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L'agriculture urbaine dans la métropole de Mexico

Agricultura urbana en el área metropolitana de la Ciudad de México

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Urban Agriculture in the Metropolitan Area of Mexico City

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Abstract. Mexico City and the rest of the country do not escape from the social and economic inequalities of the present economic model applied worldwide. Agriculture is a traditional activity in Mexico. This urban productive process has particular features: the predominance of smallholding, the restricted use of physical space, and the use of recycled materials and organic wastes. The population engaged in agriculture is heterogeneous, and includes women and children. There are a couple of production systems: the suburban, which uses the "chinampa" to produce mainly vegetable and flowers; and the periurban system, which has two sub-systems, the "terraces" producing nopal-vegetable and maize and the "Valleys" producing tuna (fruit) and amaranth. The wastes of other systems (straw and manure) are used in these places. The production systems combine pre-hispanic and modern tools, such as the tractor and coa. The products of these sites are sold in tourist areas of ecological importance. These technologies are reproducible, socially inclusive and environmentally friendly, but government support is needed.

Keywords. Developing countries, recycling, sub-urban, peri-urban, Opuntia, chinampa.

1 Introduction

In Mexico City agriculture is an activity with roots going back as far as the foundation of the great Techochtitlán which was one of the most important urban centers in Mesoamerica (Palerm 1990). The cultivation of the milpa with maize as its principal product stimulated the creation of the technological, social, economic and religious foundations of this culture that goes back over thousands of years. The arrival of colonial life and Christianity constituted a powerful force for the diversification of ancient Mexico without destroying links with the surroundings and the indigenous nucleus (Bonfil, 1987). Thus, urbanization of agriculture is a response to the interests of the city. Despite its destructive effects on the environment, 20th century modernity has been adopted by urban farmers in order to adjust intensive technology to their own forms of production. The new values of western society, related to preoccupations with health and beauty, have contributed to the development of ancestral crops. The city's organic rubbish has found a use for animals and the waste is recycled in the agricultural zones providing nutrients for the soil, thus constituting a step towards the aspired sustainability of urban zones.

2 General situation of Mexico City

2.1 Location and extension

Mexico City is in the Valley of Mexico basin, located in the southern portion of the Mexican High Plain. This is the center of most of the country's economic, political and administrative activities, it is established on the old bed of a lake, with an extension of 1,479 Km^2 (equivalent to 148.971 hect.), at an average altitude of 2,238 meters above sea level. The new official boundaries of the Metropolitan Zone of Mexico City (MZMC) related to the increase in public transport systems, cover 7860 Km^2 which include the Federal District, 53 municipalities in Mexico State and one municipality in the state of Hidalgo. However, the urban zone and the part taken in by the tarmac continuum only takes in the Federal District with its 26 delegations and between 17 and 27 (Lacy 1996) directly neighboring municipalities of Mexico State. The population is 22 million, including that strata characterized as the "floating" population (INEGI, 1990).

2.2 Economic and legal relations and indicators

Mexico City, as well as the rest of the country, does not escape from the social and economic inequalities of the present economic model. Unemployment and the growth of the informal economy (which reaches its maximum expression in street trading) are daily problems of increasing importance and are the cause of complex problems such as the increase in the levels of violence in the city over the last ten years. The population's buying power has fallen greatly; at present (1 January 2010) the minimum wage is $5746 pesos per day (approximately between 4.5 and 5.00 US$).

In Mexico a large percentage of the economically active population (EAP) works in the informal sector, for which

reason they have no social security; also there is the fact that the country has no unemployment insurance. In addition, official figures on open unemployment do not give an adequate idea on what is really happening in the labor market because unemployment is defined as less than two hours work/week. High levels of unemployment and poverty prevent the fulfillment of basic human rights: housing, health, education and food.

With respect to the occupational distribution of the economically active population in the Federal District, the last General Census of Population and Housing (INEGI,1990) showed that out of a total population of 2,884,809 inhabitants, only 19,145 (0.7%) carried out agricultural or forestry activities, putting into relief the marginality of this activity in the metropolis's economy over all. However, again, official figures are "made up" as according to the western and modern aspirations of those in government, the presence of animals and agriculture in urban environments is a symptom backwardness. Figure 1 shows the distribution of the employed population in the Federal District during the year of the census in percentage terms.

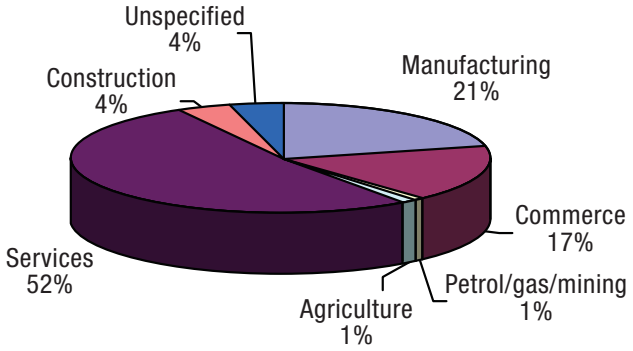

Figure 1. Percentage of the population employed according to productive sector in the Federal District (1990)

Source: Data from the section on economic indicators from the Internet page of the Government of Mexico City based on the XI General Population and Housing Census.

