MEXICO CITY: THE INTEGRATION OF URBAN AGRICULTURE TO CONTAIN URBAN SPRAWL

Pablo Torres Lima, Luis Manuel Rodríguez Sánchez and Brenda I. García Uriza

1. Introduction

The Mexico City Metropolitan Zone (MCMZ) covers an area of 7,860 km² and includes the Federal District and 54 municipalities (Programa 1983 cited by Delgado 1994). Mexico City (Federal District) is located in the Valley of Mexico, at the centre of the Mexican highlands. It extends over 1,479 km², has an average altitude of 2,238 m above sea level and is surrounded by mountains of up to 3880 m. The main soil types are litosoles, andosoles, feozem, regosoles and solonchak (CETENAL 1977). The climate is temperate, with summer rains. Mean temperature ranges between 18ºC and 24ºC, and average annual rainfall ranges between 100 and 1,400 mm.

Approximately 22 million inhabitants live in the MCMZ, 10 million of them in the Federal District. Over the last thirty years, three main zones of population concentration were formed within the Federal District:

- **Urban Nuclear Zone**: six centrally located districts in a traditionally urban zone, where housing is making way for office buildings, industry and cultural services. The population density, which used to be high, has been decreasing as a result of migration to the periphery;
- **Rural-Urban Fringe**: the six most rural districts are located to the south and east of the Federal District. This area has the lowest, but a markedly increasing population density. The increase was mainly at the expense of agricultural land and was followed by an increase in residential zones, tourism and services; **Intermediate Urban Zone**: this is a heterogeneous area. These districts have experienced a rapid increase in their populations since the late 1970s, which resulted in both ordered and disordered (shanty) settlements. In particular, all of Iztapalapa and Alavaro Obregón have been the main sinks for large peasant migratory waves. Within these zones, some remnant agricultural production exists, albeit of little economic significance, as the zones are practically completely urbanised. Many of the settlements are relatively recent. The districts house most of the population within the Federal District. The majority of these settlements have been established on the least suitable
areas, including ravines, old lakebeds, hillsides and unstable soils. As a result of this, the settlements suffer from flooding and landslides.

Mexico City, like the rest of the country, experiences great economic inequalities and underdevelopment. Unemployment and the subsequent growth of the informal economy (obvious in the abundance of street-sellers) are problems which increase by the day, generating further and more complicated problems. Buying power has also decreased greatly; by December 1998, the daily minimum wage was 48.00 pesos or approximately US$ 4.

According to the last General Population and Housing Census in 1990, there were 2,884,807 people formally employed within the Federal District (35% of the total population), of which only 19,145 (0.7%) were engaged in agriculture or forestry. This demonstrates the marginality of the sector in the metropolis. In 1991, the primary sector generated only 249,076 million pesos out of a total of 178,423,467 million pesos generated (INEGI 1995).

1.1 Rural land tenure in relation to economic liberalisation and urban expansion

In order to understand the dynamics of the urbanisation process in Mexico City, one has to look at the land-tenure situation and the conceptualisation of land as a commodity. The area of rural land was reduced by continued land expropriations by the government in the last 60 years, which altered the social character of the area. From the 1970s until the beginning of the 1990s, the greater part of the expropriations were to create new space for housing and urban services. This process did not slow down until 1997.

During the last decade, land has been expropriated in order to form nature reserves; however, continued peasant invasions and establishment of shanty settlements within these "protected" areas (often aided by corruption) reduce the size of the green areas as well as the occurrence of agriculture and forestry. When these lands lose their "social character" and take on an urban function, either legally (through expropriation) or illegally (through land invasion), the land becomes a commodity. The urban use increases the value of the land. In the same context, the new reforms to Article 27 of the Constitution directly favour the conversion of ejidal (common ownership) land into a commodity.
Terraces planted with nopal cactus, maize and vegetables in the periurban area of Mexico City (Picture Luis Manuel Rodrigues)

“Plants for sale”. Ornamental plants produced in the Chinampa system. A highly intensive production system in the suburban area of Mexico City (Picture Luis Manuel Rodrigues).
2. Characteristics of urban agricultural activities in Mexico City

Urban agriculture can be defined as all forms of agricultural production that benefit from the infrastructure provided by human concentrations in towns or cities (Ellis & Sumberg 1998). The productive urban agricultural process can be defined by attributes, activities and an identity which are distinct from traditional rural agriculture:

- small agricultural properties predominate;
- animal husbandry uses little area;
- recycled materials are used to construct animal sheds;
- food industry and household wastes are fed to animals;
- cow dung is intensively used as a source of manure, macronutrients (NPK), water and heat;
- the use of local knowledge and technology predominates, and the transfer of local knowledge is by word of mouth;
- products are sold in local markets and/or to neighbours;
- urban and agricultural activities co-exist within family units;
- urban and rural cultures co-exist; and
- production is for both home consumption and sale; urban farming often complements urban subsistence strategies through the generation of income and/or the consumption of self-produced products.

The urban agricultural systems perform a gamut of functions and go beyond simply producing foodstuffs. Typical, for example for backyard animal rearing, is that this is not fixed to the house and that can be moved in the event of external pressures.

