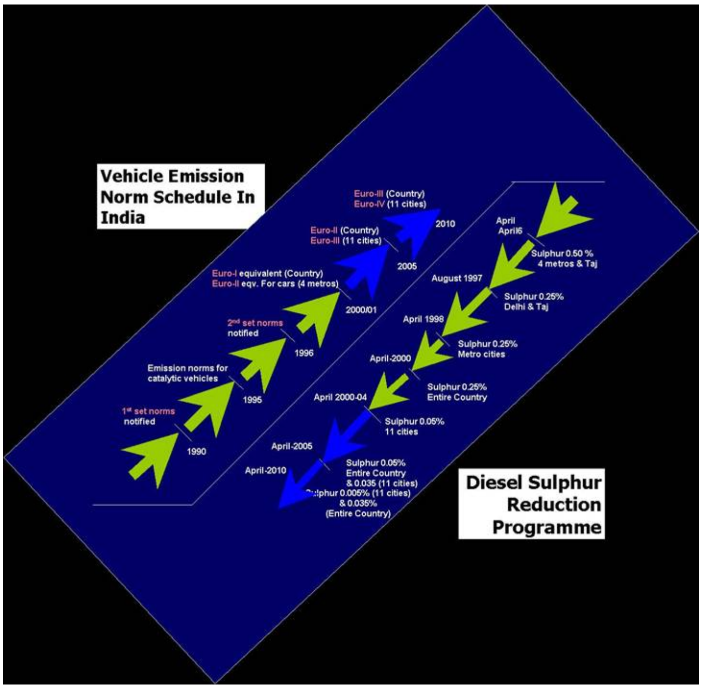


Transport sector in Delhi – focus for policy interventions and their impacts

The transport is the key sector responsible for emissions of a significant amount of pollutants as we have seen in our previous discussions. The total pollutant loading from vehicles in Delhi has been estimated to be 70%. The denigrated ambient air quality in Delhi had attracted attentions of all the stake holders and as a consequence, several policy interventions have now been implemented in Delhi's transport sector which are now being followed in other cities also. For example road maps[61] for tightening of vehicle emission norms (from first notification of norms in 1990 to implementation of Euro-II norms in 2001), sulfur reduction in diesel from 0.5% to 0.05% during 1997-2001 period), lead phase out in gasoline (complete elimination of leaded petrol by 2000 from entire country) and gasoline benzene reduction (from no norm in 1996 to 1% in 2000 for Delhi) being successfully implemented in India are shown in figure 24:

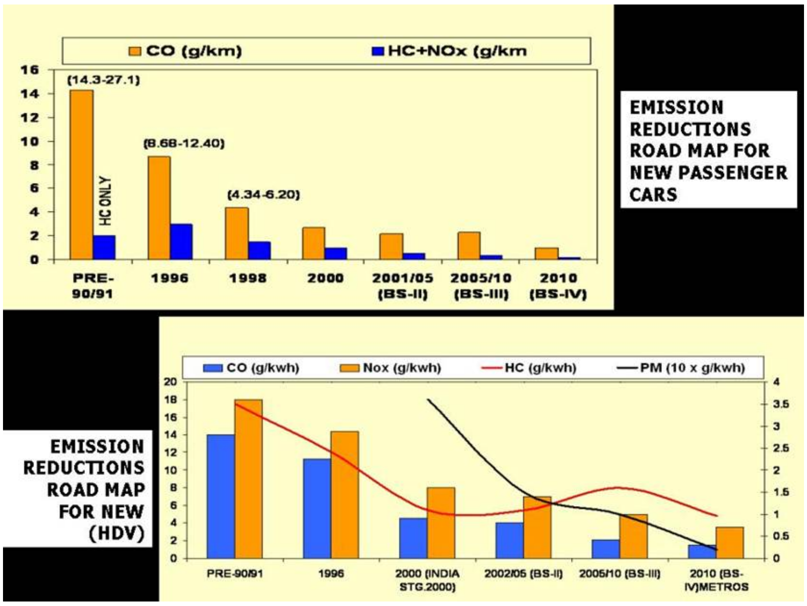
[61] Central Pollution Control Board, Presentation at Better Air Quality 2004 (BAQ 2004) Workshop held at Agra, India

Figure 24: Policy interventions in transport sector



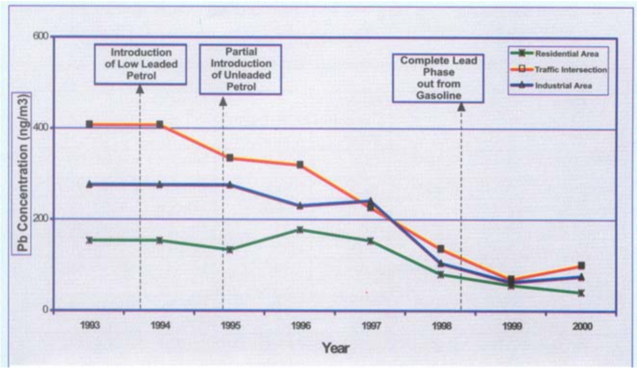
The road maps for emission reduction from cars and heavy-duty vehicles are shown below (figure 25):

Figure 25: Road maps for Emission Reduction from cars and heavy duty Vehicles



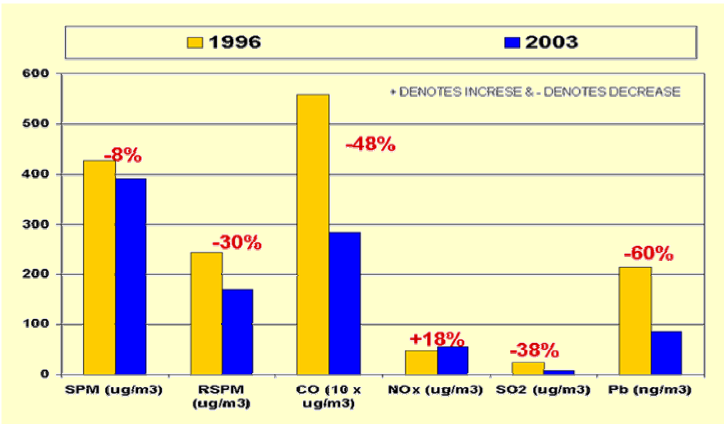
These steps have already shown results as evident from the reduction of lead content in Delhi's ambient air (Figure 26):

Figure 26: Reduction in Ambient Lead Concentrations in Delhi as a result of introduction of unleaded gasoline



The overall impacts of these policy measures in Delhi's environment is also positive as reflected by the general reduction in most of the pollutant's concentrations as observed in 2003 compared to 1996 (figure 27).

Figure 27: Impacts of policy interventions in Delhi's ambient air quality in 2003 compared to 1996



CNG introduction in transport sector

To improve the air quality status in Delhi, the Supreme Court of India on July 28, 1998 directed that all public transport vehicles comprising of taxi, three wheeler & buses in Delhi to run on Compressed Natural Gas (CNG) after April 2001. This program has been successfully implemented. Table 21 shows the estimates of CO_2 emissions from CNG consumption.

Table 21: CNG consumption & corresponding CO_2 emission estimates

Year	CNG consumption 000,ton/year	CO2 Emission (Gg CO2)
1999-00	3.0295	8.142414
2000-01	17.52	47.08866
2001-02	97.455	261.9307
2002-03	206.59	555.2538
2003-04	277.4	745.5705

The CNG consumption is increasing in Delhi. In 1999-00, it was 3.03 thousand tons which increased to 277 thousand tons in 2003-04 and correspondingly, CO_2 emission also increased from 8.14 Gg to 745.57 Gg during the 1999-00 to 2003-04 period.

13.8 Policy Interventions and decrabonization pathways

The phenomenal surge of Delhi's physical growth and the under-development of its surrounding areas is primarily a problem of relationship rather than a problem of scarcity7. For example, the total journey time from Delhi to the farthest towns in the region is so short that no big center of transportation and trading activities has developed in the outer ring of the National Capital Region (NCR). The entire region outside the Delhi Metropolitan Area is thus registering a relatively slow growth rate leading to lopsided development of the region characterized by the 'Metropolis-Satellite' syndrome, where part of the economic surplus of the periphery is extracted by the core and whatever development takes place in the periphery, mostly reflects the expanding needs of the core. Under this phenomenon, the region, rather than adding or accelerating its growth went on supporting the growth prosperity of Delhi thus setting an uneven system tied up in a chain of 'Center-periphery' relationship. This relationship helped to raise the income levels in Delhi. Delhi with per capita income of Rs. 19,779 at current prices (1995-96), as compared to all India per capita income of Rs. 9,321, has the distinction of having the highest per capita income in the country. Thus, ample job opportunities coupled with higher wages and earnings provide enough opportunities for the people to migrate to Delhi.
The urban layout plan of Delhi has been based on rings and radial roads systems which encouraged road transport; Delhi’s transport sector with one of the largest fleet of vehicles in India is the major contributor of pollutants in Delhi amounting to about 70% (remaining 20% is emitted from industries with major share from thermal power plants and the remaining 10% from other sources). Due to this reason, Delhi has been subjected to a number of policy interventions especially in the transport sector. Some of them were the results of pressure built up by NGOs and general public and ordered by the Supreme Court of India while others are government’s own initiatives as part of its development policies, which often paralyzed by delays due to considerations of “vote banks” and lobby groups.

