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Peri-urbanization, illegal settlements and environmental impact in Mexico City

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In 2005 Mexico City had just under 20 million inhabitants in the whole metropolitan area. Although over the last 20 years the city has registered a slower population growth, its urban area continues to expand. The particular problem with the expansion to the south is that urbanization is invading a so-called Preservation Zone (*Suelo de Conservacion*) that represents a territory subject to preservation given its ecological value in terms of climate regulation, water recharge, forest communities, agricultural cultivation, and hilly landscape. In this particular space, there is a process of diffused urbanization with very low densities in the Preservation Zone. In recent years it has been possible to identify a high number of illegal settlements of low income populations within its limits. This is a continuous, small-scale process, but in the medium and long term it means a significant loss of land with high ecological value. This process happens despite land use planning regulations being in existence since the late 1970s. From 1970 to 1995 just over 10 thousand hectares were lost including irrigation land and forest areas. The analysis includes, the dynamics and main patterns of urbanization in the Preservation Zone, the description of planning norms, and a precise measurement of illegal settlements. The paper concludes that this peri-urban process shows, a marked environmental damage, lack of effectiveness of planning norms and of increasing living standards of the poor, all of which show an ineffective urban governance, that does not contribute to sustainability in the Preservation Zone and in the city in general.

Keywords: Urban sustainability, environmental degradation, peripheral urbanization, Mexico City

Metropolitan peripheries and environmental impacts

Urban research from the last decade has put particular emphasis on the transformation of urban or metropolitan peripheries because it is in these spaces where the most dynamic changes are happening. Analysis of big cities shows that metropolitan expansion has a different dynamic to that of previous decades. In demographic terms, growth rates of big cities particularly in Latin America have decelerated in the last two decades. In economic terms, major economic concentration persists in the main metropolis, though there is a falling trend in manufacturing activity and a clear rise in the importance of the tertiary sector in the urban economy. In territorial terms, from a relatively compact space in previous years, at present there is a pattern of urban expansion with *dispersion* trends, either close to or more distant from the built-up area. This process progressively incorporates small towns and rural peripheries into a wider and more complex metropolitan system, with new municipalities constantly being integrated (Aguilar, 2002, pp. 122–123).

Cities have spread rapidly but not uniformly; urban expansion is not a consistent process in all directions

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beyond the built-up area. This differentiation is due to a range of factors: size and structure of the city, physical barriers like mountains; layout and orientation of the road network; land tenure systems; land values; land use in the immediate periphery, etc. Political-administrative limits also influence this process if there are two or more states involved. As a result, different types of transition zones between city and rural areas can be observed. For example, some areas show a highly uniform peri-urbanization with compact and extensive developments, other zones contain small urban patches with open spaces among them, and others constitute lines of development along corridors like roads or rivers. These areas vary in width and their rate of change depends on the social actors involved.

As a consequence of this dispersed urbanization occurring at the edge of the city, there is a formation of a wide rural–urban fringe with more and more diffuse limits between the urban and rural realities. A process of deconcentration of diverse activities of an urban character also takes place within this space. This process/space has been variously characterized and labeled in the literature: peri-urbanization, rural–urban interface, metropolitan periphery, rural–urban fringe. However as yet there is no universally accepted definition of this zone. Perhaps a more adequate position is to adopt an approach of an urban–rural *continuum*, given the difficulty of defining a boundary which changes constantly in a situation of accelerated expansion. It is more appropriate to examine the continuum between the poles of urban and rural, and understand the dynamics of change as they affect particular parts of the peri-urban zone, as well as shifts in the position of the zone as a whole (Simon et al., 2006, pp. 10–11). The rural–urban gradient may change over quite short periods of time, depending on the nature of pressures within the growing metropolis and of migration towards it.

It is important to consider the rural–urban fringe as an extension of the city, and not as an independent zone, because in reality it is integrated into the city in several ways, not only through the ecological footprint but also by economic and social processes that are present within this fringe; for example agricultural markets that provide urban populations or recreational landscapes for urban clienteles. In general terms, the debate in the 1990s about sustainable urbanization helped to concentrate attention on city impacts beyond its built-up limit. The term ecological footprint was introduced (see Rees, 1992) through which the city could be understood as a sustainable part of a wider ecological system. As is known, the concept refers to a great extent, but not only, to the impact of the city on a surrounding environment that depends on its ''carrying capacity''.[1] This environment, which to a great extent coincides with the rural–urban fringe, is the source of different elements for the city, and is also the city's disposal site. On the one hand, it supplies resources to the city, such as migrant population, construction materials, wood and other energy sources, and food and water. On the other hand, the city supplies its periphery with manufactured products, services, and all types of solid and liquid wastes (including toxic waste) that are disposed of in this area. Due to its spatial contiguity, the periphery experiences perhaps the more serious and negative impacts of this exchange.

A present development in the urban periphery tends to follow a pattern of low density, with polycentric islands, expanded fringes, and linear developments of higher densities (Aguilar, 2006, p. 7). Contrary to the model of the past decades, when the periphery was a space subordinated to the city, with poor accessibility, deficits in basic services, and lack of amenities, nowadays this space represents another type of city: it has another centrality, it has more provisions, and it represents totally a new form of city expansion.

With all the transformations in peripheral land uses, there are specific impacts on local productive activities, on people's way of life, on urban forms, and particularly on the local environment. Specifically in the case of environmental impacts, it is important to identify the main changes and process that characterize urban peripheral spaces in big cities. To this end, we can mention some important processes related to the environment (see Aguilar, 2006, p. 6; Douglas, 2006, p. 18): lack of support for agricultural activities combine with real estate pressure causes their decline and leads to urban occupations; promotion of a dispersed pattern of urban occupation for residential developments or big infrastructures; establishment of illegal settlements by poor groups, with precarious housing conditions and basic services; disposal of solid and toxic wastes; exploitation of construction materials; environmental stress on green and recreational areas; exploitation of superficial and underground water, and alteration of river courses; flooding and land sliding.

What needs to be identified in any city are those sectors and spaces where it is necessary to improve the environmental performance of urban growth, and how refers to what can be integrated with the socio-economic and political objectives of sustainable development. In other words, the right approach is not to focus on ''sustainable cities'' but rather on how urban consumers, firms, and local governments can *contribute* more to sustainable development (Satterthwaite, 1999, pp. 94–104). It is more important to try to evaluate the degree of sustainability and the ways in which the city experiences transformation; to know if there is a weakening or strengthening of urban sustainability. Since the term urban sustainability comprises four fundamental dimensions: economic, social, environmental and political, its discussion is *multidimensional* (McGranahn and Satterthwaithe, 2003). Therefore a state of urban sustainability is understood as one of the equilibrium among these four dimensions. The point then is to analyze to what extent there is an imbalance among these components in a particular place, and what areas are more neglected or are not making a contribution.