2.3 Geo-climatological characteristics of the Valley of Mexico

The Valley of Mexico basin is closed or endorheic, with internal hydraulic and edaphologic run-off. Amongst the main mountain systems we should mention the Sierra del Ajusco the Sierra del Ajusco because of its height, the high point reaching 3,880 meters above sea level. The high ranges do not rise sharply from the plain, but instead have wide, moderately steep foothills that erode easily, which is why there are zones cut through by numerous gullies and canyons, the most extreme case of which is the Cañada de Contreras in the western region of the city. According to the FAO-Unesco soil classification, the main edapholic units include lithosols, andosols, phaeozems, regosols and solonchak. The region is within the temperate zone characteristic of Mexico's mountain ranges where it rains during the summer. The mean annual temperature range is 18º to 24º C. Precipitation varies from 700 to 1,400 per year.

3 Urban Agriculture as a concept

Urban agriculture (UA) has been defined by a number of authors as a form of agriculture for the production of food and/or goods by those people who benefits from the service infrastructure of urban human concentrations (towns and/or cities). The urban productive process in Mexico City has particular features which differentiate it from the rural process not linked to the city and which gives urban agriculture its own identity. These include (a) the predominance of the minifundio or smallholding, (b) the restricted use of physical space for livestock activities, (c) the use of recycled materials for the construction of livestock shelters, (d) rubbish, waste from the food industry and households used for feeding livestock, (e) intensive use of excreta from milk cattle as a source of organic matter, macro-nutrients (N, P, K), water and heat for agriculture, (f) predominance of local knowledge and oral transmission in production technology and (g) the sale of products in local markets or to neighbors. Some researchers have criticized the interest in urban agriculture given its reduced contribution to national food production or to the regional economy. However, the importance of the phenomenon is due to the contribution it makes to the life-style of the unprotected sectors of the population and to the reduction of the city's ecological footprint as it uses elements considered as high entropy waste for productive purposes. This means it is a step towards the new sustainability targets.

4 Spaces where urban agriculture is carried out

From the point of view of the use of physical space, UA is carried out in four spaces defined as urban, sub-urban, peri-urban and valley agriculture (Losada *et al*, 1996). These are differentiated from each other by the physical place where the activity is done, the type of population and the structuring of the activity in the family environment, the inputs, products and environmental management of the waste caused by the presence of different production systems.

4.1 Physical space in the city environment

The differentiating features of the spaces where UA is carried out are product of the density of buildings, streets, open spaces and some specific characteristics kike the presence of bodies of water and/or woodland (Table 1). These characteristics were obtained by an analysis of the distribution of land use in each space based on the Guía Roji (García, 1992).

In the urban spaces, there is a large proportion of buildings and streets as well as a notable reduction in the number of open spaces (parks) in comparison with sub and peri-urban spaces where building and street density is low, while open spaces constitute most of the surface. The presence of bodies of water and woodland are particular features of the sub and

Table 1. Spaces in the city in which agriculture is practiced

Characteristic	Urban	Sub-urban	Peri-urban
Buildings/km^2	0.829	0.125	0.002
Streets/km^2	0.156	0.015	0.002
Open spaces/km^2	0.010	0.850	0.880
Canals/km^2	–	0.005	–
Woodlands/km^2	–	–	0.115

Source: School survey 2006.

peri-urban spaces. Valley agriculture is carried out in places on the edge of city assigned for agricultural and livestock use and which benefit from urban infrastructure.

4.2 Population and family characteristics

The type of population engaging in agriculture in the urban space is heterogeneous, local or migrant, but who have retained their original culture. The sub-urban space has been the reception center for migrants from the provinces near the city where they look for permanent employment, while a significant percentage comes from the native population (Amigos de Xochimilco, 1990). The result is that the population type is multicultural. Lastly, the type of population in the peri-urban space and valleys is predominantly mono-cultural with strong ties to the land and their social and cultural traditions. With respect to the family structure in each of the different spaces we frequently find the presence of various mono-nuclear families (2-3) living on the same plot of land in urban spaces. This is a fact which can be explained by the strong pressure on the use of urban land (Losada *et al*, 1996), while productive plots in the sub and peri-urban spaces are generally inhabited by a single family (Soriana *et al* 1993). Depending on the type of work to be done the participation of family members is divides into two structures: the head of the family and the wife and children. Tasks which require strength are done by the head of the family and in some cases, the adult male members, while the activity of the wife and the younger children is centered around the upkeep of some systems (for example, the backyard and family kitchen gardens), decision making and the commercialization of some products. Auxiliary labor (farmhands) is frequently used in the production systems that require intensive labor or when market pressure makes it necessary.

4.3 Production Systems

The existing production systems in different spaces are presented in Table 2.