However since the plan process began in Delhi in 1961, the town planners have been trying to develop the city into a more sustainable living area to cope with the constraints of limited available land for urbanization in Delhi. In recent years, and especially in the draft master plan for Delhi for 2021, more thrust has been put on the development of an ‘eco-friendly world class urban city’. At present Delhi is growing as an ‘urban continuum’ with seamless boundaries in the NCR region amalgamating surrounding townships. The plan process has identified the following strategies which might also result in decarbonization of urbanization as a co-benefit –

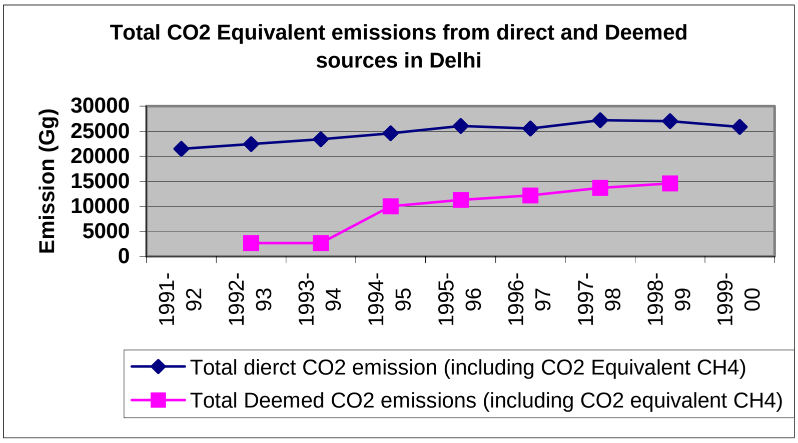
1. Development of counter magnet townships in the NCR region to dampen the in-migration in the core area of NCR (Figure-2).
2. Incentives in terms of better livelihood and urban space for out-migration in the NCR region for decongestion

However, as the planners have acknowledged that the master plans so far have not been able to keep pace with the unprecedented urbanization, the envisaged goals have not been able to be met so far. The growth of urbanization in Delhi has shown contrasting features – in the initial days, it was a compact, high-density township where working places and residential areas coexisted and thus required very little energy for transportation. But in the colonial period, the development of a ‘garden city’ with large vistas, separate office and residential complexes and satellite townships for service providers necessitated more consumption of energy in terms of transportation which gradually changed from non-fossil fuel to fossil fuel based systems resulting in Delhi becoming one of the cities with the world’s worst ambient air quality. The deterioration in ambient air quality was further compounded by the absence of an adequate mass transport system in Delhi. In recent years, the government has initiated an ambitious program to put in place a Mass Rapid Transport System (MRTS-Metro rail) to develop synergy between work and residence (termed as development of synergy between transport and urban development in the Draft Master Plan Document of Delhi for 2021). There is also a shift in the transport planning to attract personal vehicle owners to use mass transport systems through a mix of incentive and disincentive measures. This would also lead to reduction of carbon intensities of Delhi’s urbanization.

Another important aspect of current planning process of Delhi revolving around the implementation of Metro rail installation is the plans for re-densification /intensification and redevelopment along the MRTS corridors, so that the synergy between work and residences and, generally, between transportation and urban development could be achieved. This has a potential to greatly reduce vehicle emissions and thus reduce carbon emissions as well as have high energy efficiency because of higher density and use of common resources.

The estimation of direct and deemed CO_2 emissions including CO_2 equivalent CH_4 from Delhi shows interesting trends during the last decade. While direct emissions show a gradual increase over the last decade with a slight reduction in recent years, the deemed emissions show a sudden jump in emissions around 1994 (Figure 28) which is also the time when the Indian economy started witnessing the results of open economic policies introduced around that time. This sudden increase is probably due to increased consumption of energy; however, the causes for this feature are presently still being investigated.

Figure 28: Direct and Deemed Total CO2 Emission



14.0 Appendix 8: Preliminary synthesis paper

Integrating carbon management into urban development in Asia: a preliminary synthesis

By Antonio Contreras, Ooi Giok-Ling, Louis Lebel

14.1 Introduction

The way urbanization and urban transformations unfolds over the next few decades in Asia will have profound implications for emissions and sustainability (Global Carbon Project 2003.; McGranahan & Satterthwaite 2003). Understanding the trajectory of the process of urbanisation and the implications of urban transformation will provide the information needed to incorporate carbon management into urban development pathways. The current state of affairs in cities of the Asia-Pacific region gives little indication that the present level of emissions or sustainability are likely to have a major impact on policy decisions or the development trajectory of cities unless more research information or data can be brought into consideration by policy decision-makers at both the urban and national levels. The Asia-Pacific region contains at least nine of the world's fifteen cities with the highest levels of particulate air pollution. Five of the world's ten most polluted cities are in China with its overwhelming reliance on coal. Among these cities are the major metropolises of Beijing, Shanghai and Guangzhou.

The challenge to maintain urban air quality with continuing economic growth while also minimizing emissions disruptive to regional air-sheds and the global climate-atmosphere system will increase and so will demand for effective actions (Betsil 2001). Finding pathways of transformation for regions and urban areas that are less carbon-intensive would therefore be highly desirable, especially, if they can still deliver social development gains and aspirations of the developing world. Understanding of such pathways in developing regions may also provide insights to mature industrial economies about how to de-carbonize their patterns of consumption while maintaining a high quality of life. Value and culture changes are likely to be part of any such transitions and therefore also need to be confronted and understood (Lebel 2004b).

There is an urgent need to question the inevitability of the development pathway that is characterised by higher emissions levels with growing urbanisation and also higher incomes in societies of the Asia-Pacific countries. Certainly this is the pathway highlighted in the five case-studies – Metro-Manila, New Delhi, Ho Chi Minh City, Jakarta and Chiangmai.

Although geographical regions with largest emissions, typically industrial corridors and mega-cities, are clearly important and increasingly targeted for research and policy, the more numerous smaller, but rapidly growing emissions sources, are also likely to be ultimately important for effective action.

The goal of this paper is to explore how carbon management—a carbon's eye view of development—can be integrated into development strategies of cities. The primary analyses and most illustrations are drawn from our understanding of how urbanization has unfolded in the regions around the five cities in Asia mentioned above. In some places, however, we also draw on the detailed studies, especially of mega-cities in the wider Asia-Pacific region (Dhakal 2004; Marcotullio 2003; Xuemei Bai & Imura 2000).

For this study carbon stocks and fluxes include carbon dioxide (CO_2), methane (CH_4) and black carbon. CO_2 and CH_4 are two of the most important greenhouse gases. Black carbon, on the other hand, is one of the classes of aerosols that impact radiative balances, and therefore influence climate. It refers to the various carbonaceous end products (chars, charcoals and soots) of the incomplete combustion of fossil fuel and biomass. Aside from climatic influences, black carbon is a major health concern in most cities in the Asia-Pacific region.

Most research on greenhouse gas emissions have focussed on improving inventories, both from combustion of fossil fuels, cement production and land-use and land–cover changes. The emphasis within those studies that consider development policy implications has usually been on considering incentives for alternative technologies, energy sources, and land management.

This study, however, differs from most others in that it places a strong emphasis on integrating understanding of behavioural, cultural and institutional issues with the conventional emphasis on inventorying and modelling greenhouse gases and atmospheric pollutants. Our reasoning is that a more socially and politically nuanced understanding of underlying causes and constraints on responses will provide greater policy relevance to biophysical and technologically oriented research on emissions and the carbon cycle.

This paper is organized as follows. First the carbon consequences of the different pathways for urban growth are described. Second, we review past efforts to reduce carbon emissions and some potential new initiatives that could be consider. Finally, we address some of the main social justice and governance implications of efforts to manage carbon at various scales.

14.2 Carbon consequences and challenges

What is urban?