One of the most important, and perhaps most ignored, aspects in cities of developing countries is the need to build up an institutional structure that allows making

[1] At present, developments in the transport system introduced the possibility of dissociating the scale of renewable resource-use in cities from the productivity of its region; a big and prosperous city can draw its food and raw materials from a variety of countries, in this case what is the link between this consumption and its ecological consequences? (see McManus and Haughton, 2006).

progress towards sustainable urbanization. To a great extent the aggravation of urban problems such as precarious housing, lack of provision of basic services, urban violence, lack of application of land-use norms, or environmental damage emerges from the incapacity of local governments to manage the rapid urban growth, to provide the public goods for all social groups, and to show adequate political and technical capacity. But in the discussion about sustainable urban development not all the responsibility rests on the shoulders of the state, the actions of both the market and civil society (poor and rich peri-urban communities) are very important as elements/actors in urban and regional processes.

In order to take advantage of all the capacities in each city, good ''governance'' is required which can guarantee better social and economic performance and less environmental degradation. For a good urban governance,[2] neoliberal thinking and recommendations from international development banks lay great emphasis on the contribution to be made by: greater democracy and public participation; reduced centralization and dependence from the national state; and privatization. But in practice, this question is complicated because at present urban governance involves multiple stakeholders. A crucial question is, how governance is exercised? The choice of governance strategies influences who is likely to be included or excluded.

In fact, evidence indicates that urban territories are becoming more and more heterogeneous as a result of the growing social and economic differentiation of urban society; this social fragmentation is demonstrated by the growing socio-spatial inequalities in cities. But fragmentation is also reflected in the government structure with a greater number of local authorities and ad hoc bodies in metropolitan areas; and with the increase of NGOs. This in essence instead of promoting coordination, negotiation and building consensus, increases the fragmentation of the capacity of collective action, and sets a paradox for cities: in a globalization time when cities should act as collective units to confront competition, they are encountering increasing difficulties in mobilizing resources, which hampers their capacity to build the necessary coalitions of actors or structures of governance (United Nations Centre for Human Settlements, 1996, p. 59). A recent study for a Latin American city concludes that, there is no simple ''best practice'' for urban governance that can be used in other cities, current policy recommendations hold some promise but only when used in combination with others like: innovative ways to increase the city income, a degree of technocratic management, or taking measures not necessarily popular (Gilbert, 2006, pp. 414–415).

Despite the importance of all the environmental processes and impacts, little attention has been paid to peripheral spaces. Particularly, lacking is an approach to the periphery which would allow comprehensive analysis and policy elaboration. Such an approach would involve understanding the periphery as an integral part of the city, rather than examining it by fragments and thus inhibiting a comprehensive view. However we have to recognize that in practice there are several factors that bar a comprehensive approach of the periphery: (i) peri-urban spaces generally fall within different administrative jurisdictions each with variable financial and technical capacities; (ii) supply and maintenance of infrastructure and services are the responsibility of different agencies at local, state and federal level; (iii) very often statistical data do not cover the whole peripheral space, do not coincide with its boundaries, vary in quality, or have restricted access; (iv) in terms of ecological footprint, government officials tend to avoid the discussion of their responsibilities about the disposal of wastes and environmental damage downstream, so they avoid the city-region or peri-urbanization approach that considers a wider ecological system rather than merely the built-up or administrative area of individual cities; and (v) for local inhabitants the term of urban–rural fringe lacks meaning because their identity is deeply rooted to a single location and their interest is to preserve their place histories, traditions and identities (Simon et al., 2006, pp. 11–12).

In this fashion, in the study of urban sustainability we need more evidence about the main difficulties to implement this process; this paper intends to contribute in this area with particular data about a space environmentally important in Mexico City's periphery.

Recent trends in Mexico City's urban growth

Mexico City is the biggest city in the country and one of the largest megacities in the world. In 2005 its whole metropolitan zone registered 19.2 million inhabitants. The city has expanded over three different entities: the Federal District where it was founded originally; the State of Mexico, a neighboring entity that now contains a little more than 50% of the city's population; and a portion of the State of Hidalgo that recently has been incorporated into the metropolitan zone (see *Table 1*) (see Aguilar and Ward, 2003).

In general terms, demographic growth in this space over recent decades has been characterized by a diminishing growth rate. Before the 1970s, the city grew at an annual rate of 5%, but data show that in the period 1970–1990 the growth rate was 2.6%, and that in the following decade, the rate fell to 1.69%. In the last 5 years (2000–2005) data show that demographic growth maintains a slow pace, at a rate of 0.89%. However, it has to be emphasized that a great disparity in demographic growth exists within the different components of the metropolitan zone. On the one hand, the Federal District showed a growth rate of 0.44% in the period 1990–2000, and the central city, located within this entity, registered a rate of −1.31% in the same period, while on the other hand, the rest of the metropolitan periphery in the states of Mexico and Hidalgo had a growth rate of 2.9% for the same decade.

These data highlight several important processes: a slower population growth in the Federal District in

[2] A definition from United Nations for urban governance states that: ''Urban governance is the sum of the many ways individuals and institutions, public and private, plan and manage the common affairs of the city. It is a continuing process through which conflicting or diverse interests may be accommodated and cooperative action can be taken. It includes formal institutions as well as informal arrangements and the social capital of the citizens'' (UNDP, 1997, pp. 2–4).

Table 1 Population growth of Mexico City's metropolitan zone, 1970–2005

	1970	%	1990	%	2000	%	2005	%	Growth rate[c]		
									70–90	90–00	00–05
Country total	48,225,238		81,249,645		97,483,412		103,263,388		2.64	1.84	1.16
ZMCM[a]	9,281,907	19.25	15,563,795	19.16	18,396,677	18.87	19,231,829	18.62	2.62	1.69	0.89
Federal District	6,874,165	74.06	8,235,744	52.92	8,605,239	46.78	8,720,916	45.35	0.91	0.44	0.27
Central city	2,902,969	31.28	1,930,267	12.40	1,692,179	9.20	1,677,358	8.72	−2.02	−1.31	−0.18
Rest of Delegations	3,971,196	42.78	6,305,477	40.51	6,913,060	37.58	7,043,558	36.62	2.34	0.92	0.37
Metropolitan Periphery[b]	2,407,742	25.94	7,328,051	47.08	9,791,438	53.22	10,510,913	54.65	5.72	2.94	1.43

Source: Own calculations from the population census data 1970–2005 from INEGI.
[a]ZMCM, Mexico City's metropolitan zone.
[b]Municipalities of the States of Mexico and Hidalgo.
[c]Annual medium growth rate.

comparison with the other entities, and a transference of population from the former to the latter; an expulsion of population from the historical city; a higher growth of the Federal District periphery that doubles that of the whole entity; and an accelerated growth of the metropolitan periphery particularly in the states of Mexico and Hidalgo (see Aguilar, 2002, pp. 132–135).