The great pressure on land use in the urban space has determined that most of the production systems reported

Table 2. Production systems in different spaces in Mexico City

Space	Production model	Agricultural system	Livestock system
Urban	New	Family garden	Milk and meat production, Backyard, Piggeries
Sub-urban	Chinampa	Vegetables and flowers, Family kitchen garden, Greenhouse Ornamental plants	Milk and meat production, Backyard, Draught animals
Peri-urban	Terraces	Nopal production, Family kitchen gardens, Maize Agro-forestry-pastoral Woodland	Milk and meat production Draught animals, Backyard, Bees, Sheep
	Valleys	Tuna production Family kitchen garden, Maize, Amaranth, Agro-pastoral	Milk and meat production, Draught animals, Backyard, Bees, Sheep

involve animals, although there is also a marginal form of agriculture where the family garden permits the domestic production of: vegetables and condiments in association with ornamental plants. The predominant form of dairy and meat production is in stables where the animals are kept for the whole of their productive lives. Urban backyards house a wide range of species on a small scale and include pigs, hens, turkeys, ducks, geese, pigeons, quail, rabbits and in some cases fighting cocks and song birds. As well as backyard pig production there is also another form that could be considered semi-intensive involving herds of up to 100 pigs for fattening and then sale at local slaughterhouses.

The sub-urban model par excellence is the Pre-Hispanic chinamapa which has survived the onslaught of urban expansion (Soriana, 1999). The geographical distribution of this form of production in which the classical chinampa uses spaces surrounded by water for agriculture and inputs for livestock (grasses),while on the banks (villages, barrios) an association of agriculture along with livestock is found. Exceptions to these two production environments are the presence of dairy cattle and sheep on degraded chinampas (grassed over) and a specific type of nursery agriculture in urbanized zones. Chinampa production concentrates on the

production of vegetables: spinach, chard, celery, romeritos, broccoli, cabbage, cauliflower, parsley, lettuce, purslane, epazote, huazontle, chile manzano, chile cuaresmeño amongst others, while flowers include: marigold and the composite cempazuchitl, stock, roses, daisy, pinks, taste and baby's breath. The presence of maize, on its own or in association with squash, vegetables and flowers also prevails in chinampa agriculture (Canabal, 1997). In animal production, the prevailing systems are small-scale milk and meat production in stables, backyard production of hens, turkeys, fighting cocks, pigs, rabbits, sheep and songbirds. Lastly, despite the minor importance of the peri-urban space, there are draught animals (mainly mules and horses) used to draw carts for transporting bovine excreta to the smallholdings as well as for human transport and for the amusement of visiting tourists at weekends.

In the peri-urban production space there are two production models: the terrace in the southeast of the city and valley agriculture on the periphery, including Teotihuacán. The production systems reported in these zones show a rigid spatial distribution determined by their dependence on Man as well as the intensity of labor and environmental factors (low temperatures) which inhibit or propitiate production. In the terraced area there are four productive spaces associated with characteristics mentioned above: the village space, which concentrates on milk and meat production in stables, animals for work and transport (mules, donkeys and horses), the backyard: with hens, tuerkeys, ducks, rabbits, pigs and birds of prey and finally, the family orchard for the production of vegetables, vegetable nopal, fruit trees, condiments, medicinal and ritual plants as well as ornamental plants. The space immediately around the village is dedicated to the intensive production of nopal generally grown in the traditional system and occasionally there are also vegetable production systems (huauhzontle, French lettuce etc.) and legumes (beans) sown on land which will later be planted with the perennial nopal crop. A frequent association in the nopal plantation is the geranium, sold for planting out in city gardens. The neighboring zone to the nopal, considered by some researchers transitional (Losada *et al*, 1997) is that of maize sown alone or associated with squash, chile and broadbeans, the last of which is a substitute for beans. Finally, the last production zone is that area close to woodlands used for honey production, forage plants (mainly oats), natural grasses and the woodland as agro-ecosystem in itself for the production of timber, firewood, mushrooms, resins and leaf-mould. In this environment, it is common to find the presence of agro-silvo-pastoral systems articulated with the nearby maize producing zones and the grass and woodlands producing wool and meat from sheep as the final product.

Valley agriculture constitutes the conventional model of permanent agriculture although it there are some important differentiations within it. The spatial distribution of the systems includes only three work zones. The village systems which concentrate on the production of milk and meat in stables, animals for work and transport (mules, donkeys and horses), the backyard with hens, turkeys, ducks, rabbits, pigs and song-birds and the family orchard for the production of vegetables, fruit trees, condiments, medicinal and ritual plants and also ornamental plants. In the southeast of Mexico City the space immediately around the village is dedicated almost exclusively to producing amaranth used for making sweets and gruels. Maize on its own or in association is found, as in the rest of the country, to be the crop in the space immediately around the village where the presence of bees for the production of honey is reported. Some zones with surface water irrigation opt for the cultivation of high quality forage plants such as alfalfa used in milk production. The following space, generally considered as common land, is dedicated to pasturing of cattle, sheep and work animals and transport in natural grasslands as well as the production of maguey plants for pulque. An exceptional case is that of the intensive production of tuna nopal (fruit) reported in the Teotihucan Valley to the northeast of Mexico City. This system is set up to permit a second form of agro-pastoral production, permitting the production of tuna during the summer and the use of grasses in winter and spring, which coincide with the dry season.