While there has been some understanding of the measures in use for defining the urban, no universal definition exists because urban boundaries are always subject to local definitions and negotiations (Lebel 2004a). Typically, however, the idea of urban brings with it a set of expectations about the population sizes and concentration, relatively higher availability of services and infrastructure, greater range and perhaps also regulation of economic activities, higher costs of land, and denser human settlements of people whose dominant livelihood is in industry or service sectors. Urbanization results from intrinsic population growth, migration adding population to existing urban areas, and human settlements reaching a certain threshold size or density after which they are formally recognized as urban by their national governments.

If there is less agreement about what urban is, there appears to be far more consensus in assessing urbanisation levels as the proportion of national and global populations which are living in urban areas. Urbanization however, is clearly both a social and ecological process (Alberti et al. 2003; Collins et al. 2000; Machlis et al. 1997). What is less clear-cut is the relationship that links the social and the ecological in the urban transformation that is unfolding through much of the developing countries of the Asia-Pacific. Urban social-ecological systems link diverse people, through their consumption and production activities, with different sub-sets of ecosystem goods and services (Lebel 2004a). Moreover, urban areas also create multiple opportunities for new relations among people and firms to develop that may help stimulate technical and institutional innovations. It is however, necessary to understand whether such innovations occur if the opportunities are created. If they do not, then clearly the need arises to also establish what have been the factors preventing such innovations.

At the same time, the high density of activities means that relatively modest individual emissions can in their aggregate more easily exceed thresholds of local ecosystems to assimilate pollution or levels risky for human health and comfort. Scale-dependent effects and interactions in ecosystems are also present in governance and market arrangements making long-term trajectories for urbanizing regions inherently unpredictable even where the legacy of major infrastructure may remain imprinted in the evolution of urban form for decades or more (Lebel 2004a). The implication of all these considerations is that urbanization is often not going to proceed as planned if there is indeed any planning done, and is difficult to manage in a strict engineering sense. Furthermore, the planning process differs greatly among cultures and cities.

It should not be assumed that the planning approaches or the areal units and sectors involved are uniform across cultures and cities.

The concern here in this paper may be less with what urban is and more with the aspects of changes which urbanization have implied for the Asia-Pacific region in terms of development, space and society. There are administrative, as in political (fiscal, budgetary, regulatory) definitions of the urban as well as economic and cultural. Such definitions can be highly dynamic subject always to debates about the meaning of the rural-urban dichotomy that still exists in reality in the region (UN-ESCAP 2000).

The United Nations suggests that 80% of the population growth in the next few decades will be urban rather than rural. In the Southeast Asian region, this is clearly manifested in the manner the proportion of the population residing in urban areas have grown from 17.6% to 35.5% between 1960 and 2000. This is projected to increase to 50.6% in 2020 (United Nations 1990). Apart from the growth in the population living in urban areas, other trends that have contributed to urbanization in Southeast Asia include the integration of the region into the global economy. This has led to rapid industrialization and the restructuring of economies with a major impact on urbanization (Ooi 2000; Ooi 1995).

In addition, there has been the rise of what researchers have labeled as mega-urban regions or the extended metropolis beyond the primate city boundaries (Ginsburg et al 1991). Jakarta and Metro-Manila, which are two of the case studies that have been conducted, represent such mega-urban regions or metropolitan regions. Jakarta effectively encompasses the neighbouring cities of Bogor, Tangerang and Bekasi. Urban growth has exploded along the major highways constructed to connect different parts of the city region. At a different scale, such ribbon development has been progressing along the highway connecting Chiangmai to neighbouring Lamphun.

Within cities, there has been the growth of incomes and the rise of a middle class that has effectively stimulated new urban developments and the mega-urban projects that have characterized urban growth in the 1990s (Benton 2000; Ooi 2000). State actors have been as important as speculative capital in driving real estate development and large infrastructural projects in the cities of the Asia-Pacific.

The case studies of Manila, Jakarta, New Delhi, Ho Chi Minh City and Chiangmai provide a range of the examples of urban development patterns as well as the rate and nature of the urbanization process in the Asia-Pacific region. Concentration of urban growth in capital cities since the colonial period has resulted in the dominance of the primate cities in many countries in the Southeast Asian region. Manila and Ho Chi Minh City would be examples of such Southeast Asian primate cities. Urban development pathways would have diverged in the post-independence period because of the differences in development ideologies and hence, the urbanization agenda in the respective countries of the Philippines and Vietnam. In the latter, there was actually a process of de-urbanization during the 1970s and early 1980s (Forbes and Thrift 1982), due in large part to the control of the process of rural-urban migration.

On the other hand, integration into the global economy starting in the 1970s but escalating towards the late 1980s and 1990s for much of Southeast Asia's market economies has led to rapid industrialization. Such industrialization has seen the establishment of industrial estates and export processing zones that were developed outside many of the largest cities. New patterns of labor force formation have been seen with growing numbers of women drawn to work in semi-conductor factories and such assembly line activities.

Mega cities like Manila, Jakarta and New Delhi, which have populations of 8 million and higher, like the rapidly growing cities in the region, have seen burgeoning population growth fuelled by poverty in the rural areas and the expectations of employment with better wages in the cities.

Increasingly national and international trade and other banking, financial transactions as well as services have been channeled via these cities. Urban expansion has been explosive, covering entire corridors that link a few cities. In Malaysia, the entire corridor extending from the former capital city of Kuala Lumpur to the port city of Port Klang is now an urban conurbation. The Metro-Manila region is another example of the development of such mega-urban regions.

Urbanisation is likely however to be most rapid in medium-sized and smaller cities in the region. Chiangmai and Ho Chi Minh City are case studies of such cities. Yet if these two cities can be grouped together as medium-sized urban areas, it is evident that their development pathways diverge to a large extent. This means that the development agendas of both cities need not be the same in terms of the trajectory driving urbanisation in their respective countries. An example is the rapid proliferation of settlements along ecologically the most vulnerable places in Ho Chi Minh like the canals and riverbanks compared to the urban sprawl that appears to be at the centre of much of the ecological issues facing Chiangmai.

Rapid economic growth

The pathway for economic development provides a historical context for urbanization in Asia. In earlier periods of nationalist development, the policy of import-substitution industrialization has led to the concentration of industries in capital cities. Policies of economic protectionism can enhance the initial urbanization phases, as in the case of Manila, as it centralizes the location of industry in more urban centers during periods of rapid economic growth. However, the urban growth of cities declined during the onset of urban diseconomies manifested in increasing congestion, increasing value of land, and pollution. This halted the economic growth of original urban centers and caused the relocation and expansion of industry outside its perimeters.

The succeeding periods of export-oriented economies has created a new set of urban industrial centers, mainly located in former rural peripheries. Economic liberalization also greatly influenced the present spatial structures of cities. The globalization of production, mainly through the operation of transnational corporations (TNC's), deepened the integration of a country to the world economy. Capital cities and other rising urban centers are now less attractive for primary industries due to rising land rents, enabling the development of commercial and financial capital that serves as the entry point for global commerce and finance capital to come in. Industrial dispersion, whether induced by government policy or by sheer market forces, taking advantage of technological innovations, has allowed the spatial separation of the production process and has enabled TNC's to locate their production units in industrial enclaves in the fringes of the metropolis. This allowed the metropolitan core to retain its commercial nature, where trading in goods and services is the core economic activity, even as industries are relocated to the urbanizing peripheries. This is what has been described by Reyes (1998) as a process of tertiary urbanization, where previously non-metropolitan areas are spatially integrated in the metropolitan region, with no accompanying shift in the sectoral and occupational structure of the regional economy. Although there was a shift to the non-agricultural employment, labor shift was not from primary to secondary but to tertiary services, particularly the service sector.

Most of the five cities studied are parts of the spectrum that inhabit this pathway. Manila, Jakarta and Delhi have seen the expansion of their metropolitan spaces from capital cities to become an urban sprawl with a core city that is now basically a commercial and service center, with industrial corridors radiating outwards into the periphery that has become a part of the larger urban space. Ho Chi Minh is becoming both an industry and trade center. As a former capital of South Vietnam, it has seen an industrial pathway where it served as core. Its trajectory of following the Jakarta, Manila and Delhi pathways was interrupted when the South was reintegrated into the North. At present, the policy of economic reforms, and the increasing integration of the Vietnamese economy in the global economic order, may become drivers that would eventually transform Ho Chi Minh to take a path very much like that taken by Manila and Delhi.

Of the five cities studied, it is only Chiang Mai, being a regional city that is a remote periphery to Bangkok, which may see a different trajectory, where the industrial phase may not be seen as a precursor to the service and commercial phases. Instead, these could, simultaneously, lead to an urban sprawl that is similar to other bigger cities with a service and commercial oriented core and an industrial periphery.