The Preservation Zone in the Federal District: main characteristics

Creation and importance of the SC

The Preservation Zone (*Suelo de Conservacion*, SC) is a special category created in urban legislation for city territorial planning that establishes restrictions for urban land uses due to the natural characteristics of its ecosystems. It has a total of 88,442 ha that represent 59% of the Federal District, and it is distributed in nine administrative delegations (see *Map 1*). This special zone comprises most rural areas to the south of the city and includes large portions of the mountains slopes of the Chichinautzin, Las Cruces and Ajusco ranges. To the east it includes the Cerro de la Estrella and the Santa Catarina range, and the ex-lake beds of Xochimilco, Tlahuac and Chalco.[3]

From an ecological point of view, the SC comprises ecosystems with more than 1800 species of plants and animals. It provides environmental services and goods to the Federal District, which are essential for the sustainability of the whole city and the life quality of its inhabitants. Among these natural processes we can mention: weather regulation through the capture of carbon dioxide (CO_2); infiltration of rain water for urban supply[4]; retention of suspended particles that diminishes atmospheric pollution; preservation of biodiversity; and recreational activities and scenic value (PAOTDF, 2005, p. 4). In relation to main land uses, most of the territory is occupied by forest (43%), followed by agricultural activities (32%), grasslands (12%), and urban land uses (11%). The latter mainly corresponds to 36 traditional towns that have existed in this part of the city since ancient times.

Zoning and regulations in the SC

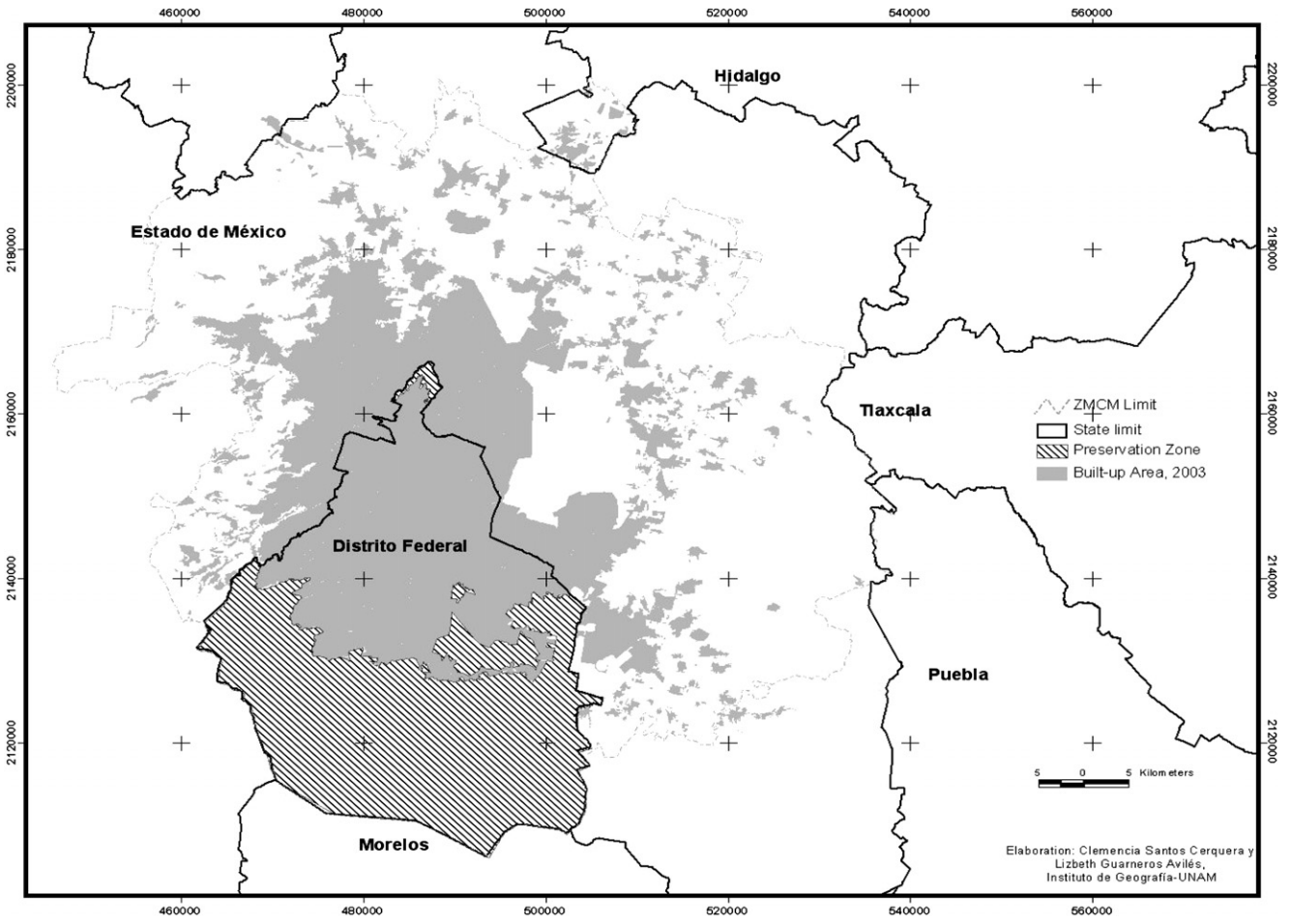
The existence of the SC goes back to the beginning of the 1980s, when the Urban Development Plan for the Federal District established a zoning that divided the territory into two main zones: the urban area and the non-urban area. In the latter, two main zones were approved, the ''buffer zone'' that represented a transition area between the urban and the rural realities, and the ''Preservation Zone'' with a strict policy to preserve the area against urban pressures. This area was the antecedent of the present SC (see Departamento del Distrito Federal, 1980).

Since then, urban regulations for this zone have been updated, always with a view to preserving the ecological characteristics of this zone. At present, land use policy consists of two main regulations that establish the norms for the occupation of the SC: (i) The General Program for Urban Development in The Federal District (2003), that follows the norms of the Law of Urban Development for the Federal District (1996) and (ii) the Program for Ecological Planning of the Federal District (2003), that is based on The Ecological Law of the Federal District. Analysis of the main elements of both regulations affirms that there is an ambiguous interpretation of the SC, and that this situation favors illegal land use occupations. *Table 2* shows a comparison of the approved zoning in the SC according to both regulations.

We can see that these different regulations lead to vastly different approaches to zoning. The zoning that derives from the Ecological Planning (EP) has a more regulatory nature. It is based on the natural and ecological characteristics of the different zones, and the existence of environmental units. It is more rigid in its approach, as it seems to ignore the social complexity in the SC, such as the presence of illegal settlements. It seems zoning is based on homogeneous areas related to: the capacity of each settlements to sustain productive activities; the recharge of the aquifer; and the preservation of biodiversity. It includes four main zones: traditional towns, natural protected areas, forest zones, and agricultural and livestock areas.

[3] It has to be emphasized that the North also includes a small proportion, in the form of the Guadalupe range and the Cerro del Tepeyac.

[4] The SC supplies 57% of the city water consumption.



Map 1 Mexicao City's Metropolitan Zone (ZMCM): built-up area and location of the preservation zone, 2003.

On the other hand, zoning which is linked to the Urban Development Program (UDP) responds to a historical trend of land uses and to social pressures; it has a more strategic nature and defines a more general zoning where human occupation is expected and incorporated with three main zones: regeneration areas; preservation areas; and rural and manufacturing production.