4.4 Building materials and production technology

In general, urban agriculture is n expression of agricultural production adapted to new conditions. In this way, the city producer has developed their abilities to recycle materials as a way of providing shelter for animals as well as for use in other agricultural activities. While stabling for milk and meat production and semi-technified pig production technology for marketing which use conventional materials for shelter and animal upkeep (mainly concrete and brick), most henhouses in urban spaces are built with waste timber from the construction industry and secondhand utensils from the kitchen or house and from the soda drinks industry provide the feeding and drinking vessels used in backyard production. The technology used in the sub-urban chinampa zone includes (coa, cortachapín, cuero de lodo, cahuistle) along with other conventional instruments or those from the house (spoon, knife)

The technolgy used in the family kitchen garden includes conventional implements: pick, hoe, spade, rake, pitchfork, household instruments: knife, spoon, scissors, machete, and buckets as well as instruments of prehispanic origin: palo and coa. The technology for handling nopal in the terraced zone includes a wide range of implements: hoe, tlalacho (pickaxe), knife, wheelbarrow, pitchfork, baskets, leather gloves, sickle, rake, spade, pick and machete. The use of the plow drawn by mules is the predominant form of cultivation while horses are frequently used to transport products from the fields to the house. Lastly, in valley agriculture, the presence of machinery (tractor) alone or combined with mule or ox teams is frequent in crop maintenance. The use of dynamite to break up volcanic tepetate soils for tuna nopal cultivation is frequent in the Teotihuacán Valley. (Alfredo Rosas, 1998, personal communication)

4.5 Inputs

The inputs used in urban agriculture are divided into two categories: those going directly into the system in the form of

Table 3. Tools for agricultural work in the Chinampa zone

Task	Instruments
Plowing	Hoe, plow, spade, pick, rake, tractor (small and occasional)
Cross ploughing	Hoe, laminilla, harrow, tractor
Harrowing	Hoe, spade, harrow, rake, tractor
Sowing	He, coa, cortachapín, spoon, knife, harrow, cuero de lodo, tractor
Harvest	Cahuistle, machete, spade, pizcador, pitchfork and scythe

Source: Soriano *et al*, 1993

household waste and the others coming from the city's local infrastructure industry. Both types of resource are used to generate products to satisfy human needs.

4.5.1 Inputs associated with production

Generally it can be said that the technology used in UA requires low levels of external inputs. In this sense, technologies used in the urban space tend to use solid waste as an important source of animal feedstuff. Three types of waste are used: from markets, from the food industry and restaurants and finally household waste. The most important market wastes in quantity are the waste vegetable leaves (principally broccoli, cabbage, cauliflower, lettuce, radishes, maize and turnip) from the 300 hectare Central de Abastos (the main wholesale market) which receives and distributes vegetables and fruit for the whole of Mexico City (López, 1988). On the other hand, there are products such as carrots, squash, beetroot, maize and others that, once they lose their freshness, are fed to animals. Data reported by Huelgas (1997) indicate that 100 tons of waste per day is channeled for use as animal feed. According to estimates of consumption in local stables, this volume of waste is used to feed approximately 2,500 dairy cows that produce an estimated 37,500 liters of milk/day. A certain amount of the fruit from this market is used to feed pigs (mainly tomato). Leaf and fruit waste from local markets throughout the city is used principally to feed rabbits. The solid waste from the food industry (tortillerías, nixtamal mills, bakeries, biscuit factories amongst others) are used as a source of food concentrates rich in starches mainly in the stables but also for backyard and semi-intensive livestock rearing. Both systems also receive solid waste from the household. Some grasses present on roadsides and central reservations are a source of secondary forage in urban space dairy stables.

In the sub-urban and peri-urban space, the most important input in prevailing agricultural activities is the intensive use of fresh and dry dairy cattle excreta as a source of organic material, macro-nutrients (N, P, K), water and heat, these last two being of particular importance for the cultivation of nopal leaves in the terraced zone. The chinampa model and permanent valley agriculture use dry excreta (20%) which is composted with the soil (chinampa) or added directly to the crop (maize). An alternative form of use of this input in the chinampa zone is for the building up of artificial soils for producing purslane in nurseries. (Soriano,1999, Losada *et al*, 1998). In the case of the tuna nopal, excreta are used in a specific way as the full quantity is deposited at the foot of the plant and propitiates the gradual use of the components throughout the year (MO and macronutrients). Data reported by our group indicate the use of the equivalent of 800 tons of excreta/hect./year in the chinampa zone, 600 tons/hect./year in the nopal leaf zone and 56 tons (dry)/hect./year in the tuna nopal zone (Soriano, 1999). An extremely important input in the terraced zone is vegetable material from the nopal orchards during the pruning season (March, April and May) which permits the incorporation of approximately 15 tons/hect./year of material into the soil.

