

Urban agriculture in the metropolitan zone of Mexico City: changes over time in urban, suburban and peri-urban areas

H. Losada, H. Martínez, J. Vieyra,
R. Pealing, R. Zavala and J. Cortés

All but one of the authors are from the Animal Production Systems Area, Department of Biology of Reproduction, Universidad Autónoma Metropolitana in Mexico City. R. Pealing is a researcher from the UK, sponsored by the interchange CONACYT- British Council. The authors wish to thank Mr. Richard C. Bennett, a researcher from the UK sponsored by the interchange CONACYT- British Council, for reviewing the paper and the authorities of the Universidad Autónoma Metropolitana (Autonomous Metropolitan University) for the facilities given.

Address: Animal Production Systems Area, Department of Biology of Reproduction, Division of Biological and Health Sciences, Universidad Autónoma Metropolitana-Iztapalapa, Av. Michoacán y La Purísima, Col. Vicentina, Iztapalapa, CP 09340, México DF 1. Mexico.

SUMMARY: *This paper describes the scale and nature of agricultural production in urban, suburban and peri-urban zones of Mexico City and how these have adapted to the changing demands from urban populations for food, wood and recreation. It also demonstrates how agricultural producers have successfully adapted their products and their production methods, including building on traditional production systems, despite the environmental deterioration brought about by urban development and the lack of support from government. These agricultural producers have also devised new ways of using degraded land and large volumes of waste. The authors also describe how appropriate support for this diverse production brings many ecological advantages and supports a great range of jobs – but also implies important changes in the ways in which city authorities manage urban expansion.*

I. INTRODUCTION

THIS PAPER DESCRIBES the transformation of agriculture in Mexico City from a conventional rural form to a new urbanized model, as a reaction to urban development and the availability of waste products from the city as well as a response to the demands of recreation and tourism. From this has emerged a new concept of the rural producer or urban farmer who now has access to an urban infrastructure, to education and research. The development of these new production systems has also influenced spatial organization, with the introduction of new crops to meet a changing urban demand. The final part of the paper looks at the development of these urbanized systems within the context of sustainability.

II. HISTORICAL ASPECTS OF MEXICO CITY'S AGRICULTURE

1. Cardoso, M.D. and E. García (1982), "Vegetation and climate in the basin of Mexico", Latin American regional conference IGU, Brazil, "Geographical Topics of Mexico City and its Environs", Instituto de Geografía, UNAM, México, pages 19-24.

2. Armillas, P. (1949), "Notas sobre sistemas de cultivo en Mesoamérica. Cultivos de riego y humedad en la cuenca del río Balsas", *Anales INAH*, México.

3. Clavijero, F. (1979), "Historia antigua de México", Porrúa, *Colección Sepanquantos*, México.

4. Ixtlixóchitl, F. (1975), *Obras históricas*, Ed. O'Gorman, México, UNAM, Instituto de Investigaciones Históricas: historiadores y cronistas de indias 2, México.

5. Semo, E. (1995), "México, un pueblo en la historia. De la aparición del hombre al dominio colonial", Alianza Editorial, séptima edición en El libro de bolsillo, México.

6. Rojas, T. (1990), "La agricultura en la época prehispánica" in *La agricultura en tierras mexicanas desde sus orígenes hasta nuestros días*, Consejo Nacional para la Cultura y las Artes, Grijalbo, México.

7. Romero, M.A. (1990), "La agricultura en la época colonial" in *La agricultura en tierras mexicanas desde sus orígenes hasta nuestros días*, Consejo Nacional para la Cultura y las Artes, Grijalbo, México.

THE VALLEY OF Mexico is made up of many different regions and sub-regions, each with its own distinctive natural conditions and diverse ecological characteristics.⁽¹⁾ It is situated at an altitude of 2,429 metres above sea level, covers 9,600 square kilometres and is surrounded by a volcanic mountain range. It includes parts of the states of Mexico, Tlaxcala, Puebla, Hidalgo and the federal district of Mexico City. The climate is temperate humid in the south, temperate dry in the centre and the north, with permanent snow in the mountains, and the natural vegetation consists largely of pine forests and grasses.

The first inhabitants of the valley appeared 22,000 years ago and consisted of nomadic groups who were hunter/gatherers.⁽²⁾ The change to a sedentary population, in approximately 8,000 BC, coincided with the introduction of an incipient agriculture.⁽³⁾ These populations formed the first human settlements (ca. 700 BC) and gave rise to highly complex and organized urban environments such as once existed at Teotihuacan. At the beginning of the Christian era, urban structures increased in both number and organization, which led to the formation of important political, economic, religious and administrative urban centres, culminating some time between 1200 and 1500 AD when the greatest cultural changes occurred.⁽⁴⁾ At this time, there was an estimated population of 20 million in Mexico.⁽⁵⁾ The sustenance of such a variety of urban cultures was undoubtedly related to the complex pattern of intensive agriculture and to the different forms of production that existed. These were closely linked to the environmental conditions and topography of the region. Within this complex agricultural landscape, six models of production stand out:

- the *chinampas* (floating plots) in the wetland zone, a form of intensive agriculture that used silt and human excrement as a source of organic matter;
- slash, fell and burn;
- slash and burn;
- the terraces of the highland zones;
- the family orchard (or kitchen garden);
- the backyard, where a mixed cultivation of maize, vegetables, flowers, fruit, turkeys, ducks and dogs existed.⁽⁶⁾

The conquest of Tenochtitlan by the Spanish in 1524 brought with it fundamental changes for the valley of Mexico, with the incorporation of new species of vegetables, domestic animals and grains, and the introduction of European technologies.⁽⁷⁾ These new techniques had an important effect on the ecological conditions of the valley. The growth of mining activities, a new politico-administrative structure and the devaluing of native agricultural technologies were among the factors that had a detrimental impact on the environment. Examples of these impacts include:

8. Hernández, X.E. (1985), "Exploración etnobotánica y su metodología. Xolocotzia", *Revista de Geografía Agrícola* Vol.1, pages 163-188, Universidad Autónoma de Chapingo, México.

9. Miño, G.M. (1991), *Haciendas, pueblos y comunidades. Los valles de México y Toluca entre 1530 y 1916*, Consejo Nacional para la Cultura y las Artes, México.

10. Bataillon, C. (1972), *La ciudad y el campo en el México central*, XXI Siglo Veintiuno Editores, S.A. México.

- the draining of the system of lakes into one single lake (Xochimilco-Chalco), inevitably affecting the *chinampas*;
- the deforestation and intensification of labour in the highest areas of the valley, restricting the development of the terraces and the slash, fell and burn agricultural systems, and replacing them instead with permanent agriculture.