These twofold approaches give rise to the main contradiction in the SC: while there is excessive regulation in the zone, the regulations are not sufficient. None of the legislations regulate all the activities and actions in the SC in a comprehensive and precise way. This ambiguous situation has obstructed coordination between ecological authorities and those related to urban development to establish solid and unique policies to control illegal settlements and constructions, and to provide protection of forest land and ravines from pollution and urban occupation. In general, ecological norms tend to be more restrictive, for example every action or work in the SC requires an ecological assessment. Therefore, in addition to the general poor enforcement of the law, such strict norms are systematically violated (PAOTDF, 2005, pp. 24–26).

In addition, in several cases the personnel responsible for applying norms and dealing with illicit actions in the SC do not have sufficient up-to-date knowledge about the right interpretation of the legislation for different activities and works. They do not have clear understanding of procedures to verify land use norms, and consequently we find diverse institutional criteria when applying ecological and urban development legislations. In other words, there is no uniformity in the institutional criteria for alternative actions that are envisaged for particular problems, e.g. illegal settlements.

Largely as a result of this situation, it has been impossible to stop urban expansion on this territory since the creation of the SC, despite the explicit prohibition of this sort of occupation in the zone. For instance, in the 1980s, illegal settlements were the main means of human occupation in the SC, and planning norms did not establish land market controls either to restrict land availability in this zone or to supply land to poorer groups in other parts of the city. Additionally, the State was highly tolerant of illegal occupations in the SC (Aguilar, 1987, pp. 286–287). In the late 1990s it was reported that urban expansion in the SC had damaged the environment mainly through deforestation, occupation of river beds, the occupation of high productivity agricultural and livestock areas, and aquifer recharge areas (Bazant, 2001, p. 137).

Socioeconomic characteristics in the SC

Demographic growth

At present there is an important demographic pressure on the SC since its population growth is above the average of

Table 2 Zoning in the preservation zone of the Federal District, 2003

Program for Ecological Planning in the Federal District 28th August 2003 (Ecological Units)	Urban Development Law of the Federal District, 29th January 1996[a] (Article 31)
Traditional towns	*Restoring areas* Areas with natural conditions altered by the presence of unsuitable uses or by inadequate management of natural resources Actions will be carried out to restore the ecological equilibrium
Protected natural areas	Programs will establish coefficients of maximum occupation and land use Generally in these areas, illegal human settlements are located Ecological restoration includes land uses such as: dwellings, services, tourism, recreation, forest, infrastructure, Natural Protected Areas, and traditional towns
Forest under protection Present forest land use, located between agricultural-forest land and the better preserved forest areas	
Forest under special protection Forest zones with grassland that have experienced transformation in the vegetation cover due to agricultural and livestock activities. There are also ecological restoration activities and efforts to recover forest boundaries.	*Preservation areas* Natural areas which have not been seriously altered, and which require land use control measures in order to develop activities which are compatible with preservation It will not be possible to carry out urbanization works or actions in these areas
Forest for preservation Land with natural vegetation with the best preservation conditions. It is located in the south-west limits of the Federal District. This land is adequate for preserving biodiversity and recharging the aquifer.	For *ecological preservation areas*: fishery, forestry, agricultural equipment and infrastructure
Forest for special preservation Forest areas close to traditional towns, with great value for recharging the aquifer and preserving biodiversity. These areas are favourable for eco-touristic activities due to their scenic value, and can generate economic resources for traditional towns and communities	
Agricultural and livestock ecological zones There is predominance of traditional agricultural and livestock activities with an integration of appropriate techniques to improve quality and productive yield	
Special agricultural and livestock ecological zones These zones comprise the Chinampa areas and the humedales of Xochimilco and Tláhuac. Due to their vulnerability, these areas are subject to a special regulation to preserve their ecological, traditional and cultural characteristics	*Areas of agricultural and agroindustrial production* Those intended for agropecuaria, fishery, forestry tourism and agroindustrial production For areas of agricultural production: low density dwellings, rural dwellings, dwellings with commerce, agricultural services and equipment
Agricultural, livestock and forest zones Zones with a predominance of forest, with a transition between forest and agricultural and livestock land use. In these zones there are a multiple presence of land uses such as agricultural activities, forest exploitation, fruit trees, and shepherding	
Special agricultural, livestock and forest zones Areas with predominance of forest, located on the borders of the Forest for Preservation Area. In these zones there is an specific ecological normativity to develop agricultural and livestock intensive activities, introducing methods to avoid the expansion of agricultural and livestock activities over forest land	

[a]Indicators of the Programa General de Desarrollo Urbano del Distrito Federal, 31 de diciembre de 2003, are incorporated.

the Federal District (DF) as a whole. In the last two decades, the DF has experienced a decrease in the population growth, with an annual growth rate of 0.4% in the period 1990–2000. Those delegations[5] that contain the SC registered a growth rate of 1.9% for the same period, and the AGEBs[6] in the SC showed a rate growth of 3.6%. This implies a growth rate that is eight times higher in the SC than that in the DF, and double the average growth of del-

[5] The term ''delegation'' refers to a sub-district or municipality within the Federal District (DF). The latter is integrated by a total of 16 delegations.

[6] The Basic Geo-Statistical Areas (AGEBs) represent the smallest units with statistical information in the Mexican population census. In this study Urban AGEBs are used that refer to built-up areas that are an integral part of the city. Although rural AGEBs exist, they were not yet available for analysis.

Table 3 Population distribution and growth in the SC[b]

Delegations with Preservation Zone	1990	2000	Absolute difference	Growth rate[c]	1990 (%)[a]	2000 (%)[a]
Cuajimalpa	52,018	64,560	12,542	2.2	46.4	43.1
Iztapalapa	80,257	126,077	45,820	4.4	5.4	7.1
Magdalena Contreras	24,349	43,382	19,033	5.6	12.5	19.6
Milpa Alta	57,288	90,728	33,440	4.5	100.0	100.0
Álvaro Obregón	40,198	52,624	12,426	2.7	6.3	7.7
Tláhuac	66,277	10,0851	34,574	4.1	32.2	33.5
Tlalpan	82,229	122,089	39,860	3.9	17.1	21.2
Xochimilco	162,487	216,884	54,397	2.9	60.6	59.5
Total SC[d]	565,103	817,195	252,092	3.6	16.4	19.6
SC delegations total	3,452,432	4,164,446	712,014	1.9		
DF[e]	8,235,744	8,605,239	369,495	0.4		
ZMCM[f]	15,563,795	18,396,677	2,832,882	1.7		

Source: Own calculations from the Population Census Data, 1990 and 2000 from INEGI.
[a]Population share in the SC.
[b]SC, preservation zone.
[c]Annual medium growth rate.
[d]These data correspond to the AGEB's total in the SC.
[e]These data correspond to the Federal District total.
[f]Refers to the last definition of the Mexico City Metropolitan Zone defined by SEDESOL, CONAPO, INEGI (2004).

egations with SC. The growth rate is even higher than that for the whole metropolitan zone (see *Table 3*).

Population concentration in the SC, then, shows an upward trend. In 1990, there were 565,103 inhabitants in the SC, and by 2000 the population had increased to 817,195. The delegations growing at the highest rate (above 4.4%) are Magdalena Contreras, Milpa Alta and Iztapalapa (see *Table 3*).