The presence of other external inputs, although minor, prevails in all the spaces and their production systems. In what has been considered by different authors as a technological spin-off from technified zones, the urban spaces acquire gestating dairy cows in neighboring zones as a way of adapting the system to the restrictions of land use and the elimination of the reproduction of heifers, as a source of animals for the future to replace sick or unproductive animals. (Losada *et al*,1996) In the case of pigs and poultry, the acquisition of animals is of lesser importance to that reported by the dairy stables. In the animal production systems in these spaces there are other inputs like animal vaccines (cholera mainly for pigs and of lesser importance, Newcastle for poultry), patented medicines for the treatment of illnesses, frozen semen (artificial insemination), balanced animal feed, mineral salts, vitamin supplements amongst others. The use of inputs in livestock production in sub and peri-urban spaces is smaller in some aspects, for example in the case of cows, as the availability of physical space provides favorable conditions for reproduction. In the case of pigs, the presence of a number of technified government owned farms has permitted the introduction of specialized races of pigs and sheep while the use of external inputs like vaccines and medicines, etc. remains the same.

Similarly to the case of livestock the use of external inputs for agriculture in sub and peri-urban areas is concentrated on the acquisition of seeds for vegetable and some flowers, inorganic fertilizers (Triple 17, Ammonium Sulfate, Urea), herbicides and insecticides, growth promoters and greenhouse inputs.

4.5.2 Inputs associated with the management and infrastructure

An over all view of the inputs used for the management of the production systems in the three spaces where urban agriculture occurs is presented in Table 4.

In these agricultural activities there is intensive use of labor associated with the intensive work carried out in

Table 4. Inputs from the city linked to the productive activities in urban agriculture.

Input	Livestock systems	Agricultural Systems
Labor force	2/day	5/day
Electricity	0.4 Kw/day	0.28 Kw/day
Water	200 l.	93.5 l.
Gasoline/diesel used in transport	5 l.	15 l/journey
Gasoline/diesel used in activities in the fields		10 l/activity/hect.
Transport	2 hrs/truck/day	4 hrs/truck/day

particular in vegetable, flower and nopal production in the chinampa and terrace models respectively (Canabal, Torres *et al*, 1992). In contrast, although there are some systems of livestock production that use labor intensively as is the case of dairy production in stables, in general less human activity is requited. With respect to electrical energy use, dependence on human beings means there is more use of this input than in the agricultural systems. Water use seems to be similar to that of electrical energy in the case livestock, although in agricultural systems such as the chinampa, the use of water is intensive, which increases values significantly. The greater use of gasoline and the transportation of products in agriculture could be explained by the transporting of excreta from the stables to the fields and of the products obtained to local markets.

4.6 Production objectives and products

The logic behind the production in urban systems includes a wide range of functions that go well beyond the production of goods for the population to consume although this is a major consideration in some cases. One feature associated with the objectives is that some systems, like backyard production are not permanent features of the producer's home but instead, changes places depending on a series of external factors. In the dairy production systems in urban spaces, the primary objective is to produce milk for retail within a given sphere of influence in the neighborhood (including the producer's own home consumption),while the surplus is transformed into cheese, cream, yogurt and crème caramel or instead is given fed to bull calves being fattened for sale (Losada *et al*, 1996). The semi-industrial production of pigs is linked to the sales through local slaughterhouses and this generates income for the producer to supply their family's need for a number of goods. In contrast, backyard pig production is sold when times are hard or to cope with unplanned expenses. Poultry rearing in this system (backyard) is in general for household consumption or for sale in emergencies locally. The production of rabbits and pigeons is destined for traders who supply the tourist corridors on the outskirts of the city, as local consumption is limited by cultural considerations associated with the flavor of the meat (xochiac). Fighting cocks are general raised for the sale of adult males and/or prepared by the producers for combat in the local palenques (arenas) that operate publically (Losada *et al*, 1996).

The livestock production systems that exist in sub and peri-urban spaces are managed with a similar logic to that in urban spaces. However, the number and function have been related to the availability of employment in order to guarantee the family salary. That is to say at times when there is a good supply of jobs in the city, the number of animals falls and vice versa, thus determining a specific functional dynamic. A similar situation would be the presence of backyard animals (hens, turkeys, pigs and sheep) linked to religious, social and festivals (mayordomías) for the preparation of regional culinary dishes. Other production systems show a dynamic associated with the market as is the case of sheep production in order to supply the demand for barbacoa and wool, the local sale of milk and beef production for sale to local slaughterhouses which complement the supply for the city.

The aims of agriculture in the sub and peri-urban spaces also include a wide range of functions from income generation within complex market economies. This is the case of nopal leaves, tuna, flowers, ornamental plants, vegetables and meat, household consumption (maize, vegetables, fruit), bartering of products or sales to complement the family budget which include vegetable materials for propagation in family kitchen gardens, medicinal and ritual plants and condiments amongst others. Unplanned expenses are not necessarily taken into account amongst the aims in these systems.

4.7 Mass and energy flows in the spaces

A notable feature of urban production systems is their articulation as potential eco-systems as most of the inputs are obtained from the bioregion, following a model similar to the way they functioned in Pre-Hispanic times. Although some production systems such as urban dairy production, the forage resources from the Central de Abastos come from neighboring zones, a central aspect being that the waste used by animals are local rubbish which, under different circumstances, would increase problems of pollution. On the other hand, as we have described, the waste excreta from stables and semi-technified pig rearing in the different spaces constitute an input of great importance for agriculture in sub and peri-urban spaces and determines the presence of functional autotrophic systems.