Therefore, urban agriculture in Mexico City can be explained only from a perspective that goes beyond analysis of production or economic impact. Agriculture is framed within the context of broader cultural activities where, for example, festivals and celebrations important for community cohesion co-exist alongside natural phenomena and agricultural cycles, as well as technologies and services implicit to city life.

There is also a continuous movement of urban and periurban farmers between the rural and urban environments. For example, the numerous nopal (prickly pear cactus) producers in Milpa Alta commute to the city centre daily, to work in typical urban jobs (guards, civil servants, construction workers, etc.). For the rest of the day and in the weekends, they work their milpa (cornfield).
Urban agriculture has developed under an apparently "chaotic" informal organisation which, in most cases (such as the cowsheds/stables in the central urban zone) responds to the current cultural and economic conditions, although often violating government regulations and formal institutional arrangements.

Three areas of agricultural and forestry development can be identified: urban, suburban and periurban. They differ in their locality, resident populations and farming systems. Other differences are defined by the density of buildings, the presence of streets, open spaces and other more particular characteristics such as bodies of water and/or forests\(^1\). These characteristics are identified in Table 1.

Table 1: Urban infrastructure and the availability of open space/km\(^2\) (in %)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Central urban agriculture</th>
<th>Suburban agriculture</th>
<th>Periurban agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buildings / km(^2)</td>
<td>83.00</td>
<td>13.00</td>
<td>0.20</td>
</tr>
<tr>
<td>Streets / km(^2)</td>
<td>16.00</td>
<td>1.50</td>
<td>0.20</td>
</tr>
<tr>
<td>Open spaces / km(^2)</td>
<td>1.00</td>
<td>85.00</td>
<td>88.00</td>
</tr>
<tr>
<td>Canals / km(^2)</td>
<td>0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest / km(^2)</td>
<td>2.00</td>
<td>0.00</td>
<td>11.60</td>
</tr>
<tr>
<td>Agricultural systems</td>
<td>Family gardens: Community vegetable and medicinal plant production, milk and meat production, backyard pig rearing</td>
<td>Chinampa: Legumes, flowers, family orchard, greenhouses and ornamental plants, production of meat and milk, draught animals and small animal husbandry</td>
<td>Upland agriculture; Production of nopal cactus, family orchards, maize, agrosilvipastoral, forest meat and milk production, draught animals, backyard rearing, beekeeping and sheep rearing</td>
</tr>
</tbody>
</table>

Source: Losada et al. 1998

The agricultural production systems in central urban zones and their impact are as yet unstudied, little appreciated and of unknown potential. For example, the place of agricultural production in the informal economy is unclear, as well as whether they are restricted to projects by social organisations. Systems in suburban and periurban zones have been studied to a far greater extent and have much more impact and visibility in economic and sociocultural terms.

In general, urban agriculture uses few external inputs. Solid wastes produced in the urban environment are an important source of animal nutrition, with obvious environmental benefits. In the prevailing forms of urban, suburban and periurban agriculture, cow dung – both fresh and dried – serves as a source of organic
material, macronutrients, water and heat, and is highly valued. Water and heat are particularly important for producing *nopal* cactus and vegetables in the terraced zone. To a lesser extent, other external inputs are also applied in all production systems. The greatest use of petrol and transport in Mexico City agriculture is for transporting excrement from cowsheds and stables to the field and transporting the products to market. In the Chinampa system, the use of water is intensive, augmenting production costs significantly.

Livestock production in Mexico City consists mainly of backyard animal husbandry. A wide range of animals is reared, including poultry (wild turkey and chickens), sheep, goats, rabbits and – to a lesser extent – cattle and horses. In a few places, people started to produce chinchillas. In 1995, 3738 ha were dedicated to raising 16,391 head of cattle, 22,592 pigs, 19,309 sheep and goats, 571,200 chickens and 11,691 turkeys. In the same year, 12,563 litres of milk were produced. As yet, fish farming is not very extensive, being restricted to a few specialised farms, natural parks, agricultural training centres and government lands.

Lactating cows are acquired from rural areas as a way to adapt to the restrictions on land use and breeding; newly bought cows serve to replace unproductive animals (Losada et al. 1996). Swine and poultry are more rarely traded than milking cows.

In animal production systems, vaccines are used to fight cholera in pigs and, to a lesser extent, Newcastle disease in poultry, among others. Frozen semen for artificial insemination, processed animal feeds, mineral salts and vitamin supplements are also used. The use of inputs in suburban and periurban zones is lower in certain respects, because of the availability of open spaces. The existence of specialised state farms has facilitated the introduction of special races of sheep and pigs, and sustained the use of external inputs like vaccines and medicines.