In terms of carbon consequences, while urban growth based on the service sector may not produce carbon emissions in the same levels as when it is based on industry, this may only be true in the core metropolitan areas that are formerly the home for these industries prior to their relocation to the periphery. Such emissions are now “exported” or “relocated” to these new industrial enclaves, now popularly called as export processing zones. In fact, there is even evidence that attempts to change the location of industries in Metro Manila, through the establishment of industrial estates and export processing zones outside the metropolis, had little impact on energy consumption and use (Pernia and Israel, 1984)

However, a different driver for carbon emissions that is not determined by the presence of industry also exists. We refer to the effects of urban sprawl and automobile-dependency.

Urban sprawl and automobile-dependency

Residential decentralization is an attendant process when urban areas expand outwards, and where inner core cities have declining population densities. The growth of suburbs in the metropolitan fringes and the adjacent provinces is foreseen as the reaction of the growing middle class to high land values, traffic congestion and overcrowding in the metropolitan core. This expansion of urban areas directly affects transport activity in the metropolis by increasing the distance traveled from the residence to the workplace, and that required for hauling goods and services.

Even without suburban growth, rapidly urbanizing areas are always associated with increased vehicle density. These are discussed in the case studies particularly those on Chiang Mai, Metro-Manila, Jakarta and Ho Chi Minh City. The problem of road congestion in these cities as well as in Delhi suggests that emissions based on energy consumption remains a growing urban problem. City authorities fail to consider the problem that has long been recognised in the difficulty of keeping road construction at a fast enough pace to match the growth in the number of vehicles in cities (Ooi and Kwok 1997).

Furthermore, the construction of road infrastructure has generated further opportunities for sprawl development along the major highways. Since the late 1940s, Jakarta for example, has been growing southwards as well as east and westwards. Land has been developed for urban uses – housing, services, universities, commercial complexes and of course, highways – in relatively disparate and uncoordinated ways largely because of a lack of transparent guidelines concerning land use development goals in relation to expanding urban needs. Such efficiency in coordination of land use development decisions need to be seen far more within the urban areas as well as between the urban and national governments.

Demographic transitions

Demographic transition is a process that is attendant to the urbanization process in the Asia-Pacific region or Southeast Asia. This is because the demographic transition refers to fertility decline in urbanised and urbanising societies, such as what happened to Chiang Mai, as well as the ageing of the population that is happening very rapidly in Japan, Singapore and advanced industrialized societies like those of Europe. Natural increase in population declines in its contribution to population growth in cities and the growth of urban populations tend to be proportionately more a consequence of in-migration, either rural-urban or even as a result of regional and international migration of labour.

In-migration will therefore remain important in most large cities because of the job opportunities that will be available or at least more likely to develop compared to jobs in rural areas. This introduces the dimension of the rural-urban linkages (travel, remittances of cash and goods, seasonal employment patterns) that are addressed in the mega-urban development that has been highlighted in the discussion above.

The population of the Chiang Mai – Lamphun urbanizing region has progressed overall at a steady rate just below 1% per annum for several decades despite a very sharp fertility decline. By the mid-80's fertility had reached below replacement levels in northern region of Thailand. This has profound implications for demographic change, with sharp rise in median ages, family structures and dependencies, and combined with rural-to-urban migration and death from AIDS the prospects of significant collapse of many rural communities. These profound over-arching demographic changes help shape and bound transformations of housing stocks, patterns of land inheritance and car ownership. Urban growth in the Chiang Mai case study is not predominantly a demographic phenomenon. Over the past two decades this growth is expressed more sharply by the massive increase in infrastructure, in particular, roads, housing estates and commercial land-use, beyond the historical compact old city areas that greatly exceeds changes in residential populations. Rural-to-urban commuting, seasonal migration in construction and service sectors, and the consistently large number of tourists also shape the size of the effective consuming population of Chiang Mai.

For its part, the contribution of migration, as a demographic force, to urban growth, has declined in Manila due to urban diseconomies. For example, the percent contribution of migrants to the total population of Metro Manila appear to be declining, from 18.2% in the period 1975-1980, to 11.5% percent in 1985-1990. However, this could not be said of Delhi, where migration remains a significant factor in population dynamics. Nevertheless, change in population density is not uniform all over Delhi, where some parts are experiencing significant increases, even as these large increases are not seen in other parts.

The incidence of poverty may not necessarily be increasing during urbanization. For example, Pernia and Quising (2003) estimated the poverty incidence in Metro Manila in 2000, based on headcount ratio, at 5.6%, which was much lower than the national estimate of 27.3%. Metro Manila continues to have the highest income per capita, valued in 2000 at PHP 29,577 (in constant prices). Other demographic indicators in the economy, such as expenditure per capita of the poorest quintile (PHP 29,577), functional literacy (>90%), cohort survival rate for secondary education (75.6%), and life expectancy at birth (70.1 years) are similarly the best for Metro Manila and more economically advanced regions of the country (Pernia and Quising, 2003).

For its part, Delhi's socio-economic profile remains relatively "better" than the rest of India. The per-capita income in Delhi is relatively higher than the average for India. In 1993-94, while the incidence of poverty in all of India was 35.87%, it was only 14.69% in Delhi. In 1999-2000, the figure for Delhi was 8.23% while that of India was 26.1. These figures appear to support the trend in the Philippines, where poverty in urban areas is lower. However, a desegregation of

Delhi's figure to its rural and urban parts points to a different picture, where relatively rural portions of Delhi have lower incidences of poverty than urban portions, even as the reverse is true for all of India. This unique trend requires further investigation, as the case study did not provide in-depth analysis of the figures. However, what this simply implies is that the relationship between poverty and urbanization is a complex process that could not be easily generalized.

However, despite this, it is easy to generalize that population growth remains a problem in urban areas, considering that it remains as a driver for consumption not only of commodities, but also of energy. Nevertheless, while it is also easy to assume that more people would lead to more carbon emissions from energy consumption and industrial production, an equally important parameter would be to consider the lifestyles and livelihoods of such population.

Transforming lifestyle and livelihoods

It is an urbanizing world and we need to shift cities to more sustainable development pathways than they have taken. In the Asia-Pacific region, urban expansion has led to peri-urbanization. Examples abound in China where in cities like Beijing, households have settled in areas outside of the city because they are not allowed to live in the city. These are households that have urban livelihoods in the construction sector as well as small and medium-sized industries that have thrived because of MNCs and TNCs that have established themselves in the largest cities. A major aspect of the extended metropolitan region that has developed in the Asia-Pacific countries has been the employment of women and such rural people in contract work for global firms located in cities that are hundreds of kilometers away from where these people are living. The growth of the urban agglomerations or conurbations we are seeing throughout the Asia-Pacific region has been the increasing proportion of people who live in surrounding rural areas or smaller towns who commute to work in the mega-cities or larger urban centers.

The central issue in urbanization is whether as a process it actually contributes to reductions in energy and material use. There are many reasons to expect that a household getting wealthier but remaining in a rural setting will use more resources than one which has moved or been transformed into an urban one because of greater access to public transport, shorter commuting distances to regularly used services, and smaller more compact settlements and thus social relations. On the other hand, the shift to an urban context also transforms lifestyles and patterns of consumption. Invariably wealth and disposable incomes also changes, and not always upwards either. There is surprisingly little direct data about such transitions in developing country contexts. This clearly should be a focus of future research.

Qualitatively, however, the Chiang Mai case study suggests that urbanization in at least this setting is "incomplete" in comparison to what might be observed in Asian mega-cities or industrialized economies. In many households, the landscape and social organization straddle urban-rural linkages that defy attempts at simplistic boundary setting in space or classification of households or people. A portfolio-style of logic is needed to understand changes in livelihoods and perhaps, also lifestyles as even these may shift seasonally and vary among individuals in the same household.

Income is likely to be strongly associated with direct and deemed emissions. Our interest here is to what extent differences at particular income levels associated with lifestyle are present and whether policies around carbon management could foster less carbon-intensive lifestyles. Again no numbers, but transport modes, vehicle choices and use and housing size and design are likely to be good indicators.

14.3 City and regional initiatives

What has been tried?

The case-studies strongly suggest that the national governments of the countries in which the cities – Metro-Manila, Jakarta, Delhi, Chiang Mai and Ho Chi Minh City – are located, have since the 1990s, set up either the institutional resources or the frameworks for effort to reduce carbon emissions. Institutional support for carbon emissions reduction appears to be strong in the Philippines. Legislation has been introduced in support of clean air initiatives. Several public sector agencies have been specifically assigned the tasks of improving air quality, transport as well as the quality of fuels being used. Initiatives have been extended to energy consumption with the public sector taking the lead at promoting energy efficiency. Incentives have been worked out for the market sector involving schemes for technology transfers to achieve energy savings.