There were, however, some positive impacts. For example, new species of plants were very successfully introduced (indeed, Mexico has been described as "an adaptation laboratory for new species",⁽⁸⁾) as were some important species of livestock such as cattle and horses, sheep, goats, pigs and poultry.

Over time, agriculture in the valley of Mexico maintained a mixed form of production that both supplied the urban population and met subsistence needs. There were some basic changes in land tenancy but these did not affect the organization or distribution of goods. During the first half of the nineteenth century, three major zones of supply could be identified:

- the area to the north and west, where the *haciendas* supplied the urban centre with maize, wheat, barley, beans, potatoes, livestock and their products;
- the area to the east, which supplied maize, wheat, barley, beans, fruit and *pulque* (a partially fermented drink produced from the agave);
- the region to the south of the city, which supplied vegetables, horticultural products and other fresh goods such as meat, milk, butter and cream. This region was also very important as a major producer of *pulque*.⁽⁹⁾

At the end of the nineteenth and the beginning of the twentieth century, within the context of the country's programme of modernization under president Porfirio Díaz, the development of urban or industrial land use was favoured at the expense of the agricultural sector. This resulted in the displacement of agricultural land, the diversion of water for domestic or industrial uses, and the strengthening of the paper, wood and charcoal industry. The exploitation of the forest related to the latter stimulated the development of a new form of agricultural production, the *tlacolol*, made up of small parcels of land within the forest which allowed the seasonal cultivation of maize, beans, squash and chillis, for subsistence use.⁽¹⁰⁾ These models of production, which were supplying the metropolis, prevailed until the middle of the twentieth century, at which stage urban growth entered a new phase, bringing about profound changes in the way agricultural activities were carried out in the region.

III. EXPANSION OF THE METROPOLIS AND ENVIRONMENTAL DEGRADATION LINKED TO THE AGRICULTURAL SECTOR

THE PERIOD OF the Mexican Revolution (1917-1919) and the Lázaro Cardenas régime (1930s) saw the realization of promises of agrarian reform and support for the development of a rural infrastructure within Mexico. The end of the 1940s saw the Green Revolution⁽¹¹⁾ and the resulting phase of agricultural prosperity known as “the Mexican Miracle”. Associated with the success of the Green Revolution was a steady migration from rural areas to the metropolis. As a result, Mexico City began a phase of enormous population growth and developed “western” aspirations that were to have serious repercussions on the regional models of agriculture. To illustrate this, data available⁽¹²⁾ for the period 1940-1980 show an expansion of the urban zone from 11,753 to 100,000 hectares, the city’s greatest growth since its foundation by the Spanish in 1524. This growth was, undoubtedly, connected to migration and to the demographic explosion that occurred during this period (see Figure 1).

11. Reyes, C.P. (1981), *Historia de la agricultura. Información y síntesis*. AGT, Editor, México.

12. Departamento del Distrito Federal DDF (1985), “*Imágen de la gran capital*”, *Enciclopedia de México*, S.A. de C.V. Almacenes para los trabajadores del Departamento del Distrito Federal, Ciudad de México, MCMLXXXV.

Figure 1: Population Growth in Mexico City

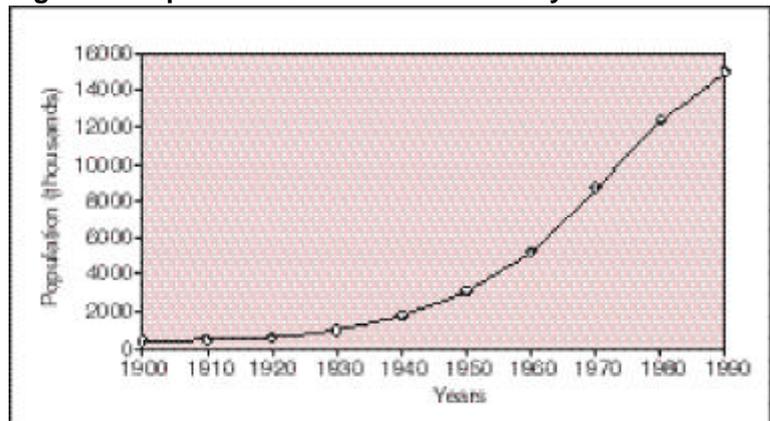
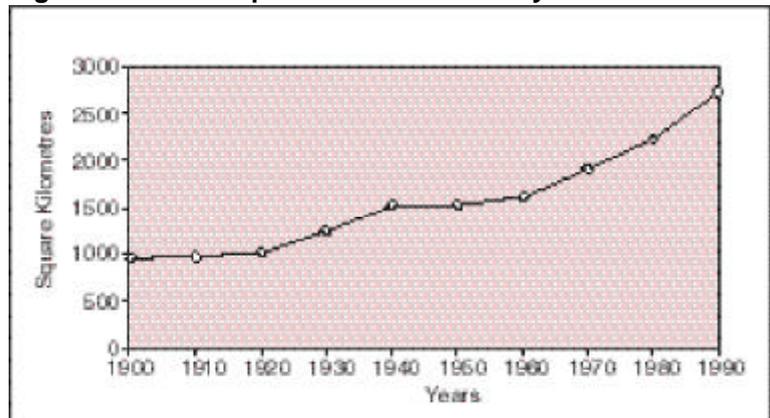


Figure 2: Urban Expansion of Mexico City



SOURCE: Departamento del Distrito Federal DDF (1985), “*Imagen de la gran capital*”, *Enciclopedia de México*, México; also INEGI (1994), “*Estadísticas históricas de México*”, Instituto Nacional de Estadística, Geografía e Informática, México.