The use of external inputs for crop production in suburban, periurban and rural zones is focused on the purchase of vegetable seed, a selection of flowers, inorganic fertilisers (including *Triple 17*, ammonium sulphate and urea), herbicides, insecticides, growth promoters and greenhouse inputs. In the Federal District, vegetable and flower production is higher than that of grains and fruit (Sagader, 1999). In certain areas of the Chinampas, about three flower yields and five or six radish or purslain yields per year are harvested (Canabal 1997). The output of this production system is considerable, as is the range of crops that is cultivated in the Chinampas.
The production of vegetables, legumes, flowers and nopal is labour-intensive within the Chinampa and terrace systems. In cattle-rearing systems, human input is generally lower, although some of the animal production systems do involve higher levels of labour input, such as cowshed-based milk production.

3. Types of urban agriculture: location, practices and analysis

3.1 Agriculture in the central urban zone

The people who practise agriculture in the central urban zone form a mixed group and are of migrant origin. In some cases, people have managed to retain some of their original culture. Frequently, several nuclear families (2-3 family members) live in the same urban plot because of high land-use pressure in this zone (Losada et al. 1996).

In this zone, agriculture – especially vegetable production – is incipient, whereas milk and meat production is more developed, although its irregular character makes it difficult to quantify. Backyard animal husbandry is highly pronounced in immigrant districts, where a small but diverse number of species can be found, including pigs, chickens, turkeys, ducks, geese, pigeons, rabbits and – in some cases – fighting cocks and singing birds. In general, animal breeding has a strong traditional element, which fulfils two principal objectives: to complement the daily family diet or to provide food for festivities. The primary objectives of urban milk production are retail selling at local markets and home consumption. The surpluses are converted into cheese, cream, yoghurt, flans or, if there are no other options, they are used for fattening male calves (Losada et al. 1996).

Pigs, which are bred and fattened in a semi-industrialised way, are sold to the local slaughterhouse. The income is used to buy household necessities. Backyard pig raising is a form of saving for emergencies. Production of rabbit and pigeon meat is drifting towards the tourist areas around the city. Local consumption is limited because of cultural preferences. Fighting cocks are generally reared for sale, or prepared by their keepers in order to fight in local, semi-clandestine rings (Losada et al. 1993).

The producers in the central urban zone have developed skills to recycle products for constructing sheds for their animals and for other uses in agricultural production. The beef and milk production units and the semi-industrialised pig units use conventional building materials and are an exception to this. Most urban chicken coops are built of old construction wood, just as household and industrial wastes are used in other forms of backyard animal husbandry.
Conventional tools used in family orchards include picks, spades, rakes, forks and household utensils – knives, spoons, scissors, machetes, buckets – as well as other tools of pre-hispanic origin: poles and the *coa* (a sort of small scythe).

Within the central urban zone, crop production is rather insignificant. However, a few techniques have been developed that promise to give high yields in confined spaces with limited use of water. For example, production of *nopal* has been initiated in plastic containers and small spaces using compost, manure, small rocks (*tepetate*) and gravel as substrate. To date, yields have been more than satisfactory, giving up to 60 *pencas* (cactus leaves) per square metre, and harvesting can begin after 4-5 months. This technique can be reproduced on rooftops and in urban patios.

### 3.2 Suburban agriculture

This urban zone has been the focus of migration from those provincial areas closest to the city. A significant part of the population, however, is of local origin – together forming a multicultural population (Friends of Xochimilco 1990, in Soriano 1999). In general, there is one nuclear family living in each house.

Suburban agriculture has three objectives: a) income generation through the marketing of *nopal*, vegetables, *tuna*², ornamental plants and meat; b) home consumption of maize, fruit and vegetables; and c) the exchange and/or sale of various products (plant propagation material for family orchards, medicinal and ceremonial plants, spices, etc.) to supplement the family budget.

Animal production is mainly small-scale milk and meat production in sheds and backyards, as well as the rearing of chickens, pigs, rabbits and poultry. Some draught animals are also kept - mainly mules and horses - which are used to transport cow manure to the plots and to transport local weekend tourists.

The organisation of cattle keeping in suburban and periurban areas has a similar logic as in central urban areas. Its importance is a function of the availability of gainful employment in other sectors and general household income; when family members have a job within the city and family income increases, the number of animals kept is reduced and vice versa³. Other animal production systems, such as the rearing of sheep for meat, wool and the local sale of milk, have a stronger market orientation.
The seasonal cultivation of maize (which is grown as sole crop or in association with squash, legumes and flowers), beans and oats is predominant in Xochimilco (Canabal 1997). However, flowers (roses, chrysanthemums and marigolds), legumes and vegetables (spinach, chard, various cabbage types, etc.) and herbs are also produced in the Chinampa.

The tools used in the Chinampa zone are of both pre-hispanic (such as the *coa*) and conventional or household (knives and spoons) origin.

The finest example of suburban agriculture is the Chinampa system in Xochimilco District, remnant of the pre-hispanic system that has survived the urban sprawl (Soriano 1999). The Chinampa system covers "islands" surrounded by the waters of the classic Chinampa, around which the population integrates urban concentrations of vegetable and animal production systems. An exception to this is the areas of Chinampa which have been altered and degraded by grazing milking cows and sheep, and a particular type of nursery in urban zones which have caused major changes in the ecosystem by the residues released into the water.