Research on the use of energy in urban systems has not been useful. Two approximations carried out by us in: (1) the chinampa model and (2) the production of nopal, as a crop representative of the peri-urban space (Tables 4,5 and 6) showed different degrees of efficiency with respect to the capture of energy and also macro-nutrients.

Table 5. Energy balance in the chinampa model (Soriano *et al,* 2002)

Chinampas	Net margin/ha	Gross margin/ha	Variable costs	Quotient
1	6303.45	6789.0	485.55	1.39
2	4074.77	4086.5	11.73	34.84
3	3681.93	3900	218.07	1.79
4	6897.30	7000.0	102-7	6.87

Table 6. Energy balance in nopal production on terraces

Input	Megajoules/kg	Output	Megajoules/kg
Human Labor	24	Harvest	47
Excreta	1028		
Chemical Fertilizar	35		
Straw	209		
Miscellaneous	43		
Total	1345		47

Source: Losada *et al*., 1996.

Table 7. Use of macronutrients from manure in the cultivation of nopal-vegetable

	Inputs (kg/Hect)	Outputs
Nitrogen	2152	33
Phosphorus	312	4
Potassium	515	80

Energy calculations in relation to the quantities of different inputs used for production were done using information collected in the field. The gross energy values were obtained from different publications and in the case of agro-chemicals, the estimates included the energy input as well as the energy used to produce it.

An important aspect to be considered here is that the full significance of the energy and macronutrient flows is not necessarily exclusively based on the absolute levels of the energy and mineral balance. Instead, we should take into account the fact that most of the inputs are biological in origin and constitute renewable resources in contrast to conventional production systems which depend greatly on non-renewable resources and fossil fuels. A collateral aspect in both models is soil formation, which in the medium and long term will have positive repercussions.

5 Society and economic relations

Urban agriculture, in contrast to rural activity, maintains a dynamic behavior in close relation to the society and the effects of the city, as a source of employment generation, convenience, transport etc. Levels of production can change in inverse proportion to the family economy. In this respect, urban agriculture is not something that is simple for governmental or non-governmental agencies to control. Instead, it depends on the needs and objectives of each family that produces and these can be different to those frequently demanded within the reductionist view, the increase of production per animal or in relation to surface, often considered the functional basis of the technified and/or efficientist production systems.

An important aspect of the existing production systems in urban agriculture is their clear tendency to follow the behavior homogeneous in relation to dimension of the productive business. While in conventional rural systems the variation range of the systems is often very large, these urban systems operate in the medium and small-scale production environment, which means that broad sectors of the population benefit from their presence as they make up part of the informal economy. In addition, the urban systems for example, combine the dwelling with livestock activity thus determining a rational use of space in a city with strong pressure on physical space. We should take into account that the availability of open spaces/inhabitant in Mexico City is one of the lowest in the world (2 meters/inhabitant), which suggests that the agricultural systems have found a way to fit in naturally with the conditions in the metropolis.

Given the wide diversity of functions in which the production systems articulate themselves, the range of ways they contribute to family income has proved to be considerable. Dairy production in stables has been shown to cover 100% of family income (Losada *et al*, 1996), while the contribution of semi-technified and backyard pig production is in the range of 10 to 40% of the family income. Backyard poultry production is for household consumption, which is why its contribution to income is practically nothing. In the sub and peri-urban spaces, maize agriculture provides between 10 and 30% of the family income as most of the grain produced is kept for home consumption. In contrast, vegetable production provides up to 80% of the household income and even more in the case of the sale of flowers and ornamental plants. (Soriano eta al, 1993) The nopal-vegetable and tuna are products which supply Mexico City's markets so their income contribution is 100% in the seasons of highest productivity (summer) or highest prices (winter). In this sense, it can be said that equality, associated with the standard of living offered to people with few economic resources by the local

authorities is improved on by the individual effort of the producer in urban agriculture who wants to improve family consumption and/or complement their income.

6 Tourist corridors

An important place in the use of products in urban agriculture is to found in the tourist corridors that form a new concept combining tourism with green spaces and food. These corridors receive local tourists from the city who are eager to find a "village" environment wiped out by the excessive expansion of the urban areas. To date, seven tourist corridors in the city's environs can be identified Xochimilco, Milpa Alta, Amecameca, Texcoco, Oaxtepec, Marquesa and Teotihuacán. The relationship between the tourist corridors and urban agriculture is that the corridors function as sales points for a large proportion of the animals (rabbits, pigeons, sheep etc.) and to a lesser extent for plants (mainly, nopal, tuna, maize) produced in urban agriculture. In these corridors the working animals have found new forms of occupation (equestrian sports) which generate resources to complement the family income. The provisions for animals is in general handled in the local markets of most importance which function as supply centers, managed by intermediaries.

The original inhabitants of the Valley of Mexico conserve their indigenous roots (Nahuatlacas) and are conscious of their history in relation to their ancient Nahuatl culture. This has persisted in their life- styles, forms of production and consumption and today is vital to understanding key aspects of urban agriculture such as the oral transmission of knowledge and the high degree of creativity shown in the elaboration of complex agricultural production techniques. Examples of this creativity can be seen in the adjustment of the chinampa model of production to the sub-urban space as well as the production of nopal on terraces in Milpa Alta and/or tuna nopal in the peri-urban space of Teotihuacán. These, adapted to the present conditions of the metropolis, use great quantities of bovine excreta as a source of organic material, macronutrients, water, heat and artificial soil.