In contrast to the major contemporary urban centres in other parts of the world, where vertical development has occurred, the nature of the sub-soils and the high water table in the valley of Mexico determined that the growth of Mexico City should be predominantly horizontal, occasioning the invasion of agricultural land and rural outskirts that had previously made up a natural "green belt" around the city. The three previously mentioned zones of agricultural supply were replaced, with the areas to the north and west of the city being developed as industrial zones, and the areas to the east and south being diverted towards housing. The changes that have taken place in this latter area have affected the ancient system of canals and impeded the natural flow of water. This, in turn, has led to the irreversible process of salinization, causing stagnation of the Xochimilco-Chalco lake. The lake's deterioration has been further exacerbated by the diversion of its natural water sources to meet the city's growing need for potable water; also, liquid waste disposal from the expanding urban and industrial zones has increased the concentrations of heavy metals, detergents and pathogenic organisms in the water.⁽¹³⁾ These new conditions caused the water hyacinth to flourish, making navigation of the canals difficult and inhibiting the growth of endemic flora. These changes have also substantially altered the land use patterns of the *chinampa* zone. Sensitive crops such as tomatoes have disappeared and the conditions that enabled cultivation could only be maintained with the use of chemical fertilizers, insecticides, herbicides and fungicides, further augmenting the levels of water, soil and air pollution⁽¹⁴⁾. Furthermore, the paper manufacturers and timber companies, who were located in the adjacent highland zones, have initiated an irreversible process of deforestation leading to extensive areas of erosion. This has been exacerbated by indiscriminate use of the area by city dwellers in their pursuit of "open space" and countryside activities. The cultivation of *maguey* for the production of *pulque* has been affected by climatic changes, and the temporal lands where subsistence crops such as maize, beans, wheat etc., were cultivated have been abandoned due to a shortage of water.

At the beginning of the 1970s, a presidential order reclassified the city's administrative and political regions into "urban" and "agricultural". Of the city's 16 political regions, only seven were allowed to develop as agricultural zones.⁽¹⁵⁾ This new classification led to important changes in land prices, with land becoming more valuable for its potential for urban development than for its original agricultural use, thus stimulating the urbanization of any remaining areas of "green belt". Within this process of uncontrollable urban growth, livestock production and agricultural activities that had previously taken place in these regions were either displaced (and relocated in neighbouring zones) or engulfed by the urban mass to remain as "islands" of agriculture within the metropolis (such as the dairies of Iztapalapa⁽¹⁶⁾). This phenomenon has been strengthened by the creation of large distribution centres where agricultural products from the surrounding states are collected and redistributed within the city. Such centres include the metropolitan food

13. Balanzario, Z.R. (1976), "Contaminación de las aguas en los canales de Xochimilco", UNAM, Facultad de Filosofía y Letras, Colegio de Geografía, México.

14. Canabal, C.B., Torres-Lima, P.A. and R.G. Burela (1992), "La ciudad y sus chinampas. El caso de Xochimilco. Primera parte. La expansión metropolitana y el medio rural del Distrito Federal", Colección Ensayos, UAM, México.

15. Sánchez, L. (1982), *Comisión coordinadora para el desarrollo agropecuario del distrito federal. Memoria 1978-1982*, Fuentes Impresores, S.A. Departamento del Distrito Federal. México.

16. Losada, H., Cortés, J., Grande, D., Rivera, J., Soriano, R., Vieyra, J., Fierro, A. and L. Arias. (1996a), "The production of milk from dairy herds in the suburban conditions of Mexico City. I. The case of Iztapalapa", *Livestock Research for Rural Development* Vol.8, No.4, page 53.

Table 1: Indicators of Air, Soil and Water Pollution

Air pollution: mean values of air contaminants in the city			
Pollutant	MIEC (one year average)		
Nitrogen dioxide	40		
Carbon monoxide	47.5		
Sulphur dioxide	32.5		
Suspended particulates	142.5		
Ozone	103.5		
*Metropolitan Index for Environmental Contamination. The scale used to express concentration of air pollutants is as follows:			
MIEC value	Health effects		
100	Good — no danger to health		
200	Unhealthy — people with heart/respiratory problems should reduce physical activity		
300	Very unhealthy — as for 200; also applies to elderly people		
400	Dangerous — healthy people to avoid outdoor exercise		
500	Very dangerous — people advised to avoid physical activity and use of vehicles		
Mean values of contaminants of soil and water in Xochimilco's lake (which is used for agriculture)			
Soil contamination	Water contamination (parts per million)		
Aluminium	7,000 ppm	Iron	144.25
Mercury	0.90 ppm	Copper	11.67
Cadmium	0.49 mg/l	Magnesium	3.5
Nickel	13 ppm	Zinc	104.18
Chromium	14 ppm	Lead	19.61
Lead	5.98 mg/l	Chromium	2.77
Zinc	1.28 mg/l	Cobalt	4.13
Copper	0.44 mg/l	Nickel	2.88
Iron	9,000 mg/l	Cadmium	0.758
SOURCES: Departamento del Distrito Federal (1994), <i>Red de Monitoreo Ambiental de la Zona Metropolitana México</i> ; also Peralta, M. (1983), <i>Determinación de algunos metales pesados en suelos agrícolas de Xochimilco</i> , Tesis de GRB, ENCB, IPN, México; Miramontes, B., Arroyo, L. y J.M. Tarín (1988), <i>Informe final del proyecto de investigación: estudio ecobiológico de la zona lacustre de Xochimilco-Tláhuac</i> , Departamento de Producción Agrícola y Animal, UAM-Xochimilco, México; and Moreno Y., Méndez T., Arana F. and A. González (1996), <i>Estudio preliminar sobre la concentración de metales pesados en tres de las especies de carpas más importantes en la zona lacustre de Xochimilco: memorias del 2do. Seminario de Xochimilco Tomo II</i> , México D.F.			
Coliforms in water, vegetables and soil of Xochimilco			
Source	Faecal coliforms per 100 ml	Total micro-organisms per 100 ml	
Irrigation water	1,600	13,000	
Vegetables	1,000	3,200	
Soil	1,200	100,000	
SOURCE: Couñño, M. (1984), <i>Evaluación bacteriana en vegetales irrigados con aguas negras en la zona de San Gregorio, Xochimilco</i> , Tesis de Biología, Facultad de Ciencias, UNAM, México.			

supply depot in Iztapalapa which, constructed on an ancient area of *chinampa*, generates huge quantities of fruit and vegetable waste.

The general effect of urbanization has been the generation of urban pollution as shown in Table 1. This has inevitably affected the resources – water, soil and air – and the agricultural environment, reducing the production of traditional crops such as maize. This situation has been compounded by the aban-

donment of agricultural activity in favour of steady work within the city, leading to a vicious circle of deserted farmland, urban expansion and pollution. The extent of the detrimental effects of these pollutants on humans, animals and plants has not yet been well evaluated. In order to hide the real effects of air pollution, the government produced an awkward system of measurement called the Metropolitan Index for Environmental Contamination (MIEC) based on an arbitrary scale as shown below.