Economic activities by sector

In previous decades, agricultural and livestock activities were predominant in the SC. However, with the gradual urbanization process and proximity to the city, there has been a sectoral economic transformation, and recently there has been an increase in population engaged in manufacturing and services activities. Obviously, there has been a clear fall of employment in primary activities that shows the weak and stagnant condition of the primary sector. The average percentage of population dedicated to manufacturing in the SC showed a decrease during the period 1990–2000; from 29% in the first year to 26% after 10 years. The associated rise in tertiary activities was clear, from 61% in 1990 to 67% in 2000. These data mean that less than 10% of population is dedicated to agriculture and livestock, and that there is a marked influence of city activities on the local economically active population. It is worth mentioning that these trends are a reflection of wider trends in the Federal District and the whole metropolitan zone, a drop of manufacturing employment and a marked tertiarization process (see *Table 4*).

Economically active population by main occupations

Main changes by economic sectors are reflected in the main occupations of the economically active population. First, there was a stable participation of waged employees and blue collar workers of around 70% during the period 1990–2000, that represented the highest proportion of occupations clearly linked to urban occupations. Second, there was a diminishing trend in the proportion of piecework workers, generally related to primary activities, from 6% to 3% in the same period, a trend which is widespread for all the SC. These occupations involve workers being

Table 4 Economically active population by economic sector in the SC

Preservation Zone	Manufacturing sector		Tertiary sector	
	1990 (%)	2000 (%)	1990 (%)	2000 (%)
Cuajimalpa	31.1	25.5	62.3	68.8
Iztapalapa	42.4	36.7	52.5	60.6
Magdalena Contreras	30.3	27.0	61.6	68.7
Milpa Alta	17.2	19.7	61.3	64.3
Álvaro Obregón	31.5	24.8	62.2	70.5
Tláhuac	31.1	23.9	57.4	67.9
Tlalpan	26.1	24.5	59.5	67.9
Xochimilco	25.2	23.8	66.6	69.0
Total SC	28.7	25.7	61.2	67.0
Delegations total	29.0	23.5	65.7	72.2
DF	27.0	20.8	68.3	73.8
ZMCM	32.1	25.6	62.4	67.9

Source: Own calculations from INEGI data.

contracted for short term and small jobs without fringe benefits, and are unstable and poorly paid. This important loss of occupations confirms the declining of primary activities in this part of the city. Third, a gradual increase in the importance of self-employed occupations can be observed, most of which tend to be related to informal activities associated to unstable and less productive activities of independent small scale businesses (see *Table 5*). This seems to be a sign of a more unstable economic situation for the economically active population, a trend is also observed for the whole city.

Economically active population by income distribution

The economically active population in the SC that received less than 2 minimum salaries in 1990 represented 77.3% of the total; this cut-off point represents a *proxy* for a poverty line. This proportion diminished in the early 2000s, when the active population with this salary level represented 51.6% of the total. This apparent improvement probably reflects the transference of economically active population from primary activities to urban ones with better salaries in this period. Even so, the proportion of population earning less than one minimum salary is higher on average in the SC than in their associated delegations or in the Federal District. In the same way, it is also notable that population that received the higher salaries, between two and five times the minimum wage, and particularly more than five, were located outside the SC. Thus, data tend to confirm that the economically active population in the SC earns lower salaries on average in comparison with the city urban population (see *Table 6*), and therefore, in this zone there is a higher proportion of population below the poverty line. The main implication is that, apparently, poverty is making urban expansion and degradation worse in the SC.

Water and drainage provision

In terms of the provision of water and drainage it can be affirmed that the coverage of these services in the SC is highly deficient. Data show that in the last decade there was not a notable improvement of this provision in a high proportion of dwellings as they still present marked deficits in water and drainage connections. To a great extent the absence of these services can be explained by the ille-

Table 5 Economically active population by main occupation in the SC

Preservation Zone	Active population					
	Employers and blue collar workers		Pieceworkers		Self-employed	
	1990 (%)	2000 (%)	1990 (%)	2000 (%)	1990 (%)	2000 (%)
Cuajimalpa	78.6	75.8	3.4	1.4	14.2	16.8
Iztapalapa	74.6	72.9	4.3	2.1	17.0	20.5
Magdalena Contreras	78.1	77.0	4.7	2.4	14.0	16.1
Milpa Alta	53.2	55.1	9.7	6.5	30.0	29.5
Álvaro Obregón	77.6	75.3	3.2	1.1	15.1	18.3
Tláhuac	71.7	70.0	6.5	2.9	17.7	21.6
Tlalpan	68.9	69.8	8.0	3.7	18.1	20.3
Xochimilco	70.4	67.8	4.9	3.2	20.2	22.7
Total SC	70.8	69.4	5.6	3.1	19.0	21.5
Delegations total	76.3	72.6	2.3	1.1	16.5	20.1
DF	77.2	71.8	1.3	0.7	16.1	19.6
ZMCM	76.1	70.8	2.2	1.3	16.4	20.0

Source: Own calculations from INEGI data.

Table 6 Economically active population by income distribution in the SC (%)

Preservation Zone	Less than 1 Ms*		Between 1 and 2 Ms*		Between 2 and 5 Ms*		More than 5 Ms*
	1990	2000	1990	2000	1990	2000	2000
Cuajimalpa	22.8	7.6	49.9	39.5	21.8	33.7	9.9
Iztapalapa	28.7	14.1	53.3	51.5	15.8	23.3	3.5
Magdalena Contreras	25.2	11.0	52.2	44.6	18.5	30.4	6.4
Milpa Alta	33.6	15.1	48.1	35.7	15.2	27.6	6.2
Álvaro Obregón	23.7	8.8	50.5	40.8	19.9	31.7	8.5
Tláhuac	27.0	10.3	51.4	35.9	18.2	34.9	9.6
Tlalpan	26.2	10.4	48.6	39.2	19.4	30.6	10.0
Xochimilco	25.4	12.5	51.2	36.4	19.3	29.9	9.3
Total SC	26.6	11.7	50.7	39.9	18.5	29.8	8.1
Delegations total	22.0	9.3	46.7	35.3	23.2	32.1	14.3
DF	20.0	8.3	43.5	31.3	60.5	32.6	17.8
ZMCM	18.6	8.3	45.6	33.7	26.4	33.1	14.6

Source: Own calculations from INEGI data.

Table 7 Coverage of water and drainage in the SC, 2000[a]

	Total private dwellings	Dwellings with piped water inside the house (%)	Dwellings with piped water inside the plot (%)	Dwellings with drainage connected to public network (%)	Dwellings with drainage connected to septic tank, ravine, crevice, river, lake or sea (%)
Cuajimalpa	13870	55.8	37.3	81.1	13.9
Iztapalapa	26222	27.3	60.2	87.9	5.8
Magdalena Contreras	9523	42.2	41.6	62.3	23.4
Milpa Alta	19997	38.3	52.2	72.0	17.1
Álvaro Obregón	11829	53.4	36.6	84.5	13.6
Tláhuac	22549	56.0	38.1	76.9	17.8
Tlalpan	26684	33.9	36.0	43.4	49.0
Xochimilco	46401	43.3	42.8	59.0	28.9
Total SC	177,075	42.2	43.9	68.3	23.3
Delegations total	961,016	68.5	26.8	87.6	9.8
DF	2,132,413	76.8	18.7	91.8	5.0
ZMCM	4,346,942	65.8	26.6	86.6	6.2

Source: Own calculations from INEGI data.
[a]Data refers to the AGEB's.

gal condition of a great number of properties. The population inhabiting those dwellings tries to solve their water supply by informal means: for example, carrying water from distant sources, public taps, or buying it from trucks. In terms of drainage, it is common that it is connected to septic tanks, cracks, or ravines.