The links between culture and agriculture persist in all aspects. In the villages and barrios in the Valley of Mexico the animals are blessed at church on 17th January, on 2 February (Candlemass) which coincides with the presentation of Christ in the temple, the maize, bean, broadbean, pea and nopal leaves are blessed. On 3rd May, the day of the Holy Cross, one of the most important ceremonies in the agricultural cycle is celebrated and is related to the beginning of the rains (the feast of Tlaloc and the tlalocan) when offerings of crosses decorated with flowers are placed on the mountains surrounding the Valley. On the 15th March, the day of San Isidro the Farmer, sowing begins and the animal teams are blessed. In the month of July, the feast of Tonantzin (mother of the Virgin Mary) associated with earth fertility rites. On the 15th August the Virgin of the Assumption is celebrated in Milpa Alta, where she is lain on a bed apples and red roses that symbolize sins. At the beginning of November (1st and 2nd) the day of the dead is celebrated, coinciding with the harvest period, with offerings of cempazuchitl flowers and numerous dishes prepared with regional products.

7 The role of women, children and the elderly in urban agricultural activities

As happens in most family economies in Mexico, there is division of labor along gender lines that fulfills specific functions. In this sense, we must emphasize the role women, children and the elderly play in sustaining urban production systems, independently of the space or the type of production. Three strategies involving women have been identified in urban agriculture. The first is the full control they have over production when they are single or when their husbands are working outside the home during the day. The second function is their participation, on equal terms with other members of the family, in production activities in order to economize on labor costs and lastly, as future business women, to take part in the activities of the family home before gaining their independence. This last strategy is found in mononuclear families where co-opting of resources from urban agriculture will later enable them to become independent from the primary nucleus and function as independent producers. The time women dedicate to urban agricultural activities vary. On the whole backyards are dealt with when household chores are finished or during times allocated to chores in general. Although social attitudes in the city reflect a cult to men and their participation, urban producers recognize the contribution of women to obtaining a wide range of high quality products. These include flowers, vegetables, ornamental plants, songbirds, sitting hens, diary cows, prolific pigs amongst others.

An example of the participation of women in city agriculture is to found in the groups in the Fraccionamineto San Blas in the municipality of Cuauhtitlán in the north of the city where, with some help from the local government, they formed a consumer cooperative, in which they established what could be characterized as a new urban agriculture project. This aims to separate domestic waste and to produce compost and vegetables on a collective plot on their housing estate. The space is one of the few green areas that exist there and today has two demonstration vegetable gardens in participants' homes.

8 Environment, climate change and greenbelts

As an activity, urban agriculture has undeniably contributed to the supply of food and benefitted the city since its Pre-Hispanic origins. In the framework of its contribution in the environs of Mexico City and the problems it faces as the biggest metropolis in the world, urban agriculture has shown an important growth linked to the phenomenon of urban expansion and to the quality of life of the inhabitants. It could generally be said that urban agriculture has been the chief victim of the pretentions of a western model of city development as a means of industrializing the country. That is to say, the environmental deterioration that urban agriculture could cause is minimal compared to the negative effects of the habitation structure of the city. In view of the technology based on restricted use of external inputs and the tendency to behave homogeneously as a productive system, urban agriculture gets close to the offers of sustainability required, or a at least demanded by urban centers. Another role forms of

urban agriculture have played recently is that of functioning as greenbelts which retain urban farmers in their places of origin and thus restrict urban development by providing an added value to the land. A clear example of this phenomenon is chinampa and terrace agriculture for the production of vegeables and flowers and also nopal-vegetable respectively. It has also been suggested that management practices in agro-silvo-pasortal systems increase biological diversity and inhibit fires in forested zones. This activity also functions in the conservation of the landscape, which in industrialized countries is promoted by means of specific economic policies (Rivera eta al, 1998)

Noxious effects of this new form of production within the city's environments could be detected because of the intensive use of dairy cattle excreta in the chinampa, terrace (vegetables and nopal) and tuna (Teotihuacán) agricultural models. The suggestion that this is the case has been related to the contribution of N and possibilities of lixiviation that could contaminate the water tables. However, in the terraced zones and in Teotihuacán, the depth of the water table is 300 meters, which seriously reduces the possibility of contamination. Thus, the chinampa model could be considered the most sensitive. Without ignoring or minimizing the negative effects that urban agriculture activities could have on environmental deterioration, the suggested N contamination is not clearly present in the results reported in woodland zones. Here there are high levels of nitrates from the great contribution of dead organic tissue and the presence of this component from the acid rain associated with atmospheric pollution. In urban zones the presence of animals, waste, odors, flies etc. could be a factor that inhibits potential producers from keeping livestock although we have detected two different responses from neighbors (Losada *et al*, 1996). Those new to a neighboring stable for example made complaints about the production unit, while the older inhabitants do not report it, which shows that the custom of seeing animals as part of the environment is a more important factor than the nuisance of the animals "per se". However, ways of controlling undesirable smells, insects, etc. could be useful.