Urban expansion was such that outlying villages became incorporated into Mexico City, forming the concept of a municipal conurbation or metropolitan zone. The metropolitan zone is defined as the area containing the city centre and the political and administrative functions. Its characteristics are typically urban, representing the place of work and residence of non-agricultural workers. The process of urbanization "burst" the political boundaries of the politically defined federal district and a number of municipalities from the state of Mexico were incorporated into the city, engulfing livestock production, causing the abandonment of other agricultural activities and leading to further deterioration in the environment. The neighbouring regions of these degraded areas, such as what remains of the old lake Texcoco, have started to generate new forms of pollution made up of dust and excrement storms (suspended particles). These reached such a level in the 1980s that the government implemented its first "ecological rescue plan" aimed at eliminating the dust-excrement storms and returning the lake to its original role as a habitat for migrating birds. Nevertheless, the urban spread continued, inevitably affecting certain ecosystems (e.g. the forest regions) not only because of building but also because of new uses for these resources as a result of urban demand. Examples include the demand for Christmas trees, the extraction of leaf mulch for use in urban gardens and the collection of firewood for heating wealthy urban homes. This degradation of the forest environment has culminated in a devastating plague of bore worms which, to date, has proved impossible to eradicate.

The local authorities have attempted to stall the process of environmental degradation with ambitious reforestation plans, proposing the use of non-native species such as eucalyptus. However, rather than helping, this policy has accelerated the deterioration of natural habitats with the eucalyptus inhibiting the growth of native vegetation and consuming large quantities of water whilst failing to fulfil its role in erosion control and timber production.

By the end of the 1980s, the pressures of urbanization and the threats to the traditional agricultural zones were on-going. This was particularly evident in the area of *chinampa* on Xochimilco. Here, the problem was exacerbated by modifications to Article 27, which legitimized the sale of *ejidal* land (lands vested in peasant communities by agrarian reform), which was considered the last vestige of "green belt" containing the urban spread. A government proposal focusing on "ecological rescue" and the prohibition of construction in ecologically sensitive areas was their attempt to halt this movement and loss of "green belt".⁽¹⁷⁾

17. DDFb (1989), *Rescate ecológico de Xochimilco*, Folleto, DDF, México.

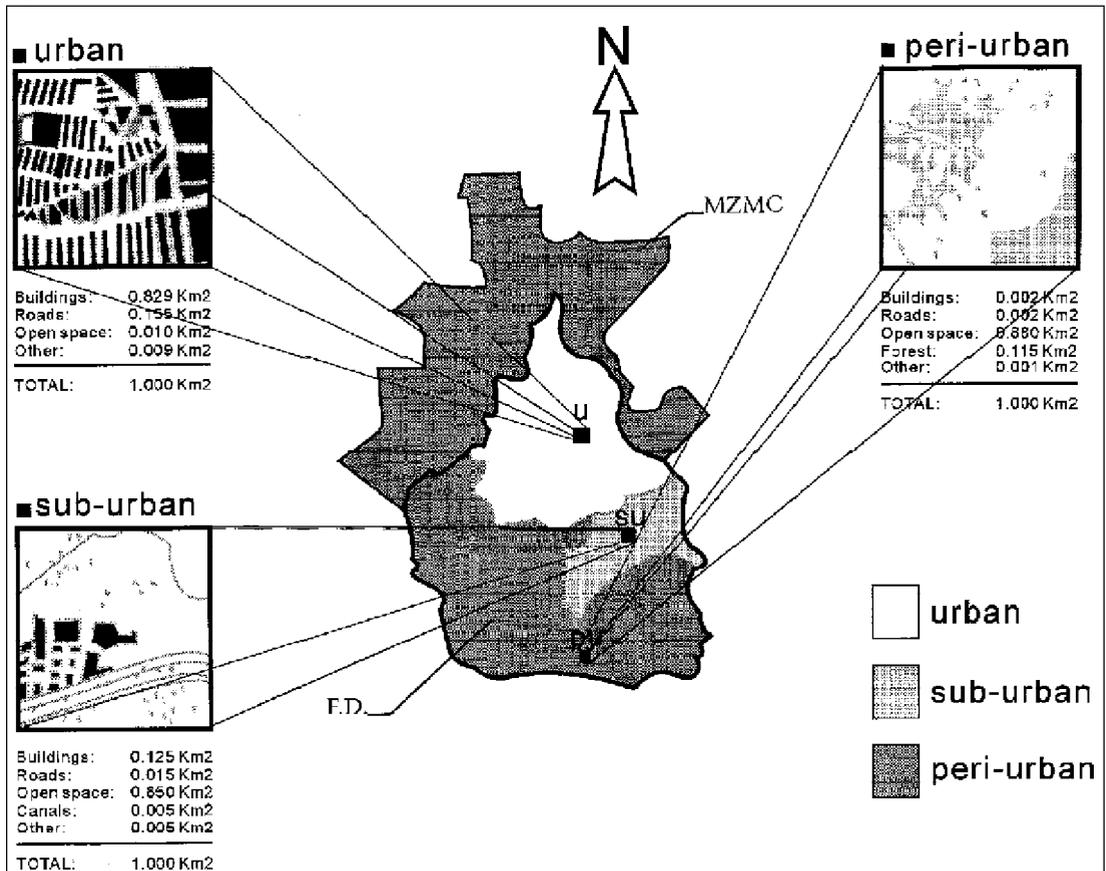
18. Schteingart, M, (1989), "The environmental problems associated with urban development in Mexico City", *Environment and Urbanization* Vol.1, No.1, April.

The 1990s marked the end of this stage of urban expansion – checked by economic crisis and a concern to conserve what natural resources remained. The result of this excessive urban growth is reflected clearly in the city environment, where the average area of open space per person is two square metres compared with an international urban average of ten square metres. During this same stage of urban growth, 73 per cent of the forest area, 99 per cent of the wetlands and 71 per cent of the soil was lost; and it has been calculated that 700 hectares of agricultural land is engulfed by urbanization every year.⁽¹⁸⁾

IV. THE ADAPTATION OF AGRICULTURAL PRODUCTION TO A NEW ENVIRONMENT

IN SPITE OF the environmental degradation and expanding metropolis which have put great pressure on the traditional forms of agriculture, the powerful pre-Hispanic antecedent whereby lifestyle and culture are strongly linked to agriculture

Figure 3: Characterization of the Metropolitan Zone of Mexico City (MZMC) including the Federal District (FD) in terms of Land Use in an Urban, Suburban and Peri-urban Space



19. García, C. (1992), *Guía Roji, ciudad de México, area metropolitana y sus alrededores*, 59ava Edición, México.

20 . Losada, H., Grande, D., Vieyra, J., Arias, L., Pealing, R., Rangel, J. and A. Fierro (1996), "A sub-urban agro-ecosystem of nopal-vegetable production based on the intensive use of dairy cattle manure in the south-east hills of Mexico City", *Livestock Research for Rural Development* Vol.8, No.4, page 66.