### 3.3 Periurban agriculture

The people in the periurban areas mainly live in extended families, and have retained strong links to the land and to their social and cultural traditions. In these zones, individual families live on the holdings. Labour tasks can be divided in heavy work for the father and adult sons, while the mother and younger children maintain and manage the backyard and family gardens, and market the produce. Extra labour is frequently hired for tasks that require more manpower, or when a family tries to take advantage of the market.

A particular type of periurban agriculture is found in the south of the city at a higher altitude. The production systems here maintain a spatially rigid distribution, determined by the intensity of the work involved and environmental factors, such as low temperatures. Within these mountainous areas, there are four production zones:

- agriculture within built-up areas, which concentrates on cowshed-based milk and meat production, work animals, backyard animal production and family orchards producing fruits, vegetables, *nopal*, medicinal herbs and ceremonial and ornamental plants;
- the zone next to built-up areas, which focuses on the intensive and largely traditional terraced-based system of producing *nopal*, vegetables and seasonal legumes (beans and *haba*). The *Malvón* flower is frequently grown in
association with *nopal*, cultivated as ornamental plants in city gardens and sold when freshly cut. A full range of tools and implements are employed in terraced *nopal* production. Mule-drawn ploughs are dominant, and the produce is transported from the field to the home by horses. In the valley, tractors are frequently used alone or in combination with mules or oxen for cultivation;

- the area neighbouring the *nopal* production area is considered a zone of transition by some researchers. Maize is produced as a sole crop or intercropped with squash, chili and *haba*, which substitutes for other beans; and

- adjacent to the forest lies a zone of integrated production which produces honey and fodder plants (principally oats) and provides natural pasture; the forest itself produces timber, fuelwood, mushrooms, resins and leaf-mould. Within the forest, an agrosilvipastoral system is applied, which is linked to nearby maize-producing zones, grazing areas and other forests, and ultimately serves to rear sheep and produce fibres.

Agricultural production is limited by environmental factors: scarce and poor-quality water (saline and contaminated by municipal drains), salinisation of low-lying areas, and upland soils not suitable for the traditional form of agriculture. There has been little transfer of technologies appropriate to the needs of farmers and the environment. Low market prices of staple grains and vegetables have not helped to promote production.

### 4. The contribution of urban agriculture to the household economy

An important aspect of urban farming systems is that they have no minimum or maximum size. The systems are managed on a small to medium scale, and thus enable large sections of the population to benefit. In addition, urban farms use space very efficiently by, for example, combining a house with a cowshed. This is an important aspect, as available land in Mexico City, at 2 m² per person, is among the lowest per person in the world. The agricultural systems have found a way to adapt to the conditions of a metropolis.

As a result of the wide diversity in urban agricultural systems, the contribution of urban agriculture to a particular household income also varies. Semi-industrialised and backyard production of swine brings in 10-40% of household earnings, while urban cowshed-based milk production can supply up to 100% of household income (Losada 1996). Backyard aviculture is practised for home consumption and, as such, brings practically no cash income.
In sub- and periurban areas, maize production provides 10-30% of the household income, although the greater part of the grain produced is directly consumed in the family. Vegetable and legume production, on the other hand, accounts for up to 80% of income, and for flower and ornamental plant production the figure is even higher. Nopal greens and tuna are largely channelled into the Mexico City market, and account for 100% of family income during the summer high season, or when prices are at their highest in winter. In this sense, the quality of life offered by the local authorities to the population with limited economic resources is ameliorated by the urban farmers' own efforts to find ways to improve family consumption or to complement the family's incomes.

4.1 Urban agriculture and employment

Urban agriculture has its greatest impact in the suburban and periurban zones, in which numerous families practice crop production and animal husbandry as a way of life. This is especially true in the areas with the greatest agricultural tradition: Xochimilco, Tláhuac and Milpa Alta. In other areas, periurban agriculture complements other economic activities in which the family engages, such as factory work, jobs in the civil service, and other formal and informal commercial activities like the preparation and sale of food and other services. Most notably, farmers in Xochimilco and the nopal-producing Milpa Alta often generate income, which either accounts for total household income or makes a significant contribution to it.

Within the southern parts of the Federal Districts, agriculture still retains considerable economic importance, especially in Xochimilco, Tláhuac, Milpa Alta, Tlalpan and Magdalena Contreras. In Tlalpan and Milpa Alta, for example, agriculture engages 1.3% and 19%, respectively, of the economically active population (XIth General Population and Housing Census 1990).

The Food and Agriculture Organisation (FAO) found in 1988 that the marshy Xochimilco zone generated around 12,000 jobs, proof enough that agricultural production still provides a significant benefit to the families involved. In Tláhuac about 1600 families continue to produce vegetables regardless of flooding and deteriorating water quality (Canabal 1997).