The help of international agencies like World Bank has been secured for the improvement of urban transport infrastructure particularly in Metro-Manila. A major initiative is to shift the mode of transport for urban commuters to rail as well as public transport. This is also the plan for the surrounding area of Metro-Manila up to 100 kilometers outside the metropolitan region.

Delhi, too, appears to have been incrementally working towards carbon emissions reduction particularly through the transport sector. There has been a shift to CNG as well as unleaded petroleum through legislation and promotion by the public sector. Such shifts have involved both public sector and private business vehicles. While the case-study focuses on other economic sectors – industry and agriculture – there was less attention paid to measures being undertaken, at least in declaration, for carbon emissions reduction in these other sectors.

Ho Chi Minh City's effort at carbon reductions emissions appears to be concentrated on the improvement of air quality. There are also emissions standards set for vehicles but so far, motorcycles have not been included in the checks that are conducted before licenses are renewed. The case study has not discussed the legislation that has been introduced or initiatives that have been introduced for carbon emissions reduction or at least effort that will contribute to such reduction.

Several internationally funded projects appeared to be aimed at infrastructure improvement in Ho Chi Minh City for transport as well as sewerage and drainage. The information is not provided which would link some of these projects to a citywide effort at de-carbonization or carbon emissions reduction.

If institutional development and resources appear to have gone the furthest in Metro-Manila, clearly there already exists some framework for monitoring emissions in the cities under review. Such monitoring also allows trends to be studied that link population and economic growth to emissions over time. There are however, issues that need to be addressed in the agendas for carbon emissions reductions in the cities being studied.

Why most efforts have been ineffective

The case-study reports emphasise the inevitability of the trends that have parallelled growing levels of urbanisation. With more economic activities concentrated in the cities and population growth, there has been ever increasing use of energy resources and rising consumption as well as carbon emission levels. Economic growth and urbanisation have been associated with high carbon development pathways.

Carbon management appears to be one of the least pressing among the many issues being addressed by national initiatives aimed at the reduction of greenhouse gas emissions and even then, it is more apparent in the Philippines rather than India or Vietnam, judging from the case studies that have been conducted. Yet the initiative does not highlight carbon reduction or de-carbonisation targets that have been reached through a process of negotiation and consensus building. Neither is there a clearly mapped out path to low carbon development pathways in any of the cities or their respective countries. Without such a vision for de-carbonisation or the setting of targets with different stakeholders, it is not surprising that the Manila case-study report highlighted the low level of awareness of carbon emissions issues in urban development among NGOs and even the state sector.

National level initiatives have to be translated to the urban or metropolitan as well as local neighborhood scales. This appears to pose a major challenge to cities including those being studied. Such scaling down of the effort at carbon emissions reduction is clearly needed in the case of Metro-Manila since the `air shed' being discussed encompasses several jurisdictions or administrative areas including municipalities and provincial authorities. There is a major concern that the local governments might not be in a position to carry out the tasks required of them if there is no support from provincial or the national state sectors.

The issues of scaling the effort that is to be mounted to address carbon emissions reduction parallel those concerning the coordination of the work being done by different agencies. This appears to be important for Metro-Manila where several national as well as metropolitan agencies – environment, agriculture and forestry, transport and energy – have been given the tasks of addressing the different problems related to air pollution and carbon emissions.   In Ho Chi Minh City, the issue appears to be more basic. There has to be clear assignment of responsibilities for different agencies that are to address the problems of carbon emissions reduction. Then coordination has to be achieved among these varying agencies working on the targets set. This coordination should extend to the information that is available in the public domain. Ideally, for greater participation by civil society and the market sectors as well as different agencies in the government sector, there should be more information. In addition, effective communication of goals and indicators that are tracked by the relevant agencies should be present.

The case study of Delhi highlights the lack of assessment of the progress being made by initiatives such as, the use of unleaded petrol as well as the shift to CNG vehicles. The indicators show relatively little change in emissions trends. Indeed, in Metro-Manila, there is concern about the enforcement of legislation that has been introduced. Evidently, such enforcement has to be achieved before assessment can be done which will meaningfully establish the contributions of different initiatives that have been introduced. There should also be greater clarification about the agencies that would be responsible for monitoring the progress being made.

The case can be made for cities to set down in the public domain a carbon management plan which can be shared by all sectors and interested parties. Lack of awareness was discussed in the case study on Metro-Manila. So much of the effort required for an effective carbon emissions reduction agenda is predicated on the behaviour of consumers and producers, there needs to be more public declaration of goals and more effective communications of the plans and programmes to achieve them so that they are shared as widely as possible.

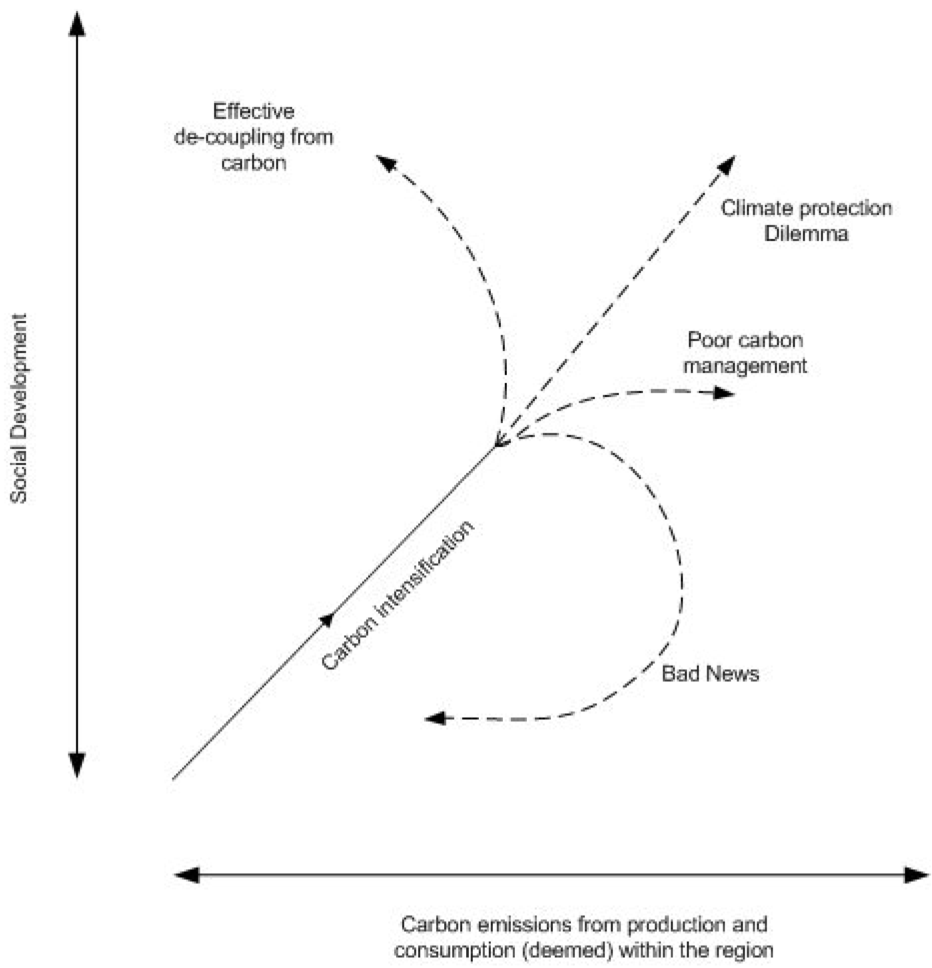
It is also here that active civil society participation has to be fostered. Civil society actors can become conduits for the development of a carbon constituency, which can be used to provide not only support mechanisms for policy initiatives, but also as venues to articulate demands and pressures for city and national governments to act. This, however, is predicated on a strong information dissemination campaign that will "popularize" the carbon discourse, something that remains a challenge in all the cities studied.

What are the prospects?

The emissions from production and consumption activities in an urbanizing region invariably increase during period of initial rapid economic growth, but with time opportunities arise for de-carbonization of both production and consumption activities. Considering both perspectives is important otherwise you can end up with clean cities with huge deemed emissions or “industrial nightmares” around which only the poor live.

Ultimately, however, the goal should be to decouple growth in carbon emissions from continued improvements in social development (Figure 14.1). The dilemma is that with current styles of urban growth and development these are often highly correlated. As shown in the diagram, increasing intensification with declines in social development would be bad and rather than continue likely lead to a breakdown scenario and lower emissions (*BadNews*).

Figure 14.1: Different pathways for de-coupling carbon emissions from social development.