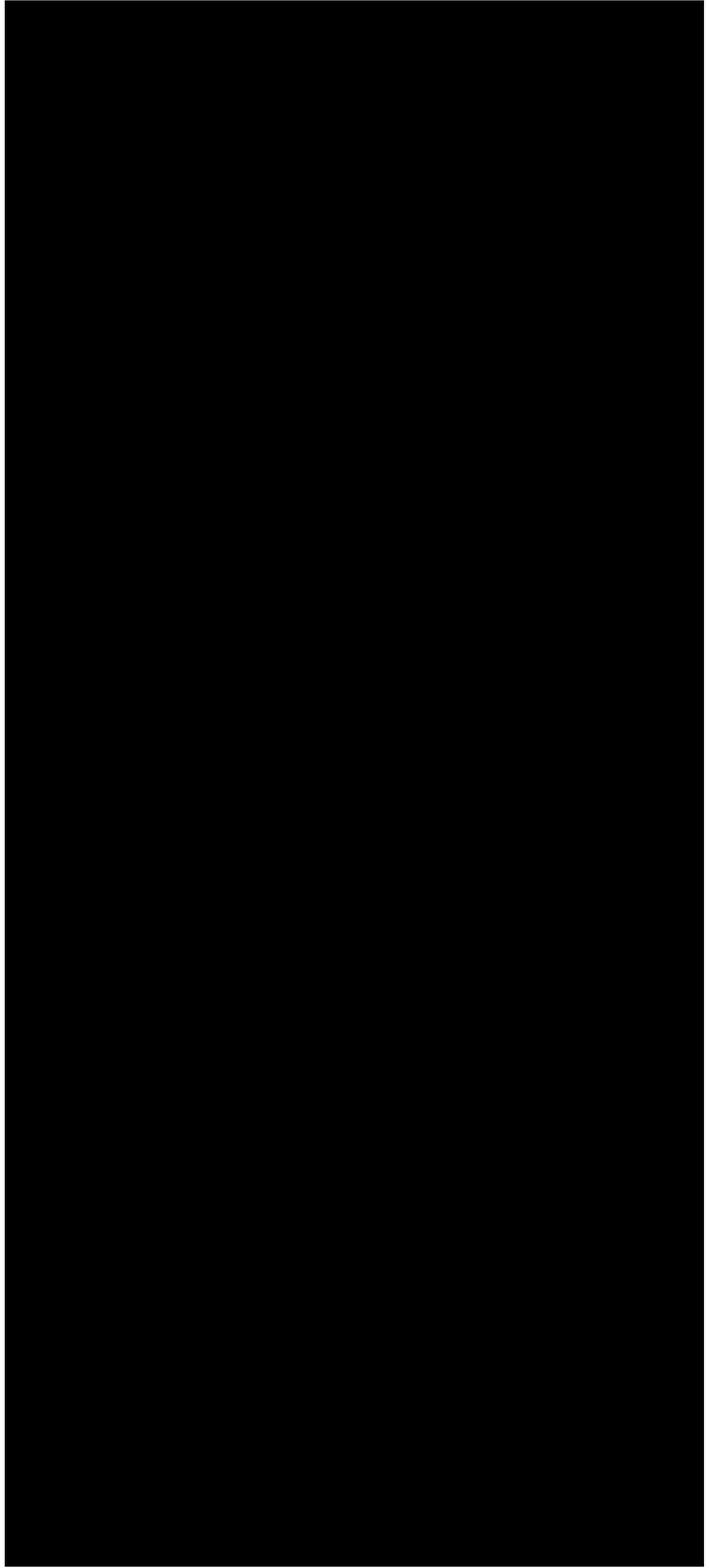
has ensured the survival of these traditional systems of production. This survival has been reinforced by the relationship between western urbanization and agriculture as illustrated, for example, in the activities of gardening or keeping pets. New ways of using agricultural space have emerged, starting with the creation of a network of socio-economic relations that have had a qualitative impact on regional agriculture. It is within this context that three agricultural spaces have been identified: urban, suburban and peri-urban. Figure 3 shows the metropolitan zone of Mexico City (MZMC), including the federal district (FD), characterized in terms of the three new land use spaces (indicated as: U, SU and PU). An area of one square kilometre was randomly chosen from the official street map⁽¹⁹⁾ to illustrate land use characteristics of the new spaces by means of several indicators relating to urban development.

a. The Urban Space

The urban agricultural production space is derived from the livestock practices that existed before the process of urbanization. An important characteristic of this model is that the farming systems are framed within the "urban" concept, with access to infrastructure and public services causing a rise in land prices. The increases in land value occasioned the combination of the home with the processes of production and stimulated an intensification of land use for agricultural purposes. An extension of this is the reversion of urban spaces, for example using the flat roofs of houses to keep animals and using public gardens and sidewalks for grazing. However, the most important characteristic of the urban model is its foundation on two fundamental premises: first, the availability of vegetable wastes from the city's large markets and food-processing plants as a supplement to the animals' diet; and second, the sustained demand from the local population for the resulting agricultural products. A further consideration is the additional pressures of producing within an urban environment that do not exist within the rural equivalent. This is most clearly illustrated by the problem of agricultural waste, the pressure of disposal of which within the urban environment has, by necessity, led to the development of a "chain of use" whereby the waste produced by the cattle and pigs of the urban agricultural model is used as a source of organic material in the suburban and peri-urban models of agriculture.⁽²⁰⁾

The dominant population in the urban space is a heterogeneous local or migrant one which has maintained its own culture, and the lack of agricultural space has ensured that animals are culturally and socially linked to the human environment. The main systems of this model include backyard livestock with chickens, turkeys, ducks, geese, pigeons, ornamental birds and "sporting" birds (e.g. fighting cocks), rabbits and pigs; dairy cattle for milk and meat production; a system of pig production derived from conventional mechanized farming systems; and, finally, a system based on the traditional agricultural orchard, the family garden which allows the cultivation of vegetables and

Table 2: Distribution of Livestock in the Three Zones of the Metropolitan Area of Mexico City in 1990



herbs, medicinal and ritual plants, and decorative plants. Table 2 denotes the presence of livestock in the three different spaces of the metropolitan zone of Mexico City. Actual figures for urban zones are likely to be higher since it is "illegal" to raise livestock in urban areas and, in some delegations, the census thus tends to ignore their presence. Also, people are likely to under-report the amount of livestock they own for fear of taxes or legal action. It is interesting to note that there is a larger number of hens in the urban space than in the peri-urban one despite the latter's much greater area and thus potential for keeping livestock. This phenomenon confirms the hypothesis discussed above that urban spaces are suitable for livestock production.

b. The Suburban Space

A second agricultural production space resulting from the urban environment is the suburban model. Here, the new urban infrastructure has been superimposed upon the original rural setting, forming a new frontier to agriculture. Despite an intensive use of space, derived from the pressures of urbanization, land prices fluctuate between agricultural and urban levels, acting as an indicator of the viability of an agricultural land use. These areas tend to be the "reception" areas for provincial migrants looking for permanent employment in the city whilst still retaining ties with their original communities. The result is a multi-cultural social structure.