Floriculture, in particular the production of poinsettia and chrysanthemum, from its most rustic form to that of pot-based greenhouse cultivation is an activity of great economic relevance.
Table 2: *Profitability of flower production*

<table>
<thead>
<tr>
<th>Crop</th>
<th>Cost of production (US$)</th>
<th>Income (US$)</th>
<th>Profit (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poinsettia</td>
<td>0.8 per plant</td>
<td>1-1.2 per plant</td>
<td>25-50</td>
</tr>
<tr>
<td>Malvon</td>
<td>300*</td>
<td>500*</td>
<td>66</td>
</tr>
</tbody>
</table>

* Total production cost (including labour) in a greenhouse.

Source: Calculation on basis of information of San Luis Tlaxialtemalco Xochimilco’s Flower Enterprise and Canabal 1997

The impact of agricultural production within a truly urban setting is often more social and educational than economic. Projects of this nature supported by non-governmental organisations (NGOs), such as COCOMI AC, supply vegetables for home consumption to four out of five households during the rainy season, plus around 1,000 pesos per month per farming group to supplement their vermicompost sales, which do not ordinarily meet the groups’ needs.

In the case of the CEDICAR programme, the average "container orchard" ensures the supply of 20-30% of the vegetables consumed by a “standard” family of four people. This programme has little significance, however, to the family economy, because the average Mexican’s consumption of fresh vegetables is low. Generally speaking, no programme has managed to generate a completely sustainable supply of food.

These programmes of NGOs like CEDICAR AC and COCOMI AC and most of the programmes supported by donor agencies and foreign embassies have not yet proven their ability to stand alone. The majority of the programmes create only one to three jobs. Only programmes developed along more commercial lines generate more jobs. The income the development programmes have been able to generate is not so much from production, but through delivery of courses and the sale of prefabricated latrines, composting bins, worms, vermicompost and educational materials.

On average, according to official occupation figures, urban agriculture does not appear to be significant; and employment in this field has been reduced by 50% in the last 40 years. If farmers in parks and on rooftops do not organise their management and technology and generate economic surpluses, urban agriculture will make only small- to medium-sized contributions to family nutrition, and there will be no basis for true development in this field.
4.2 The marketing of urban agricultural products

Generally speaking, the better part of suburban and periurban agricultural production in the Federal District is destined more for home consumption than for the market. When production exceeds the home-consumption needs (and in the case of those products specifically destined for the market such as flowers, ornamental plants, vegetables, nopal and fresh medicinal plants), surpluses are generally sold on local markets or in central urban areas such as La Central de Abastos, La Merced and Jamaica. Only a few exclusive products are exported.

The most important products are sold in the wholesale market (La Central de Abastos). There are also locally important markets for flowers (four in Xochimilco) and for Jamaica in the V. Carranza district. Xochimilco supplied 30% of the Federal District’s ornamental plants in 1986 (Canabal 1992).

With respect to sales, the economic importance of nopal output from Milpa Alta stands out, as it represents 70% of the total value of production and nearly 100% of nopal consumption in the Federal District. In contrast, ornamental plants represent only 3% of total value of agricultural output in the Federal District, yet they account for more than 30% of local supply.

5. Urban agriculture and the environment

Environmental deterioration in the Federal District has its roots in the expansion of the metropolis, and is expressed in four main ways:

- deforestation and forest degradation: annually, 500 ha of forest are lost;
- soil erosion, compaction and extraction: it is estimated that 62% of the southwestern area of the city is in danger of erosion;
- reduced rainwater retention and infiltration as a consequence of urbanisation: the area’s aquifer is annually recharged by some 224 million m$^3$ of precipitation; and
- loss of biodiversity.

The detrimental effects that urban agriculture could have on the environment are minimal in comparison to the impact of industrialisation and urbanisation. In recent times, urban agriculture has functioned as a greenbelt, limiting the outward migration of the urban poor and the spread of urbanisation, and thus ensuring multiple land-use functions. Prime examples of this are Chinampas farming and nopal production.
A potential negative impact of urban agriculture within Mexico City's green spaces could be the heavy use of cow dung within the Chinampas and terraced nopal-vegetable models of agriculture, as there is a risk of nitrate contamination of the surface and groundwater.

5.1 Urban agriculture and waste recycling

On a daily basis, more than 15,000 tons of rubbish are produced in the city, of which 49.5% is organic and could theoretically be composted.

Three types of waste are used in urban agriculture: that from markets, the food industry (including restaurants) and the home. Wastes that are derived from larger markets (such as La Central de Abastos, which receives and distributes fruit and vegetables for the whole city and covers an area of 300 ha) come from the leaves of the brassica family and maize. Additionally, edibles comprising, e.g. carrots, squash, beetroot and maize, are fed to animals when they become unsuitable to be sold.

In the municipality of Cuautitlán, under a local government initiative, a small-scale project has been developed for the separation and recycling of household wastes. The results have been promising. At present, around two tons of compost are produced each month through aerobic digestion by weekly turning the decomposition beds with an excavator. This project started in 1991; however, only in the last four years has there been constant production. The compost is sold within the region to producers that have orchards.

Urban wastes are also used as a source of animal feed. An important aspect is that these are locally-produced residues which, under other circumstances, would contribute to the endemic waste and pollution problems of the city. Huelgas (1997) reports that 100 tonnes of waste are collected daily and fed to 2,500 stall-kept milking cows which, in turn, produce 37,500 litres of milk per day.