There are certain prospective trends that may prove beneficial for carbon governance. For example, global fuel price hikes and risks to supply may provide an early impetus towards renewable energy sources and demand growth management that would be carbon-beneficial. Furthermore, faced with dwindling supply of resources, human creativity may yet evolve new ways of production and consumption that are less energy consuming and carbon emitting. The increasing globalization not only of institutions but also of cultures and lifestyles may bring a broadening of these consumer patterns that forces production systems to be less carbon consuming.

The case-study reports highlight a different trajectory in New Delhi compared to Metro-Manila, Ho Chi Minh City and Chiang Mai as well as Jakarta. In New Delhi, the impetus for the policies to introduce unleaded petrol and the shift to CNG vehicles were mandated by judiciary. These policies were initiated in response to air pollution problems and the heath-related issues. Air quality may well provide similar impetus for policy shifts in the other cities under review.

Potential strategies available to each of the cities for incorporating carbon management into their future development are not the same (Table 14.2) in part because of differences in key contextual factors (Table 14.3)

Table 14.2: Key strategies for incorporating carbon management into development strategy of the case study city regions. Five point scale of increasing importance: O o . + # with parenthesis () indicating already achieved. Scoring is tentative and needs confirmation/assessment by case studies.

	New Delhi	Ho Chi Minh City	Manila	Jakarta	Chiang Mai	Singapore
1. Reduce auto-dependency with public commuter rail system	+	+	+	+	#	(#)
2. Shape form of new urban areas with pre-laid commuter rail and road-based public transport system	+	-	+	+	#	(#)
3. Increase contribution of renewable energy in power supply by encouraging off-grid and independent production	+	+	.	+	.	O
4. Create secure nodes and corridors for non-motorized transport with good links to public transport infrastructure	+	+	-	-	+	(+)
5. Recycle and capture energy from waste incinerators	.	.	.	.	.	.
6. Decentralize but maintain standard of key services (e.g. schools, health, market areas) and make access convenient locally by non-motorized or via public transport system	+	+	+	+	+	.
7. Progressive taxes on luxury c-intensive products and services into air quality management fund	+	+	.	.	.	(+)
8. Enhance carbon stocks green	(+)	+	.	.	+	(.)

spaces in and around urban areas with large long-life trees that also provide climate control, protection of non-motorized corridors and quality recreation areas						
9. Enhance use of Information technologies to reduce inefficiency in transport logistics and enable flexible non-commuting employment	+	.	.	.	+	(+)
10. Demand increased technology transfers and financial support for adoption from cities in Annexe 1 to Annexe 2 countries	.	#	+	#	+	O

Table 14.3: Contextual factors important for de-carbonization pathways. An assessment of their importance in 5 case studies from this project and Singapore on a five point scale from being a barrier to an opportunity : O o . + #

	New Delhi	Ho Chi Minh	Manila	Jakarta	Chiang Mai	Singapore
Compactness of urban region	O	o	O	o	O	+
Degree of spatial segregation of wealthy and poor areas	.	.	o	o	o	+
Level of interest of urban civil society groups in environmental issues	+	o	#	.	.	.
Historical commitment to mass public transport systems	+	+	O	.	O	#
Demographic trends (fertility rate and migration)	o	.	O	o	+	+
Inter-city competitiveness for investments in industry or services	+	o	o	.	o	+

The abovementioned strategies cannot be taken in isolation in a uni-dimensional effort to address the shortcomings of urban governments in opting for lower or carbon-free pathways to further urbanisation and urban growth. This would be the perpetuation of the model in use among the cities in addressing the need to manage the carbon outcomes of rapid economic growth and urbanisation. The bid to address air quality problems represents such a uni-dimensional model. A de-carbonisation pathway has to coordinate urban development strategies in a variety of directions beginning with land-use development focused on walking as a basic mode of connecting people in the city to the development of public transport services that have to be closely integrated with further land-use changes. Land-use development would have to consider sequestration of carbon in terms of the development of green spaces or `lungs' that also emphasise the need for a coordinated framework for determining policies governing such land-use decisions.

Social justice and strategy

Social justice could imply a range of different developmental goals for cities. It could be defined in terms of social equity, that is, what benefits would urbanization and rapid industrialization be bringing to cities in globalizing economies. It could also be represented as public participation and highly inclusive forms of governance. Civil society or even just single-interest neighborhood associations can and have stopped the construction of incinerators from Tokyo to Metro-Manila, but what has civil society done for the poor and poverty alleviation? Urbanization may have led to greater polarization in cities and societies because of the links with globalization so that notions of social justice would be far more complex than simply public participation or citizens' engagement with policy decision-making. Thus, social justice is not an either-or proposition, but must be seen as a state of existence where social equity is achieved through good governance characterized by transparency, accountability and participation. Some examples of specific questions that arise with carbon management are listed in Table 14.4.

Table 14.4: Some social justice and governance questions that arise in efforts to incorporate carbon management into development strategies of cities and urbanizing regions.

1. Have and would measures to reduce absolute emissions or rates of growth in emissions fall disproportionately on the poor? For example, would they keep the poor immobile, in high-density low quality environments, and with few employment options?

2. Does the pricing structure of new public transport systems encourage their use by the biggest polluters, or will they still use their cars? Does the system also provide low-cost and healthier alternative to motorcycles and diesel buses on congested streets for the poor?

3. Do current plans for carbon management imply a transfer of control over land-use and lifestyles to even more centralized authorities? Or, is the view that land-use plans should be more locally negotiated within a framework of environmental standards and mechanisms for appeal and conflict resolution at higher levels?

4. Who should pay for the de-carbonization of rapidly urbanizing regions in the world? If it is to be in part a cost borne by the annexe 1 countries which have already caused the most damage to the climate system then what financial institutional mechanisms are needed that would fairly support urban-oriented strategies?

Improving urban governance

The case studies provide details of key aspects of urban management that need to be strengthened. In Ho Chi Minh City and Metro-Manila, these concern land-use allocation and the greening of urban spaces including the conservation of mangrove areas in the former. For Metro-Manila, the case study has highlighted initiatives that can be introduced to improve the vegetation cover within the city and in its surrounding region.

Urban pollution can only be solved if there is greater coordination of urban transport policies and land-use development. Most cities find the integration of both these developments a major challenge. The proposal for more pedestrian-oriented land-use development or even those that are bicycle-friendly requires such close integration between land-use and transport.

There has to be greater accountability and transparency by government agencies and private sector businesses for energy consumption as well as the technology that is in place in support of the effort to reduce carbon emissions as well as conserve energy. The Metro-Manila case study has rightly observed that so far the effort in the energy sector has been concerned with the supply of energy rather than emissions or conservation as well as the switch to renewable energy sources. There is also a need for a more participatory approach not only in the formulation of policy but also in the generation of knowledge about carbon and cities.

Implications for civil society

The complexity of the interaction between political and economic institutions in the context of urbanization is defined through the articulation of capitalist modes of production with the political agenda of social integration. This has been observed in all cities studied, even in Ho Chi Minh, where the existing political system, while remaining socialist, has opened up spaces for capitalist enterprise, albeit structured as state endeavors. Government structures in these urban areas studied perform both the function of supporting urban economic processes and of promoting the political integration of classes and groups that comprise the urban population.

In this complex setting, there is a need to deploy mechanisms that build social capital, collective consciousness, and a sense of community that can negate the emergence of a legitimacy crisis that comes naturally with increasingly complex institutions. These mechanisms include those that rely on the legitimate power of the state to consolidate society, through the deployment of policies. This modality is predominant in all the case studies. On the other hand, there are also mechanisms that rest on harnessing civil society institutions to influence the policy system, through the demands and supports apparatus of the policy process.

Here, it is apparent that there is no strong deliberate attempt to tap the participation of organized civil society in carbon management. The discourse about the technological options and innovations available remain largely a state domain, although it should be pointed out that in Metro-Manila, and in the Philippines as a whole, civil society participation has been institutionalized. This is something that is not apparent in the case studies done in Delhi and Ho Chi Minh.

The other dimension of civil society participation is in the link between policy and research, as well as in the potential role of the media and educational institutions as knowledge production centers. It is again apparent from the case studies that this is a relatively untapped element in urban carbon governance, even as there are already indications of the involvement of scientists in the generation of policy relevant knowledge. What is still in question is how robust are the "local epistemic communities", that is, how strong are their linkages to national and city policy processes, and how effective are they in influencing policy decisions and outcomes. It is in the Philippines that civil society mobilization was able to influence the direction of policy, particularly in the legislation of the Clean Air act, where NGO activity was able to cause the banning of incinerators, even as it is not entirely clear how much of this activism was informed by scientific knowledge. What is not apparent from the Delhi case study is how much of the decision of shift to CNG was due to civil society pressures, and how much of this was influenced by scientific information. The same could be said in the adoption of the policy of urban greening mentioned in the Ho Chi Minh case study.