The best example of suburban agricultural space is the *chinampa* of Xochimilco, where a traditional form of agriculture has been modified in order to function within a degraded environment. Traditionally used for the production of vegetables and flowers, the *chinampas* are now used for the cultivation of maize in order to meet the demand from the city's inhabitants for *elote* (corn-on-the-cob) and grass turf for use in urban gardens.⁽²¹⁾ An alternative is the cultivation of *romero*, a species well-adapted to degraded conditions and which reflects the traditional culture of the region (being used in the celebrations of Lent, Day of the Dead and Christmas). Also, the availability of contaminated water and silt and the lack of productivity have led to a system based on greenhouses and market gardens which can respond to increased demand for such goods from the growing middle and upper-class sectors of the city. These changes in the modes of production have led to a reorganization of the *chinampa* space, allowing traditional systems such as dairy production, backyard production and family orchards to exist alongside new uses of large areas of previously degraded land, thereby improving the quality of life for the local residents.

Another factor influencing the reorganization of the *chinampa* space is the traditional role of Lake Xochimilco as a recreational resource, attracting tourists from both Mexico and overseas. This has led to a new use of the suburban space as a centre of family recreation and as a place to discover nature and the culture lost in the process of urbanization. This combination of tourism and agriculture has provided the impetus for a revitalization of pre-Hispanic and colonial traditions, which is reflected

21. Camacho, P.R. (1995), "La situación actual de la agricultura chinampera de Xochimilco, distrito federal" in Rojas, T. (Coordinator), *Presente, pasado y futuro de las chinampas*, Patronato del Parque Ecológico de Xochimilco, A.C. y CIESAS, México.

22. Losada, H., Pealing, R., Soriano, R., Rivera, J., Cortés, J., Vieyra, J. and H. Martínez (1997), "The rapid appraisal of the sustainable Region of Xochimilco by the study of local markets in the south-east of Mexico City", *Live-stock Research for Rural Development* Vol. 9, No.3 (in press).

in the market in Xochimilco where both traditional and consumer goods can be found.⁽²²⁾ In this way, tourism has been responsible for the rescue of ancient forms of production such as the consumption of *mextlapiques* (fish roasted in maize leaves) and also for the stimulation of new forms of production to meet tourist demand such as the cultivation and sale of the Christmas Rose. Finally, it has opened the door for products coming in from neighbouring regions such as the *nopal*-legume and timber products from Milpa Alta.

Table 3 shows areas of crop land in the urban, suburban and peri-urban zones. As mentioned above, land available for crops in the urban zone is very scarce, with larger areas being available in the suburban and peri-urban zones. During the Spring/Summer season, the suburban zone shows larger areas of crop land use than the peri-urban zone. This is due to the presence of the *chinampas* in the suburban space, which is mainly devoted to vegetable production during the rainy season (May-September). In the peri-urban zone, in contrast, perennial crops constitute the greatest land use.

Table 3: Seasonal Use of Crop Land in the Three Zones of the Metropolitan Area of Mexico City in 1990

Area (hectares)	Spring-Summer	Autumn-Winter	Perennial	Not sown
Urban zone				
Total	300,334	6,203	2,619	25,922
Mean per delegation/municipality	18.4	2.6	1.2	1.6
S.D.*	108.5	2.3	0.5	18.1
Suburban zone				
Total	12,174.9	920.9	739.2	2,698.9
Mean per delegation/municipality	1,039.6	40.8	68.3	226.8
S.D.*	1,232.3	131.6	68.2	268.3
Peri-urban zone				
Total	10,931.5	338.7	12,300.2	3,477.5
Mean per delegation/municipality	525.9	17.5	131.3	169.6
S.D.*	2,129.5	61.7	4,129.7	710.0
* Standard Deviation				

SOURCE: NEGI (1990), *Censo Agrícola, Ganadero y Forestal*, Instituto Nacional de Estadística, Geografía e Informática, México.

c. The Peri-urban Space

A third agricultural production space is the peri-urban model. This consists of the last remaining rural spaces in the metropolitan zone and, although there is an urban infrastructure and clear indications of an urban influence, there remains a predominantly rural ambience. The meeting of rural and urban has created a new concept of the "metropolitan village", where a rural way of life is mixed with a city culture. This, in contrast to

the suburban model, has allowed agricultural land use to remain sufficiently profitable vis-à-vis urban land use and is due to the existence of a mono-cultural society which has prevailed despite immigration. However, it is clear that the influence of the city has affected the manner of agricultural production. One such change is in the pattern of land tenancy whereby, in recent years, private ownership has been granted to land which has, traditionally, been communal.

A second important change is the predominance of small properties rather than the large areas of cultivation characteristic of the conventional rural sector.⁽²³⁾ This is associated with the potential use of the land for urbanization and with the preoccupation of individual producer activity over the communal activities of the past. In relation to the form of production, the peri-urban model maintains a pattern of production dependent on income from both the land and urban employment so that family incomes are likely to be the sum of several activities: agricultural and commercial activities and permanent employment within the city. An additional factor which has reinforced the urban link is the introduction of an urban transport system which has made possible commuting from the "metropolitan village" to the city centre. Inevitably, this has had a strong cultural influence. The principal activity continues to be small-scale arable farming whilst livestock not for self-consumption serves to reduce "risk" i.e., in periods when there is high availability of employment in the city, the number of animals decreases and vice versa.