Data show that those dwellings in the SC with water service in the house only represent a little above 40% of the total, a figure well below the city average; and those with drainage connected to public network represent almost 70% of the total, again a figure below the city average. Yet, dwellings with drainage connected to septic tanks, cracks, ravines or rivers still represent an important proportion, 23.2%, with an evident negative environmental impact (see *Table 7*).

Main threats to the SC

Main threats to the SC are associated with the dynamic of land use changes that has major repercussions for the environmental natural conditions of the zone, in terms of the destruction of natural habitats and deterioration of the inhabitants life quality. An official document[7] from the Federal District Government gives a clear picture of the main land use changes from a comparison of maps of vegetation and land uses in two different years, 1970 and 1997. The main results show that the natural land covers have been under strong and constant pressures from urban expansion, deforestation, and to a lesser extent agricultural activities which, though are not very productive, can be a source of a minimum economic benefit. In this way, land uses that showed a diminishing trend in the period 1970–1997 were forest and agriculture: forest cover diminished by 239 ha each year and agricultural land reduced by 173 ha per year. But without doubt, the most dramatic change corresponds to urban land use, which increased by an average of 289 ha per year, representing a growth rate of 6.09% per year (see CORENA, 2000: *Tables 3 and 4*). Given the importance of urban expansion in the SC, three main types of land occupation can be identified, whose main characteristics will be specified in the following section: (i) expansion of rural towns; (ii) illegal settlements; and (iii) a dispersed occupation of middle classes.

Expansion of traditional towns

These towns are located on the slopes of the mountains, and their origin in some cases goes back to colonial times, such as Milpa Alta or San Pedro Actopan. Others were created as a nucleus of communal land (ejido land)[8] such as San Miguel Ajusco. Although ejido land was advocated to agricultural and livestock activities, the ejidatarios (owners) have sold it illegally for urbanization. In the SC originally there were 90 nucleus of communal land with an area of 51,356 ha, by 2002 this number decreased to 64 nucleus and an area of 33,856 ha; the delegation of Milpa Alta concentrates on the higher number of ejidatarios, a 42.6% (PAOTDF, 2005, p. 6). Lack of financial and technological support for agricultural activities stimulates the abandonment of this land and its probable sale what make uncontrolled urban expansion worse.

These towns have a very simple urban structure, a grid lay out and a social organization by neighbourhoods. A high percentage of the population is still dedicated to rural activities but the closeness to the urban area has caused the increase of urban activities. The expansion of the towns is mainly due to the demographic growth among the local population that is distributed in their periphery, but still within the perimeter of the towns. Peripheral

[7] This document refers to the, Comision de Recursos Naturales y Desarrollo Rural (CORENA) (2000)''Programa General de Ordenamiento Ecológico del Distrito Federal 2000–2003'' Gobierno del Distrito Federal, Secretaria del Medio Ambiente, Mexico DF.

[8] Ejido land was given to communities in Mexico with the agrarian reform after the 1910 revolution; the land was a communal good and was not owned by population individually.

Table 8 New illegal human settlements outside and within the SC, 1995–2005

	1995		2000		2005		Total	
	Number of polygons	Surface hectares	Number of polygons	Surface hectares	Number of polygons	Surface hectares	Number of polygons	Surface hectares
Outside the PDU Perimeter[a]								
Total	2326	1105.06	2550	507.87	1809	416.12	6685	2029.04
Within the PDU Perimeter[a]								
	596	225.15	327	32.44	289	57.12	1212	314.71
Total	2992	1330.21	2877	540.31	2098	473.24		

Source: Own calculations from satellite images.
[a]PDU, Urban Development Plan.

constructions present more deficient services, and although the traditional architectural style has remained, some recent middle class housing can be identified from population coming from central city areas. It has to be mentioned that while some towns are in the middle of the slopes, others are closer to the urban built-up areas, facilitating their physical and socioeconomic integration into the city. Local inhabitants, and particularly peasants, prefer to sell their plots, because of the economic benefit, to individuals or to developers for urban use, and in many cases the sale is made illegally through either false documents, or none at all as in the case of communal land.

It is evident that in recent years these towns have increased their constructed area slowly but constantly. For example, an analysis that was carried out for three main towns (Milpa Alta, San Pedro Atocpan and San Miguel Ajusco) from the late 1970s to the mid-1990s, found that their built-up areas increased at a rate of 5.5% in the period 1975–1986; and at a slower rate of 3.0 in the following period 1986–1995. As these towns are far from the built-up area it is highly likely that those towns closer to the city expanded at a higher rate (Bazant, 2001, pp. 100, 118). It seems clear, then, that these towns are increasing their constructed density and have become to a lesser degree a receptacle for population from central city areas. This process is detrimental to agricultural peripheral land, and to natural resources like vegetation and river beds.

Poor and illegal settlements

These settlements have emerged as part of invasions or illegal occupations of private or public land. They are associated with poorer groups, and at the time of creation they lack basic services such as water and drainage, the dwellings are normally constructed through a self-help process and present a mixture of permanent and disposable materials, and quite frequently are located in a risk-prone area. At present there are a variety of settlements, whereby some of them already have regular land tenure and are consolidated, while others live illegally at risk of eviction.