The other element of good governance is transparency and accountability. Here, there is a challenge to surface from the case studies the role of civil society actors—through pressure groups, consumer groups and environmental advocates, in the monitoring of the implementation of the different policy initiatives, as well as in holding government and business actors accountable for their actions. This is yet to be made visible, even in the case of Metro-Manila, where serious questions of implementation cast a doubt on what could otherwise be seen as a relatively well-developed and carbon-management conducive policy environment.

Strategic regional and international relations

Cities, while not necessarily capturing the totality of representation for a state or society's identity, remain not only as seats of political and economic power, but also as windows to regional and international alliances. The key question that is relevant in the context of carbon management and urban governance is how cities and countries can position themselves, and what tools are available at their disposal, to bargain for investments and privileges that would be beneficial not only in carbon terms, but in the pursuance of social justice.

Key to this is the building of alliances not only among countries, but also between and among cities and urban centers not only within countries, but also across countries within regions and around the world. This will necessitate not only the development of formal Track 1 processes where state and city governments interact through diplomatic channels. Even within Track 1, there is the challenge to go beyond diplomacy as mainly a tool for national governments as a whole. There must be efforts to scale this down to sub-country levels, such as cities. In fact, the adoption of sister-city modes is the beginning of this type of relationships. Exchange of information, trade missions, and cross-learning tours for city officials could become the starting point to build alliances along specific issues that are related to carbon management. On a larger scale, the development of global institutions that would provide venues for the interaction among urban centers, perhaps under the auspices of the UN, to discuss urban issues is a desirable modality. One can only imagine the enormous opportunity for a U.N. sponsored Conference on Urbanization.

Beyond Track 1, the involvement of epistemic communities through informal Track 2 approaches can bring opportunities for the knowledge communities, such as those from where most of the audience of this paper belong, to influence inter-city relationships, both within and across countries. Finally, civil society interactions, through people-to-people exchanges in the business and civil society communities in the context of a Track 3 approach, could also provide more venues to make cities "talk" to each other in the context of common issues.

The goal here is to build a Carbon constituency in various levels that involves cities and urban areas. However, in all of these Tracks, the key element will always be correct information translated in forms that could be understood and appreciated.

14.4 Conclusions

Pathways and Carbon Consequences

Economic growth in many of the countries of the Asia-Pacific region is concentrated in the largest cities. Cities like Bangkok and Metro-Manila generate about one half to a third of their countries' GDP handle most of the imports and have the giant share of the countries' industrial establishments. Generally, in the Asia-Pacific region, economic growth and rising affluence have been paralleled by urbanization. The richer countries have therefore been urbanizing more rapidly than the poorer ones. Among cities in the respective Asia-Pacific countries, however, the development is far more complex with the largest cities experience stagnating or declining populations while the medium-sized cities have been growing rapidly (Hardoy and Satterthwaite 1995).

The 5 case studies illustrate development pathways that look relatively similar to those in advanced industrialized countries from the point of energy consumption and carbon emissions. Urban growth has implied `sprawl' and unplanned expansion of urban land-uses. There has been little success with integrating such growth and land-use changes with transport services.

Data indicate that developing nations like the Philippines are replicating the development paths pursued by OECD nations in terms of their energy and mineral demands (Clark, 1993). Several factors may have an impact on and hence, retard the development of this pathway; these include declining rates of economic and population growth, conservation, substitution, increased efficiency of energy use and alternative development paths. However, Clark (1993) grimly points out that these factors mainly extend the time frame of energy and mineral consumption and development, and will not decrease total demands in the nations of Southeast Asia over the long term. For many developing countries GHG mitigation has a negative connotation because of the perception that this will deny them their opportunities for growth and hence, the means to organize human services and economic activities.

If cities like Metro-Manila and New Delhi have been discussing the feasibility of city-wide public transit systems like trains, the smaller urban areas of Ho Chi Minh City and Chiangmai appear to be only working on regulatory frameworks for air pollution control and the means for enforcing them. There also appears to have been greater concern about `cleaner' energy in New Delhi with the introduction of CNG and renewable energy resources in Metro-Manila. There is also concern about the kinds of fuel used for domestic purposes like cooking or heating which are important particularly among the poor households in the cities of the Asia-Pacific.

Similarly, land-use changes like forest clearance in the surroundings of Metro-Manila appear to have been addressed at least through the introduction of legislation. Implementation is likely to prove far more challenging as seen in the case study of Ho Chi Minh City that highlights the importance of re-introducing and converging natural vegetation areas in the city. Similarly, legislative and other measures have not been apparent in Chiangmai and there is relatively little discussion of the importance of tree cover in the case of New Delhi either.

Hence, the urban development pathways seen in the four case-studies suggest are characterized by those that have driven urbanization in wealthier and more developed countries – carbon bound and energy-intensive growth. While key areas have been identified for greater attention in urban policy agendas, it is equally clear that coordination will pose a major challenge not only among the local authorities but also among these and the national government agencies.

De-carbonization

The agendas that need to be put in place by cities to seriously address the issue of reduction of carbon emissions suggest a series of important dimensions that have to be considered. These include the coordination of different ministries managing different aspects of urban policies – energy, transport, industry and land-use development; behavioural change among consumers regarding transport; market sector contributions in energy conservation through production processes; and reviews of programmes and policies that have been implemented in order to understand their impact and further effectiveness. In other words, there is a need to go through a policy cycle in order to understand the performance of initiatives vis-à-vis the targets that have been incorporated on carbon emissions and their reduction by city governments.

The five case studies have shown that there is prospect in accelerating de-carbonization through explicitly incorporating carbon management into development strategies, planning and governance of cities and urbanizing regions. A major initiative is in the transport and energy sector, where there is a shift towards mass transit, as well as to cleaner fuel. Emission standards have also been set.

However, there is a challenge to translate national level initiatives to the urban or metropolitan as well as local neighborhood scales. There is a major concern that the local governments might not be in a position to carry out the tasks required of them. The other challenge is in handling multiple actors. Here, problems of tasking and coordination becomes of primary concern. Also crucial is the manner information is made available in the public domain, as well as the participation of civil society and the private sector in the process. It is recognized that an effective carbon emissions reduction agenda is predicated on the behavior of consumers and producers. This would require transparency as well as effective communications of policies, plans and programs.

Aside from natural economic processes, such as declining prices of fuel, there is enormous potential for human creativity to evolve new ways of production and consumption that are less energy consuming and carbon emitting. The sustainability of these tapping of the human potential to innovate, explore, and exchange ideas for better carbon outcomes will depend not only on technical rigor, but on social justice considerations. As indicated above, social justice is not an either-or proposition, but must be seen as a state of existence where social equity is achieved through good governance characterized by transparency, accountability and participation. As pointed earlier, there has to be greater accountability and transparency by government agencies and private sector businesses for energy consumption as well as the technology that is in place in support of the effort to reduce carbon emissions as well as conserve energy.

What is apparent, however, is that there is no strong deliberate attempt to tap the participation of organized civil society in carbon management. The discourse about the technological options and innovations available remain largely a state domain. Furthermore, there is much to be desired in the manner that scientific knowledge is tapped, if at all, in the formulation of policies and in policy advocacy.

Finally, there is also the challenge of scaling up the process, by going beyond the city borders and to build alliances within and across countries, with the ultimate goal of establishing a carbon constituency.

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15.0 Appendix 9: U-TURN Research Protocol for Urban Carbon Studies

15.1 Pre-amble

The purpose of this research protocol is to outline a set of guidelines for case study contributions to a comparative study that aims to explore ways of integrating carbon management into the development strategies of cities. The idea for such a study was stimulated by discussions and the Science and Implementation Plan of the Global Carbon Project (2003). An initial network of case studies has developed in Asia with the help of funding from the Asia Pacific Network for Global Change Research (U-TURN or the Urban Transformation and Urbanisation Research Network *http://www.sea-user.org/carbon_management.php*). The aim, however, is eventually to stimulate a wider international comparison. One of the first steps of the network was to gain agreement on a shared research protocol. The first draft of these guidelines first emanated from the first meeting of the research on 25-27 September 2003 in Manila, The Philippines. Since then they have been revised and refined.