9 Animal well-being

An interesting aspect to note in Mexico City's urban agriculture is animal well-being. Our own observations made in stables in the urban space have shown the presence of aggressive behavior amongst cows. This was evaluated by indicators related to fighting, butting and pushing, manifestations of sociability (licking) which has been associated with restrictions in the use of the physical space available to animals (10 m^2) as well as the system of permanent stabling in which the animals are kept. In the case of pigs, it has been suggested that aggressive behaviors in the semi-intensified systems of the urban model are associated with special restrictions, while in the backyard regime these tend to disappear in view of the reduction in the number of animals. For both species (cows and pigs) the use of distracters has been proved to reduce aggressive behavior. In the case of poultry in the urban space, there is no evidence of aggressive behavior in the birds as in general the backyard production system makes use of henhouses and the yard allows the birds to move about more (Losada *et al*, 1993). Amongst other species such as rabbits, pigeons, ducks etc., the reduced amount of space per capital required for their upkeep is not a limiting factor in any of the spaces.

10 Repeatability of the model

The possibility of repeating the urban agriculture model or parts of it has been a preoccupation of those who study it. From the point of view of the use of spaces, most researchers who have reported urban agricultural activities have noted the presence of two types (urban and peri-urban) in contrast to the third, reported by us (suburban). As different researchers have pointed out, the possibility of repeating the chinampa model is limited or null, as its implementation requires the social fabric that gave rise to it and not just technological aspects associated with it. With respect to other systems like the nopal-vegetable or tuna, again the cultural components would be limiting factors as consumption is exclusively regional. With other, less difficult systems, the possibilities would depend on the socio-economic and environmental characteristics of the metropolis, which could allow them to be established.

As part of what could be considered an attempt to replicate and/or encourage activities related to urban agriculture, some organizations or individuals linked to ecological movements have developed small-scale commercialization channels for organic products, promoted family kitchen-gardens for household consumption, created emerging micro-businesses producing non-traditional crops like mushrooms (mainly *Pleurotus ostriatus*), blackberries and ornamental plants and the processing of organic sold waste in the production of composts.

Volunteer ecologists and organizations are looking for ways to combine these new technologies, sensitize ordinary citizens about the need for environmental education and ecological management. Most of these organizations operate by offering out-reach activities open to the whole population or to those they have called sectors of interest. However, an important difference between them and the urban producer is that these organizations do not aim specifically to generate urban agriculture but rather to conserve and develop the environment. In terms of production and area of influence however, they are limited and have little over all impact on the environmental realities of the metropolis. Two important efforts which differ from the conservationist tendency are the Centro de Investigación y Capacitación Rural (CEDICAR, A,C.) which has for some time encourage the setting up of family kitchen gardens in containers such as tyres and buckets and the Grupo de Ecología Social de la Coordinadora Comunitaria Miravalle A.C. (COCOMI) in the delegación Iztapalapa. The latter is made up of 6 promoters who work on ecological production (vermicompost and horticulture) and environmental education in schools in the region. This group was set up in 1994 in response the problem of conservation and productive management and education for the Nature Protection Area. Faced with this situation, the group initially focused its attention on management. Amongst the first achievements is community use of the 7,245 m^2 green space within the Ecological Conservation Area dedicated to

environmental education for children and neighbors in the community and also intensive production of vegetables, compost, worms and medicinal plants.

11 Future development of urban agriculture

From the point of view of urban agriculture development, government policies have been centralist (a single institution is responsible for the city's agricultural development), focused on ignoring "traditional forms of production" and if at all intend to set up technified systems stemming from the green revolution, with elevated use of external inputs. Examples of these proposals is the intention to set up a complex pig producing district made up of 21 units distributed between four of the Federal District's delegations each with a capacity for 137 adult sows and four boars. The district was designed to produce 39,000 pigs/year in order to contribute to the supply in Mexico City and to benefit a total number of 3,600 families. The investment cost was $3.4 million dollars. (Sánchez, 1982) The results obtained were disastrous, as most of the animals disappeared, while the empty units remain as monuments to the useless. This form of encouraging development was repeated later when a dairy district was set up in Xochimilco with similar results. In the case of agriculture, the approach has been distribute seeds, agro-chemicals, agricultural machinery, etc. In the last three years however, actions were decentralized to the delegations and/or municipalities although their functioning still tends to be "developmental". Another aspect which makes governmental support more complex is the fact that possible external support is focused basically on the sub and peri-urban spaces, while the existing production in the urban spaces is considered illegal, non-existent, invisible. The cause of this situation was the arbitrary division of the city into two sectors, urban and agricultural, using the presence of areas dedicated to agriculture as the main criterion for making the distinction. This resulted in a significant expansion of the urban area onto lands until then occupied by the dairy district in the southeast of the city.

Although in the past government policies tended to ignore the important role plated by urban agriculture, it does in fact contribute to the well-being of the population, it conserves the environment etc., so it is possible that in the medium term this situation will change. During 1997, for the first time, the Federal District had elections to choose its first governor which opened up possibilities for citizen participation in decision making and a new city design which should emerge from the practice of democracy. Changing the developmental mentality will be the new challenge of globalization towards more sustainable forms of production.

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