The agricultural systems which are dominant in the peri-urban model are terraced agriculture in the hills to the south of the city and valley agriculture in the adjacent areas. The terraced system, with its pre-Hispanic roots, represents an agricultural system which demonstrates a long and close relationship between environment and topography and has determined the different uses of different spaces. One of the most important changes to take place in the terraced zone occurred in the 1980s and coincided with an increasing awareness of health that focused on the value of high-fibre vegetables and the effect of hypoglutens. In this respect, *nopal*-legume represented a food of great importance⁽²⁴⁾ and this international preoccupation with health stimulated the expansion of its production in the terraced zone, with an increase from 1,600 hectares at the beginning of the decade to in excess of 7,000 hectares today. This, together with a reappraisal of *nopal*-legume within the well-off population and its export to Japan and the USA, has further promoted a growth in production. This has caused prices to rise and, consequently, has improved living standards for the producers.

The expansion of *nopal*-legume production has caused a reorganization of space, such as has occurred in the *chinampa* zone, and has given rise to a new use of agricultural space. The backyard, the family orchard, draught animals and milk production have remained within the villages while *nopal*-legume is grown in a ring around the villages, along with some vegetable cultivation and has displaced maize as the dominant crop. There is then a ring of agro-forestry systems which include natu-

23. See reference 10.

24. Losada, H., Neale, M., Rivera, J., Grande, D., Zavala, R., Arias, L., Fierro, A. and J. Vieyra (1996), "Traditional agricultural and animal production in the southeast of Mexico City as a resource for sustainable agriculture. The presence and experimental utilisation of the nopal vegetable (*Opuntia ficus-indica*) as an important sustainable crop of terraced areas", *Livestock Research for Rural Development* Vol.8, No.2, page 40.

ral and introduced crops, sheep, *maguey* (for *pulque* production) and leaf mulch. Finally, there is the forest itself, providing a number of resources for the community (resin, firewood, timber, fungi, compost, etc.). Although an impressive range of production systems exist within this zone, the most important (economically) is *nopal*-legume, as shown by its location in the areas closest to the "metropolitan village". *Nopal*-legume, perhaps more than any other crop, illustrates the close association between agriculture and the metropolis. Its enormous demand, from people from all social strata, has caused an expansion in its production area, the only crop where this has occurred. A second indication of this link is the adaptation of *nopal*-legume production to available technology, i.e. the intensive use of animal manure produced from the urban and suburban agricultural models, and from the village dairies.

A similar pattern of change, responding to the city's influence, can be seen in the maize-bean-squash crop complex, traditionally characteristic of the rural sector. The traditional black bean has been substituted by the broad bean which is sold to meet the urban demand for *tlacoyos* (a Mexican snack prepared with maize and broad bean). Likewise with maize, the popularity within the city for products manufactured from blue maize has led to its cultivation in preference to the white varieties. In contrast to *nopal*-legume production, maize is cultivated largely for own consumption or retail sale but, as in the case of *nopal*-legume, the majority of maize producers use manure as their main fertilizer.⁽²⁵⁾

In the peri-urban production space, an important place is occupied by systems linked to recreation. These zones are particularly popular with the urban low-income groups who, at week-ends, visit the area in search of rural isolation and traditional foods. Within this model, two commercial systems can be identified, namely the barbecue-wool system and the *mole* system.

The barbecue-wool system is a form of production well-adapted to the forest zones south of the city. It is based on the traditional consumption of mutton steam-cooked in a wood-fired oven and has developed two aspects, namely the preparation of barbecued food to meet local tourist demand and the supply of various markets within the city. These markets include the meat market (for which up to 2,000 sheep per week are slaughtered) and the local wool market close to the village of Gualupita.

The second commercial system is the preparation of *mole* which is based in the village of San Pedro Atocpan. It represents the cultural adaptation of a traditional technology, that is pre-Hispanic cuisine, but with the components of today's production originating far from the agricultural areas of the zone.

The agriculture of the valley zones is a reminder of conventional management of the rural sector. The system is dominated by the cultivation of maize, either as a mono-crop or with squash and broad beans. Cultivated to a lesser extent is *amaranto* (a pre-Hispanic grain) which is used in the preparation of *alegrías* (a sweet) and *atoles* (a maize drink). Another relatively important system within this zone is cut-fodder production. Alfalfa is

25. Fierro, A., Losada, H., Rangel, J., Rivera, J., Vieyra, J., Arias, L., Cortés, J. and D. Grande (1996), "La tecnología de la producción de maíz de auto-consumo como un agroecosistema sustentable del sureste de la Ciudad de México", Memoria, II^o Simposio Internacional y III^o Reunión Nacional sobre Agricultura Sostenible, una contribución al desarrollo agrícola integral, CSLP, FIUASLP, CEA, CP México.

Table 4: A Summary of the Main Productive Processes found in the Various Urban Spaces of the Metropolitan Area of Mexico City

Space	Model of production	Productive processes	
		Agriculture	Livestock
Urban	New	Family garden	Backyard animals (poultry and pigs) Dairy cattle Beef cattle Pig production
Suburban	Chinampa	Legumes and flowers Family orchard Greenhouse Market gardens	Backyard animals Dairy cattle
Peri-urban	Terrace	Nopal production Family orchard Maize Forestry Grasslands	Backyard animals Draught animals Dairy cattle Eees Sheep

one example, managed intensively on a small scale. Another example is oats which are an important source of feed for fattening small flocks of sheep and small herds of cattle. A final example comes from the less fertile areas (due to salinity) where natural grassland vegetation has established and which is used for occasional grazing.

V. PERSPECTIVES OF AGRICULTURAL DEVELOPMENT IN URBAN SYSTEMS

THE PERSISTENCE OF agricultural activity within and close to the metropolis is a clear example of the strong cultural link between the inhabitants of the valley of Mexico and their agricultural antecedents of 8000 BC. An innovative population, facing the problems of serious environmental deterioration brought about by urbanization, has found ways of adapting to these new conditions and has developed new technologies allowing it to continue agricultural activities within a new pattern of production. Furthermore, this "ability" to improvise has implications within the search for a sustainable relationship between the natural environment, socio-economics and the welfare of animals.

Contrary to what might have been hoped for, city development proposals have been based on a "western model" of development, dominated by concrete, automobiles and the concept of "green spaces" within the city, such as parks and gardens, as controlled "imitations" of nature. At the same time, agriculture (historically important in supplying food to the urban centres) has been considered counter to the ideal of modern, urban life, giving rise to a curious "corruption" whereby animals exist only

as pets, as "exhibition pieces" (e.g. in zoos) or for sport; and agricultural livestock is seen as an agent of pollution – to be prohibited or for the extortion of bribes.