For this study carbon stocks and fluxes include carbon dioxide (CO_2), methane (CH_4) and black carbon. CO_2 and CH_4 are two of the most important greenhouse gases. Black carbon, on the other hand, is one of the classes of aerosols that impact radiative balances, and therefore influence climate. It refers to the various carbonaceous end products (chars, charcoals and soots) of the incomplete combustion of fossil fuel and biomass. Aside from climatic influences, black carbon is a major health concern in most cities in the Asia-Pacific region.

This research protocol, however, differs from most other initiatives in this field in that it places a strong emphasis on integrating understanding of behavioural, cultural and institutional issues with the conventional emphasis on inventorying and modelling greenhouse gases and atmospheric pollutants. Our reasoning is that a more socially and politically nuanced understanding of underlying causes and constraints on responses will provide greater policy relevance to biophysical and technologically oriented research on emissions and the carbon cycle. A set of shared research questions provide the first-level framework of our research protocol (Table 15.1).

Table 15.1: Research Themes and Questions.

Theme	Research Questions
Pathways	1. What have been the main pathways and processes by which urbanization has unfolded? 2. What are the likely consequences of these different pathways and processes for carbon stocks and fluxes? Are some less carbon-intensive than others? 3. What have been the main clusters of factors driving these changes and are these likely to continue into the future?
De-carbonization	1. What are prospects of accelerating decarbonization through explicitly incorporating carbon management into development strategies, planning and governance of cities and urbanizing regions? 2. How can the social context of cities that encourages innovation, exploration and exchanges of ideas be harnessed for better carbon outcomes? 3. What are the main institutional, cultural and social justice considerations that should be taken into account in national, regional or international efforts at decarbonization?

15.2 Theme 1: pathways of regional development

What have been the main pathways and processes by which urbanization has unfolded?

Identify key attributes of regional development. Describe changes in urban form, major infrastructure development, key technologies and life-style shifts (e.g. adoption of air-conditioning, personal motor vehicles) and demographic changes (e.g. fertility transitions and migration). Examine how land-uses within urban areas as well as surrounds have changed as a result of urbanisation.

Consider historical legacies. Are there any legacies in terms of infrastructure, urban form,culture, functional role in a regional economy or traditions in governance that have significantly constrained the pathways of development?

Construct a set of syndromes of urban development. Consider both environmentally positive and negative syndromes. Consider causal clusters producing these patterns.

What are the likely consequences of these different pathways and processes for carbon stocks and fluxes? Are some less carbon-intensive than others?

Characterize changes in carbon stocks, fluxes and key processes. At a minimum secure the 1980, 1990 and 2000 sectoral inventory of emissions and removals (industrial, transportation, electric utility, wastes, land-use changes) using IPCC data and other sources. Also consider longer-time series data where available. Consider importance of ecosystem feebacks.

Explore scenarios of future regional development. Explore consequences of plausible alternative futures for emissions from all sectors, and what it would take for these to unfold given knowledge of history of changes already taken place and measures taken to improve air quality and reduce emissions.

Classify urbanization pathways in terms of carbon consequences. Use insights from patterns and processes to generalize implications for carbon stocks and fluxes. Consider in terms of syndromes as well as in relation to key attributes.

What have been the main clusters of factors driving these changes and are these likely to continue into the future?

Identify major underlying clusters of processes and structures framing urban changes and responses. Make use of secondary data for basic proxy related to things like energy consumption and supportive land-use (e.g. footprint concepts). Extend these analyses to consider underlying values and belief systems and the role of research in changing perceptions of risk, quality of life and the desirability of alternatives.

Consider relationship of urbanizing region with wider regional and global economy. What is the role of the urban area in the national economy and how is this changing? To what extent are activities in this area helping drive, or indirectly responsible for, emissions in other areas? And vice-versa. What are the key trends underpinning city production and consumption patterns such as social, legal and physical infrastructures (e.g., industrialization, globalization, foreign debt, among others)?

Synthesise understanding about clusters of causal factors. Compare cities of different sizes, growing at different rates, and with different functional roles in wider networks of urban areas.

15.3 Theme 2: De-carbonization

What are prospects of accelerating decarbonization through explicitly incorporating carbon management into development strategies, planning and governance of cities and urbanizing regions?

Review urban and regional governance mechanisms. What is relationship to overall national development planning and policies? What avenues are there for public participation and debate around major policies and public infrastructure investments? Is there potential for creating a "constituency" around reducing carbon emissions?

Ascertain sources and levels of knowledge and awareness of air quality and greenhouse gas issues. What role does research within the knowledge system have in improving air quality, for example, to meet public health goals? Is the city part of the Cities for Climate Protection programme, and if so, what level of involvement and understanding of the issues is present?

Assess key capacities and barriers to alter incentive structures and regulations. Are bureaucratic and institutional structures likely to be able to accommodate incorporation of carbon management concerns? Are there any key incentive structures that contribute to level of emissions that are potentially changeable? What are the main regulatory mechanisms available?

Access to alternative and improved technologies. Energy resource options arising from location. Policies with respect to foreign direct investments, intellectual property rights, and scope for innovation.

Incorporating carbon management in a just way in different governance and knowledge contexts. Are the most suitable processes for considering incorporation of carbon management dependent on forms of governance? What does a comparison across case studies suggest about the importance of local versus generalized international knowledge? How does capacities and responsibilities of the state, private sector and civil society affect prospects?

How can the social context of cities that encourages innovation, exploration and exchanges of ideas be harnessed for better carbon outcomes?

Explore how social context influence research and technology options. Are there underlying norms and social context, for example, related to wars, economic booms and rapid urbanisation that either constrain or create new opportunities for technical innovations and their diffusion?

Characterise key Innovation and Knowledge-to-action systems. Are the scientific and technical parts of the private sector and public bureaucracy accessible to decision-makers? In the eyes of key stakeholders do they provide salient and credible information to support decision-making? How are competing interests, trade-offs and competition among knowledge promoters dealt with? Are the processes viewed as legitimate? Could they be harnessed for better outcomes?

Role of media. What role has the mass media played in information and knowledge sharing? How it altered the social context in which carbon-reducing innovations must succeed?

Compare impacts of social contexts on innovation. Consider broader social and cultural components of context as well as more conventional economic perspectives. Also consider "compatibility" issues with existing social norms and patterns of organization?

What are the main institutional, cultural and social justice considerations that should be taken into account in national, regional or international efforts at decarbonization?

> Decarbonization instruments. Which policies, behavioural changes and institutional mechanisms appear most promising for bring about decarbonization of development and what is the role of urbanisation in these? Who is promoting them and why? Is there any difference in interests between actors at different levels of governance? Who bears the costs?
>
> Social and environmental justice in carbon management. Determine the consequences of decarbonisation on different sectors such as urban and rural poor livelihood; impacts on the other basic urban necessities such as water and food. Are any of the policies being considered to incorporate carbon management into the development strategies of cities and urbanizing regions likely to increase the vulnerability of already disadvantaged groups? Can carbon management be used to improve well-being and livelihoods of the poorest in urban communities?
>
> Contrast powerful and weak cities in developing and develop regions. Where power is understood to be the degree to which a cities local government and citizens have control over their own development strategies. Consider justice and equity impacts within urbanizing region as well as between the focus region and larger scales.

15.4 Guide for the conduct of case studies

In general we think it is important not to be overly prescriptive in the way case studies are analyzed, because we believe there opportunities to use a wide variety of methods to probe the above set of questions. Here we offer some suggestions on setting boundaries.

Geographical Scope: Recognizing the economic influence and ecological footprints of cities, the case studies look at an urban region comprising the main city and its surround. Many cities have an extended influence over surrounding rural areas and hinterlands. The patterns of demographics, economic and ecological activities result to spatial configuration of an urban region with periodic urban concentrations and a semi-urban rural area. The project considers the peripheral areas with 10 to 50 per cent of urban land use as part of the urban region in defining the spatial boundary of the urban region, The area of the urban region considered in the research ranges from 500 to 5000 km^2 .

Pragmatic considerations of data availability by both administrative/political boundaries and present carbon outcomes accounting, however, may determine the actual spatial extent of the case study

Data quality: The data and information for the study will be primarily taken from secondary data which include, among others, published papers, reports, and government data. The selected “core” case studies will be supplemented and complemented with published cases, as well as on-going studies and some unpublished studies in the region. The variable quality, incompleteness and major uncertainties in biophysical and social datasets used in analyses should be acknowledged and taken into account when drawing conclusions.

Collaborative Process: As a collaborative endeavor, the project necessitates sharing of data, information, budget, and complimentary skills for the comparative case study analyses, as well as the conduct of each case study. Proper acknowledgment of one’s contribution (e.g., co-authorship of papers, and nice acknowledgment, among others) must be observed and upheld. A web community has been established to facilitate sharing of data and collaboration. In addition we are running an open web-conference in June-July 2004.