Waste, principally derived from tomato, is procured from the wholesale markets and fed to pigs, while in more localised markets throughout the city leaf and vegetable wastes are chiefly fed to rabbits. Solid wastes from the food industry (tortilla producers, maize millers, bakeries, confectioners, etc.) are used as concentrates rich in starch in the milk industry, backyard animal rearing and semi-industrialised pig farms. Pigs are also fed household wastes. Some pasture exists as “banks” that constitute a secondary source of forage for milking cows in urban areas.

The excreta from cowsheds and the semi-industrialised pig farms in different
places around the city form a substantial input for suburban and periurban agriculture, allowing for complex autotrophic systems to function (see Figure 1).

The farmers in Chinampa agriculture and the fixed systems in the valley, use dry manure (20% water content) applied directly to the crop (predominantly maize) or in soil/compost mixes. An alternate use of dry manure is the creation of compost beds in nurseries to produce purslain (Soriano 1998, Losada 1996). According to Soriano (1999), the equivalent of 800 tons of manure per ha per year is applied in the Chinampas and 600 tons per ha per year in the nopal-producing zone. Especially important to the terraced-based production systems are the roughly 5 tons of cuttings per ha per year that come from the annual pruning of nopal between March and May, and that are directly incorporated into the soil.

**Figure 1:**  
*Mass and energy flows between the different areas of urban agriculture*

The significance of the energy and macronutrient flows does not necessarily rest in the absolute levels of the energy and mineral balance, as the source is biological and renewable, unlike conventional production systems, which rely heavily on non-renewable resources such as fossil fuels. An important cumulative effect of both flows is that in the medium to long term, they build up soils together.
5.2 Urban agriculture and water management

In Mexico City, the potable water distribution network is in a highly deteriorated state: it is estimated that 40% of the potable water is lost through leaks. Cracks in the system result in persistent health threats, such as amoebas entering the water-supply system.

In the metropolitan area, numerous activities do not use water efficiently, e.g. the watering of ornamental plants, car washing and toilets (which on average use more than 20 litres at each flushing). There is minimal re-use of water or capture of home or community rainwater. Water-conservation campaigns have been initiated, but they incorporate only a few programmes, such as fixing leaks and promoting and installing water-efficient and/or dry toilets.

Detergents are commonly used and there does not seem to be any regulation on the horizon. It is common practice for businesses to dump oils, petrol, paint and other chemicals down the drain. Water is considered a vehicle by which wastes can be disposed of, without thought to the consequences. Within this context, urban agriculture as a strategy to manage and take advantage of water, has not been given the attention that it deserves by government, other agencies or environmental groups.

In general, the water used by the city's various cultivators to irrigate their crops is treated or grey. On occasion, the water treatment has not been adequate. It is remarkable that almost no urban farmer systematically collects and uses rainwater.

Table 3: Pollutants in Lake Xochimilco entering the agricultural cycle

<table>
<thead>
<tr>
<th>Soil</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium 7,000 ppm</td>
<td>Iron 144.25 ppm</td>
</tr>
<tr>
<td>Mercury 0.90 ppm</td>
<td>Copper 11.67 ppm</td>
</tr>
<tr>
<td>Cadmium 0.49 mg/l</td>
<td>Magnesium 3.5 ppm</td>
</tr>
<tr>
<td>Nickel 13 ppm</td>
<td>Zinc 104.18 ppm</td>
</tr>
<tr>
<td>Chrome 14 ppm</td>
<td>Lead 18.61 ppm</td>
</tr>
<tr>
<td>Lead 5.98 mg/l</td>
<td>Chrome 2.77 ppm</td>
</tr>
<tr>
<td>Zinc 1.28 mg/l</td>
<td>Cobalt 4.13 ppm</td>
</tr>
<tr>
<td>Copper 0.44 mg/l</td>
<td>Nickel 2.88 ppm</td>
</tr>
<tr>
<td>Iron 9000 mg/l</td>
<td>Cadmium 0.758 ppm</td>
</tr>
</tbody>
</table>

The problem surrounding agriculture and water resources in the region of Xochimilco encompasses ecological, political, economic and social components. It is a fact that the water is contaminated and that the lack of control regarding
water extraction from the city's aquifer, affects the lake, provoking falls in the level in some areas and flooding in others. This is not solely because of lack of information and technology, as some might claim, but more so because of political and economic matters that, under the banner of common well-being, respond to the interests of just a few.

6. Gender aspects of urban agriculture

Women - both as individuals and in groups - play a prominent role in urban agriculture. The socio-economic, political and cultural crisis with which women are confronted in Mexico has forced them to look for options to improve their standard of living. However, despite the fact that women are the principal actors in urban farming in Mexico, one hardly finds examples that intentionally focused on women's realities from the outset. A positive exception is the Social Ecology Promotion Group, which has tried to protect the environment and to improve the living conditions of its members for the last three years. Their projects have principally centred on the collective production of vermicompost and medicinal plants.