In analyzing the problems that confront the agricultural sector within the metropolitan zone, it is important to understand the leading role adopted by the local authorities. The federal district of Mexico, like the political authorities of many Mexican states, entrusted its agricultural development to the Coordinated Commission for Agricultural Development. The commission's proposals focused on the seven agricultural delegations of the federal district which are typified by suburban and peri-urban agricultural spaces, while those delegations where urban space production is practised failed to receive any government support. This means that although, clearly, animals are found in these urban delegations, they are not recognized at government level. This problem was further exacerbated by the commission's promotion of mechanized agriculture, linked to the agricultural developments of the "Green Revolution", ignoring both natural resources and the producers. Their policy failed. The supplied technology depended on the intensive use of external inputs and the cooperation of the producers which never materialized. The result of this badly implemented policy was the loss of the notion of a metropolitan agriculture. As a consequence, what might have been used for agricultural support was redirected towards plans for "ecological rescue" – one recent example being the ecological park of Xochimilco.⁽²⁶⁾ The plan consisted of isolating a small part of the wetland zone and implementing a canal cleaning programme, prohibiting further urbanization and substituting untreated waste for treated waste within the area. Yet, however well-intentioned, the plan represents an example of the loss of the aforementioned concept of "agriculture" and the producers, who are the agents responsible for any changes towards sustainability, continue to use agro-chemicals, contaminated water and silt, etc., leaving much to be desired regarding a plan of "ecological rescue".

In contrast to the blinkered view of the government, the enormous imagination and capacity of the new urban farmer has made possible agricultural production within the urban environment. This phenomenon introduces a very important dimension, demonstrating the capacity of the unprotected sectors (i.e. the urban farmer) to generate alternative solutions in the face of the ecological "catastrophe" presented by the uncontrolled growth of the city. They have reorganized space, devised new ways of using degraded land, modified conventional agricultural systems in response to the demands of the urban sector and have realized the potential for utilizing large volumes of waste as a source of food for animals and/or plants. An example of this adaptation and development of a "new" technology can be found in the delegations east of the city. Here, the metropolitan food supply depot produces huge volumes of fruit and vegetable wastes which allow the dairy stables, considered illegal by the local authorities, to exist and expand (albeit within a medium of bribes and fines). The excreta from the livestock is transferred to the terraced and valley agricultural systems (which typify the

26. Stephan-Otto, S. (1995), *Sustentabilidad de los parques ecológicos: el caso del parque ecológico de Xochimilco*, Segundo Seminario Internacional de Investigadores de Xochimilco, Memorias, Asociación Internacional de Investigadores de Xochimilco, S.A. México.

27. Bookchin, M. (1992), *Urbanisation Without Cities: The Rise and Decline of Citizenship*, Institute of Policy Alternatives of Montreal (IPAM), Black Rose Books, Montreal/New York.

peri-urban model) and is used as an organic fertilizer, as a temperature regulator and as a water provider, thus forming a chain of recycling never considered by official programmes.

Despite some more enlightened attitudes relating to sustainability, the large urban centres are generally regarded as generators of contaminants, destroyers of natural ecosystems and high consumers of external inputs. But in the light of this article, this is clearly too narrow a vision of the urban situation. The growth and development of the urban centre has led to the establishment of new markets, directly influencing traditional systems of production. One example is that of ornamental birds, which have generated a new industry supplying cages, food and drink dispensers, and other accessories, while the demand for seed, fruit and insect feed has promoted new sources of agricultural work and reduced the flow of migrants from the countryside to the city. Another example is gardening which has assimilated a significant number of urban farmers and which constitutes a new industry in commodities such as compost, flowerpots, turf, ornamental plants, tools, furniture, etc. A third and very significant example is that of *nopal*-legume. The increased demand from the city for this product has stimulated a need for labour and a re-evaluation of land values, to such an extent that *nopal*-legume growing land is of sufficient value to provide a "green" barrier to contain city growth.

A change in outlook by the authorities is currently taking place as a result of two factors. The first, namely the economic crisis, has limited development opportunities and therefore reduced the pressure to purchase land for construction. This has been reinforced by a government policy to increase the cost of living within the metropolitan area in a strategy to reduce migration from the countryside. Similarly, the second factor, that of environmental degradation and pressures on natural resources, has increased a general awareness of the need to conserve "rural" spaces. This changing attitude has generated an urban phenomenon characterized by projects of "action-rescue". Examples of these include projects implemented in the former Lake Texcoco area in the 1980s and, more recently, in the *chinampa* zone of Xochimilco. Here, in spite of the limitations of this type of "ecological rescue" project, urban development has been stalled and research aimed at diminishing pollution and regenerating production has been supported.

Within this context, the opportunity arises to find an alternative form of agricultural development for the metropolis, switching from mechanized forms of production that endanger the environment to traditional urban systems of agriculture characterized by "self-conserving" technologies which avoid pollution and ecosystem degradation, and that allow increased income generation thereby benefiting large sections of the population who have scarce economic resources. An additional objective concerns animal welfare and the search for a method of production which respects the well-being of the livestock whilst maintaining a reasonable standard of living for the producers. The suggestion that agricultural development within the city should base itself on the existing urban systems is supported

by the fact that a close working relationship has developed between different systems, forming a complex agricultural structure in which, for example, the wastes of one system (i.e. excreta) are used as a source of organic material and nutrients in another system (i.e. arable production). This allows, in the medium term, an improved, more efficient use of renewable natural resources and the abandonment of those forms of production based on the use of fossil fuels such as oil. It is necessary to stress that urbanization has only been a problem since the beginning of the modern era although cities have existed long before this. Bookchin⁽²⁷⁾ pointed out that we need to be aware of the social and ecological relationships that exist within cities beyond the economic processes of production and consumption.

Accepting a proposal such as the one presented in this work will not be easy to achieve. In the first place, it is necessary to establish a working relationship between researchers and the city authorities, in which modifications to the city environment and the emergence of a new generation of urban farming systems are acknowledged. Recognition of these systems of production would enable the implementation of relevant research, focusing on the integration of these systems with their environment, improving their management and reducing the obstacles presented by the politicians. It is also clear that the urban agricultural producer has responsibilities and an obligation to follow certain "rules" such as acceptable animal management and the elimination of the foul smells, flies and rats that are frequently associated with livestock production. In conclusion, it is clear that we need to reconsider what sort of city we really want - and this may involve a rejection of the "western" model of development where animals are nothing more than pets, in favour of a new model which searches for a development in harmony with nature and based on a system of production which originated in the valley of Mexico.