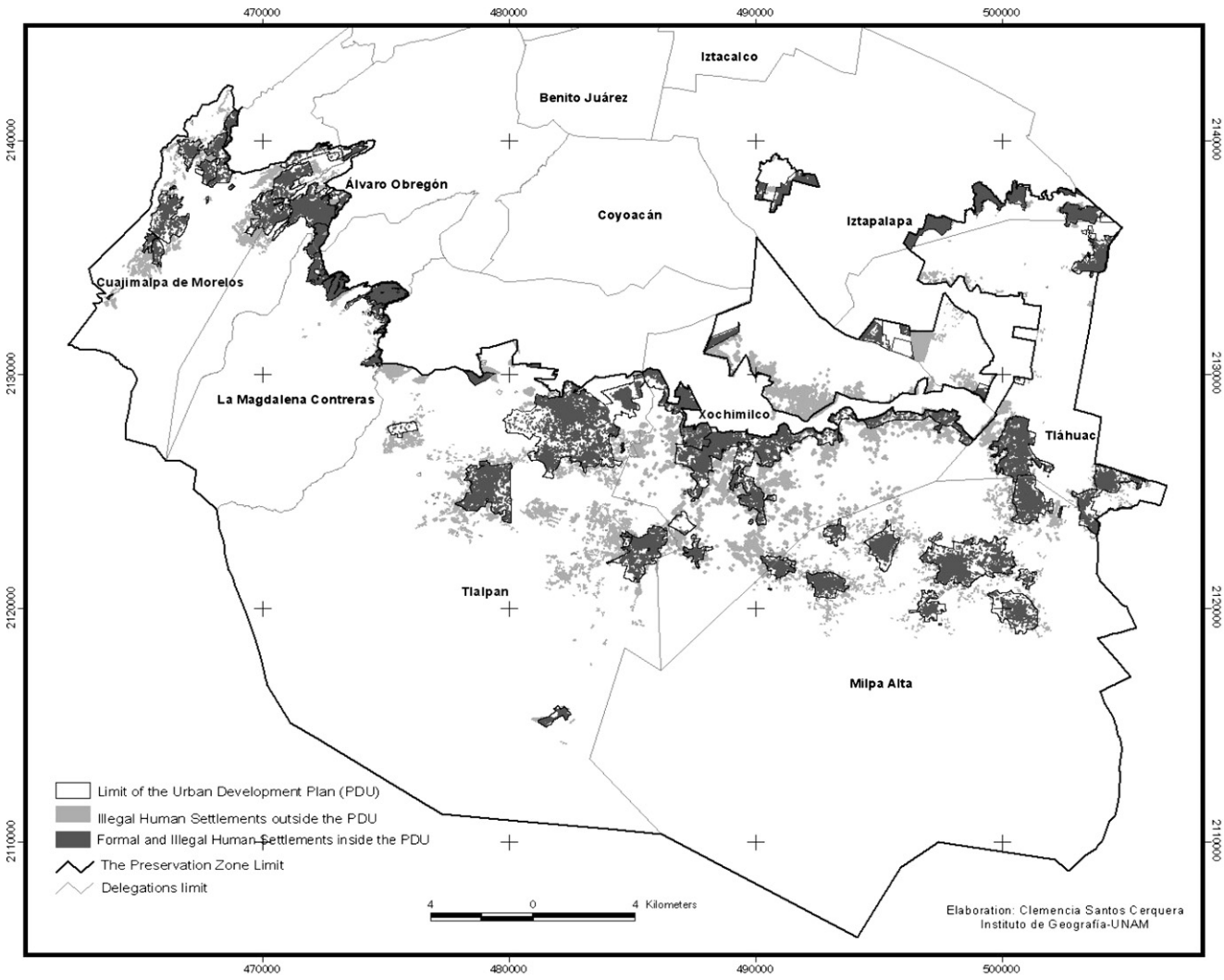
However, their illegal character does not stop them from becoming legal in a relatively short period. In most of the cases, land tenure regulation comes after a period of approximately 10 years, accompanied by a gradual introduction of services. The late provision of services and the inappropriate sites where these settlements were established (pronounced slopes, vulnerability to flooding, or land sliding) contribute significantly to negative impacts on the environment. For example, in 2002 the Federal District Government regularized illegal settlements in two delegations (Gustavo A. Madero and Iztapalapa) with more than 20 years of existence, where the area lost was 54 and 278 ha, respectively (Reforma 3/11/2002). In 2005 the land tenure situation of 10,000 inhabitants that have invaded the SC in the delegation of Magdalena Contreras was regularized (Reforma 19/08/2005). These factors stimulate new illegal occupation with the knowledge that regularization will come sooner or later.

It is a fact that illegal settlements in the SC have been emerging since the 1980s, though estimations of their number vary according to the source. Newspaper archives sources constantly report the presence of this occupation. Academic studies also mention the existence of these settlements. In 2001 a total of 709 illegal settlements were reported with a total of 64,676 dwellings covering a total of 3,457.72 ha (see Schteingart and Salazar, 2005, pp. 110–111). The Public sector also contributes to this topic. At the end of 2005, the local government estimated that illegal invasions involve between 350 and 495 ha annually, whereas the General Attorney for Ecological Planning (Procuraduria General de Ordenamiento Ecologico) estimated that the SC has lost 245 ha of forest due to the intense deforestation provoked by illegal settlements. Delegations most affected were Cuajimalpa, Tlalpan and Xochimilco, where 68% of those settlements were concentrated (La Jornada, 17/12/2005).

As part of the analysis it was included the identification and measurement of illegal settlements in the SC. For this evaluation, all the polygons[9] corresponding to these sorts of settlements were delimited for the period 1995–2005. These data are reported in *Table 8* with the precise number of polygons (see *Map 2*)[10].

[9] The term polygon is a technical measurement term that refers to the perimeter of each illegal settlement. In consequence both terms (polygon and settlement) are equivalent.

[10] For these calculations the following material was used: (i) 1995 aerial photographs, scale 1:75,000; (ii) 2000 aerial photographs, scale 1:20,000; (iii) 2005 mosaic of digital photographs, scale 1:50,000, with a resolution of 1 m; and (iv) finally a mosaic of a quick Bird satellite image 2005 was also used. The procedure included the correction of all the displacement



Map 2 The preservation zone. Illegal human settlements inside and outside the perimeter of the Development Plan, 2006.

Measurements indicate that in 1995, a total of 2922 polygons of illegal settlements existed; 5 years later, in 2000, the number of polygons had slightly diminished to 2877 settlements; and after another period of 5 years, in 2005, the number of settlements had decreased to 2098. These numbers show a reduction in the number of settlements, most marked in the last period of 2000–2005. Even so, it is evident that urban occupation continues in the SC. In terms of occupied land the diminishing trend is clearer: whereas in 1995 those settlements occupied 1330 ha, for 2005 the occupied land represented 473 ha (see *Table 8*). There is not a single and definite explanation for this diminishing trend; apparently there is a combination of several factors: firstly, since the year 2000 there was a more strict control of land use from the local government, particularly in the case of illegal settlements, to respond to social pressures to preserve the SC, it is likely that part of the demand moved to land in the State of Mexico; secondly, the diminishing demographic growth rate in the city particularly in the Federal District surely had an effect in the amount of demand for land and housing; and thirdly, there are arguments, mainly from government officials, that the policy to stimulate construction of new housing in central urban areas of the Federal District[11] had a positive effect on the urban expansion in the SC.

For the identification of illegal settlements a division was made between: (i) those settlements located near traditional towns and within the perimeter that has been delimited for their future growth, areas which are considered within the Urban Development Plan (PDU) as zones for urban occupation and (ii) those settlements that are outside such perimeters of the PDU and are located in the zone where urbanization is prohibited in the SC (see *Map 2*). Between 1995 and 2005 there was an increase of 2029 ha outside the perimeters of the PDU, and an expansion of 314.7 ha within the perimeters of the PDU. These numbers indicate that the main illegal expansion

[11] In the year the Federal District local government issued an agreement known as ''El Bando Informativo Dos'' by which new residential developments were prohibited in all the Federal District territory, with the exception of the four central delegations (Miguel Hidalgo, Cuauhtemoc, Benito Juarez and Venustiano Carranza) to stop the negative demographic growth in this city zone.

is happening in areas outside the traditional towns, in zones where urbanization is prohibited (see *Table 8*).

One of the advantages of the methodology of using satellite images is the level ohf detail that permits a very precise identification of features. As a result of settlement measurements, it was possible to identify some illegal settlements that were not in the local government records, which in this case extended over a surface of 159.6 hectares. Those delegations with the higher number of these settlements were, in order of importance, Milpa Alta, Tlalpan and Xochimilco.