The group has been obliged to organise itself, to determine participation regarding work and to take decisions with respect to the generation and distribution of resources and training, etc. The participation of the group's members has, however, been slow and difficult. It is not easy for the women to assume control and take decisions, given their personal formation. They were always taught to conform and be obedient rather than to be creative and take initiative. This is even more the case for women who suffered from both class and gender oppression. Time and again, it has been hard for women to participate in group work and carry out household chores and have a paid job, all at the same time.

All members of the group engage in temporary and informal employment. On occasion, members can go for months without a job and, although the financial help provided by the project is small, it can be important. Over time, they have realised the necessity to undertake activities that not only contribute to the betterment or conservation of the environment, but also generate income which can sustain the group’s work, themselves and their families. On the other hand, a lack of training and overestimation of the leaders retard personal development and group work.
From the foregoing, it becomes clear that any urban agricultural project must take a flexible and open approach to the work, striving to minimise the work input of women, accelerate training and group organisation, and to generate resources for the project and its participants. Only when urban agricultural programmes are able to avoid tripling the workload of women will they become a realistic option for women and their families.

The experience of the Social Ecology Promotion Group demonstrates that a common objective and working opportunities promotes the organisation of women, which –together with a process of education – generates a positive impact. The impact is not only limited to the functioning of the group, but can also transform other aspects of women’s’ lives, such as those related to work and family.

7. Government policies and urban agriculture

An important limiting factor for suburban and periurban agriculture is the lack of economic incentives. Government policies over the last decade have not protected national agriculture, as the industry has been liberalised, and subsidies have been withdrawn. Moreover, there is no integrated environmental, economic and social policy to enhance agricultural activities.

The decision-making process regarding urban agriculture is centralised: only one institution is responsible for the development of urban agriculture in the city. Within this institution, the tendency is to ignore traditional systems of production and to focus on industrialised, input-intensive systems. This “Green Revolution” type of thinking was exemplified by the construction of a milk and pork production complex that resulted in the loss of all animals. In the case of crop production, the focus has been on the distribution of seed, agrochemicals, agricultural machinery, etc. In the last three years, however, control has been transferred to the municipal and district levels, although the “Green Revolution” thrust has remained.

Agriculture in the central zone is considered illegal. An arbitrary decision divides the city into two exclusive sectors - urban and agricultural - which determine the areas in which agriculture can be practised. As a result, urban expansion goes mainly into areas which were previously occupied by family dairy farms to the southeast of the city.
The government agency, Integrated Family Development (DIF), has promoted backyard family orchards on an intermittent basis through the Urban Orchards Programme. At present, however, this programme has been suspended because of underfunding and limited impact. The programme is now confined to distribution of vegetable seeds.

The goals of government programmes are hardly reached on account of unclear mandates of the different agencies in charge of urban planning and agricultural production, lack of co-ordination and duplication of activities by programmes with identical objectives.

In September 1998, a commission to solve agrarian conflicts such as property and land use was created. One month later, the local congress published the "Federal District Integral Rural Development Law Initiative". Even though this law initiative has not yet been approved, it is significant that the city's government recognises those rural zones still present in the metropolitan area "as a strategic region for the preservation of the environment, and as a guarantee for the fulfilment of the fundamental right of the inhabitants of the Federal District to feed themselves...". It is outstanding that this law mentions the importance of urban agriculture, not only at the periphery of the city but also in backyard gardens and other places, and promotes organic production.

In addition, the city government has organised a series of gatherings and fairs to promote waste-recycling programmes and the reforestation of green and conservation areas. The first rural fair of the Federal District took place recently, gathering a large number of micro-enterprises from the six districts with rural traditions during three days at Xochimilco's Ecological Park. A great number of visitors from different parts of the metropolis visited the fair.

8. Visions and future strategies for urban agriculture in Mexico City

Because of the lack of an institutional or economic order that limits the city's population growth, and because the economic system is incapable of satisfying the economic needs of the population through the industry and services sectors, the evolution of urban agriculture is facilitated by default.

One scenario, and possibly the most likely to occur within the next few years, presumes a passive attitude of the authorities regarding the production problems of Mexico City, which will only prolong the existing situation. The prevalent government perception of agriculture in the city's heart analyses and proposes
little, and maintains a marginal status, in terms of social and economic impact. Alternative ideas of academics and NGOs on urban agriculture in the heart of the city have not as yet been put into practice.

Suburban and periurban agriculture can be seen as the remnants of the onward march of the urban against the rural, which has resulted in the loss of the land’s agricultural value and traditions. It has brought an increase in consumerism and a dependency on externally-produced goods and foods. The loss of agriculturally productive spaces is increasing in the south of the city, where people live in overcrowded conditions in shantytowns and housing complexes. Urban agriculture can check uncontrolled urban sprawl through the creation of a productive greenbelt around the city, through the organisation of producers and through sound planning. The provision of low-interest loans, the promotion of alternative commercial production packages, the transfer of ecologically-appropriate technologies, culturally-appropriate training programmes, and policies aimed at sustainable urban development could all be elements for an effective urban agriculture policy.

The suburban areas are suffering intense pressure on housing and services, and a decrease in the productive capacity of the soil. Tourism and emerging agricultural activities (such as flower nurseries and tourist corridors) have developed because of the economic gains and, therefore, will co-exist with urbanisation of the area in the long term.

A second scenario starts from the necessity to develop economically-viable options for the periurban zone, especially in tourism and agriculture for a local or regional market. A good example of this is the nopal production system in Milpa Alta. Obviously, areas with less demographic pressures will have greater opportunities for developing innovative agricultural activities, integrated with other traditionally urban practices.

The aforementioned greenbelt would have to be well organised and the following conditions should be met:

• producers should be able to count on technology that will allow them to act as a pivot in rural development, which will contain the continuous migration to the city centre;
• the greenbelt should provide habitable and productive spaces, which would facilitate the people to retain much of their original cultural identity; and
the planning of the greenbelt should respect the agricultural and forest land use of the majority of rural holdings.

However, truly urban agriculture remains marginalised to the areas where NGOs and environmental activists are working, because it is not a strategy of large social urban movements, nor of governments, although their discourse suggests it.

A third scenario suggests that public policy in conjunction with the force of civil society, could generate strategies for sustainable development, whereby agricultural and forestry production play a role in solving the problems of food supply, waste recycling and weak local economies. Doing so would allow the simultaneous development of urban, suburban and periurban agriculture.

Likewise, appropriate economic policies would impede the growth of urbanisation and, at the same time, generate poles of regional development around areas of planned urbanisation, which would respect traditional agricultural areas.

9. Recommendations

It is important to understand that urban agriculture has many dimensions. It cannot be restricted solely to economics, nor to the urban centre. Urban agriculture includes cultural and social dimensions in the suburban and periurban spaces. It generates subsistence and co-existing strategies, and technological innovations. Government policies and university research and NGO programmes should take this perspective.

We found that the development of an agricultural urban economy which both involves subsistence products and is high-yielding guarantees families part of their food supply and marketable production at the same time. Such an economy should promote fair-trade networks under conventional schemes, but also allow the exchange of produce and services through bartering. It is essential that government supports this kind of project, making available the resources necessary to start the creation of micro-enterprises.

Urban agriculture should look towards strategies that promote a sustainable market-oriented agriculture (e.g. nopal and ornamental plant production), reducing the ecological impact of fertilisers and pesticides. Schools, civil groups
and local government should promote children's awareness of domestic food production\textsuperscript{4}.

In production for home consumption as well as commercial or mixed purposes, ecological agriculture should be promoted. From an ecological perspective, the development of urban agriculture entails a profound transformation of the existing economic model, as well as a radical change in the strategies and policies for urban development. For this, material and energy scarcities also need to be take into account. Following this perspective, the management of water and waste in the Mexican Valley should be completely modified. Nevertheless, even if economic and cultural changes are necessary, the sustainability of the city depends more on democratisation, governability and citizens’ participation in the planning and management of local and regional urban development and citizens’ security.

This necessarily implies decentralising political and economic power within the city.

A key question is whether the State is willing to start this process.

To start such a process we would like to suggest some concrete proposals related to urban agriculture for sustainable development in Mexico City:

- the application of ecological techniques in housing, to improve the quality of life of the citizens and to allow a more rational and integrated use of resources;
- the generation of urban-domestic production units (e.g. vegetables, flowers, mushrooms and medicinal plant production, small-animal rearing and productive waste management) and micro-enterprises to generate income and jobs. The micro-enterprises should operate at collective, individual and family levels and produce specialist products;
- the use of recycling as a way to save energy and material;
- the growth of local economies through the integration of different local businesses into larger, more regional business. This would allow the generation of sufficiently large volumes to compete in large markets, and likewise the acquisition of technologies, services and materials in bulk at lower costs;
- efficient and "snug" family orchards to secure home consumption of those horticultural products, which are in greatest demand in the central urban zone.
This would allow the creation of a barter network of vegetable interchange between the differing households and a certain degree of specialisation within individual holdings and, at the same time, maintain a variety of choice at the local level;

• the use of alternative central urban spaces, like large rooftops, patios, abandoned and other peripheral areas, in order to establish local enterprise units of a somewhat larger size, such as regional integrated enterprises; and

• to appreciate urban agriculture in the central zone, in environmental, cultural and economic terms, its activities should not be restricted, but its proper environmental management and regulation should be strengthened.

1 These characteristics were defined according to the distribution of soil type within Mexico City's metropolitan area (García 1992).
2 Fruit of the nopal cactus.
3 This is called the Agriculture and Ranching Social Relationship Index (ARSRI). A factor contributing to the flexibility of this ARSRI is the presence of backyard animals in family-based production systems, and its relation to religious, social and cultural festivals, expressed in the preparation of local culinary dishes.
4 First-generation low-income migrants in Mexico City may develop small orchards to produce maize, squash or fruit trees in their homegardens, but their children and children’s children, who have no cultural link with the land, generally lose interest in food production.
References


Appendix 1: The Chinampa production system