Land occupations by middle classes

This type of urban occupation takes two main forms: first, the acquisition of individual plots through direct transaction with an owner of private or communal land; and second, the construction of a small group of dwellings, generally private horizontal condominiums, where there is the participation of a land developer. Given the small scale of both these types of occupation, a very fragmented pattern of urbanization is created, with highly dispersed urban patches. Most frequently these middle class developments have expanded along and very close to the main roads in the SC, for example the toll-free Mexico–Cuernavaca road.

The acquisition of individual lots from communal land owners is quite similar to the procedure followed by poorer groups. Generally the transaction is illegal in terms of land tenure, because subdivisions are not approved by the corresponding authority (notary public). This means a lack of legal property deeds that guarantees the plot transaction. These subdivisions, together with all the land tenure conflicts of the poorer groups, represent an enormous and complex problem that basically requires the regularization of hundreds of properties in the SC.

In terms of condominium developments, it has been found that in some cases these dwellings have obstructed ravines, or have contributed to land sliding and deforestation. In other cases, although the constructions had an official license, the developments were stopped due to reports from local neighborhoods committees of failure to comply with environmental regulations, as happened in the Cuajimalpa Delegation (see Schteingart and Salazar, 2005, pp. 147–179). Such denouncements against real estate developers about the damage to environmental natural conditions in the SC have proliferated. Another example refers to the developments called Obelisco, Bosques, La Punta, that invaded slopes and river beds, and are negatively affecting environmental services to Mexico City (La Jornada, 22/08/2005).

Conclusions

Clearly, urbanization has become a powerful force that transforms the environment. The continuous trend of demographic concentration in cities contributes to marked environment damage depending on the particular urbanization modalities in each city. It is urgent to make progress on the urban sustainability in all cities, particularly in megacities considering the scale and the magnitude of their problems. It is essential to identify the driving forces of peri-urbanization in each city and their direct and indirect impact on environmental services.

In the case of the SC in Mexico City it is evident that land use norms in this zone have proved to be highly inefficient in controlling urban expansion in the last decade, as was shown by the presence of illegal settlements within the perimeter of the SC. In some cases this urban growth is alarming, not only due to the dispersed pattern that represents an undesirable expansion model, but also due to the cost that the provision of basic services represents in this type of urbanization, and additionally because this expansion occurs on the mountain slopes that have a high ecological value.

The characteristics of the SC have to be visualized in a comprehensive way and in relation to the urban development of the whole city, since its preservation is essential in sustaining the social dynamic of the Federal District and to some extent in preserving the cultural features of the traditional towns in this zone. It has been evident that land use changes in the SC involve several actors and there is inappropriate governance to stop environmental degradation: on the one hand, in relation to local government, there is a lack of coordination among local institutions in administering and overseeing the zone; excessive and deficient land use regulation; and a lack of effectiveness in increasing the living standards of poorer groups; these deficiencies stimulate illegal activities that affect the quality of natural resources and ecosystems, and generate prohibited land use. On the other hand, government (in)action combine with the ruthless realities of the market, where real estate developers exerts pressure to incorporate land to urban expansion. Additionally, social groups represented by illegal settlers and middle classes take advantage of the vacuums of the law and contribute to informality. Apparently, there has been a failure to integrate and negotiate interest, to build agreements and produce cooperation. There is not an effective capacity to govern this zone.

Evidently, there are several realms where it is essential to act in order to be on the right track of urban sustainability: urban governance at local and city level; regulation of market conditions; alternative productive activities such as agriculture and recreation activities; more participation of local residents to implement policies; enforcement of land use norms; and provision of land/housing alternatives for poorer groups. The local government in the Federal District has a legitimate intervention role in a matter of city interest (the SC), but consensus must be socially constructed and is not free of conflict.

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References

Aguilar, A G (1987) La política urbana y el plan director de la Ciudad de México: Proceso operativo o fachada política. *Estudios Demográficos y Urbanos* **2**(2), 273–299.

Aguilar, A G (2002) *Las Megaciudades y las Periferias Expandidas. Ampliando el Concepto en Ciudad de Mexico*. Revista EURE, vol. XXVIII, No. 85, Santiago de Chile, Diciembre, pp. 121–149.

Aguilar, A G and Ward, P M (2003) Globalization, regional development, and mega-city expansion in Latin America: analyzing Mexico City's peri-urban hinterland. *Cities* **20**.

Aguilar, A G (2006) Introducción. In Aguilar, A G (Coord.) *Las Grandes Aglomeraciones y su Periferia Regional. Experiencias en Latinoamérica y España, Colección Conocer para Decidir, Camara de Diputados*. CONACYT, Instituto de Geografia-UNAM, Miguel Angel Porrua, Mexico, pp. 5–18.

Bazant, J (2001) *Periferias urbanas. Expansión urbana incontrolada de bajos ingresos y su impacto en el medio ambiente*. Trillas, México, DF.

Departamento del Distrito Federal (1980) *Plan de Desarrollo Urbano del Distrito Federal, I, Nivel Normativo*. Diario Oficial de la Federación, México, DF. Enero 24 de 1980.

Douglas, I (2006) Peri-urban ecosystems and societies: traditional zones and contrasting values. In *The Peri-urban Interface*, D McGregor, D Simon and D Thompson (eds.), pp. 18–29. Earthscan, London.

Gilbert, A (2006) Good urban governance: evidence from a model city? *Bulletin of Latin American Research* **25**(3), 392–419.

McGranahn, G and Satterthwaithe, D (2003) Urban centers: an assessment of sustainability. *Annual Review of Environmental Resources* **28**, 243–274.

McManus, P and Haughton, G (2006) Planning with ecological footprints: a sympathetic critique of theory and practice. *Environment and Urbanization* **18**(No. 1), 113–127.

PAOTDF (2005) *Elementos para una gestión adecuada del suelo de conservación del Distrito Federal*. Documento de Trabajo. Procuraduría Ambiental y del Ordenamiento Territorial del Distrito Federal, México, DF.

Rees, W E (1992) Ecological footprints and appropriated carrying capacity: what urban economics leaves out. *Environment and Urbanization.* **4**(No. 2), 121–130.

Satterthwaite, D (1999) Sustainable cities or cities that contribute to a sustainable development? In *The Earthscan Reader in Sustainable Cities*, D Satterthwaite (ed.), pp. 80–106. Earthscan Publications, Londres.

Schteingart, M and Salazar, C (2005) *Expansion urbana*. Sociedad y Ambiente, El Colegio de Mexico, Mexico, 201pp.

Simon, D, McGregor, D and Thompson, D (2006) Contemporary perspectives on the peri-urban zone of cities in developing areas. In *The Peri-urban Interface*, D McGregor, D Simon and D Thompson (eds.), pp. 3–17. Earthscan, London.

United Nations Centre for Human Settlements (1996) *An urbanizing world: global report on human settlements, 1996, United Nations Centre for Human Settlements (Habitat)*. Oxford University Press, Grant Britain.

United Nations Development Programme UNDP (1997) *Governance for Sustainable Human Development*. UNDP, New York.