Chapter 11

Urban Horticulture

Although crops have always been grown inside the city, urban horticulture is expanding and gaining more attention recently. Horticultural products include a large variety of vegetables, cereals, flowers, and trees. Vegetable production provides regular and high incomes to the various actors in the commodity chain and provides food to urban dwellers. Many specific techniques have been developed or adapted specifically for urban areas. If well managed, urban horticulture can play an important role in reducing socio-economic and environmental problems in cities. Urban authorities should collaborate with urban producers to strengthen the role of urban horticulture in waste recycling, community building and creating sustainable food systems.

Urban Horticulture

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Introduction

Urban and peri-urban horticulture (UPH) includes all horticultural crops grown for human consumption and ornamental use within and in the immediate surroundings of cities. Although crops have always been grown inside the city, the practice is expanding and gaining more attention. The products of UPH include a large variety of vegetables, cereals, flowers, ornamental trees, aromatic vegetables and mushrooms. Table 11.1 presents the main species cultivated in periurban horticultural systems and more specifically those presented in this chapter. The case study from Yaoundé, Cameroon, later in this chapter, is a good illustration of the large variety of species cultivated in UPH.

Generally, the types of crops cultivated vary according to the area, influenced by culture and tradition. In cities, short-cycle crops are preferred, while in the surroundings of the city crops with longer cycles are cultivated, for example in orchards.

Cai Gaojian

The houses and of in-migrants will be much improved if they stay at the place long enough

Crops are grown in small gardens or larger fields, using traditional or high-tech and innovative practices. The major production systems and practices of UPH are described in this chapter, together with the major constraints (see also chapter 10). Some new techniques that have been adapted to the urban situation and tackle the main city restrictions are also documented. These include horticultural production on built-up land using various types of substrates (eg. roof top, organic production and hydroponic production), water saving in highly populated areas, the production of pesticide-free vegetables year-round with a low content of heavy metals and human pathogens, and control of wastes and leaching (fertilisers, pesticides, organic matter, water) in the urban environment. Urban and periurban cultivation systems differ from rural systems by their proximity to cities and by the constraints of space, which often lead to greater intensification of production.

Through the large variety of crops that are produced, urban horticulture makes a major contribution to food and economic security (see chapter 1 and 6). It also contributes to strengthening social sustainability and increasing ecological sustainability by transforming wastes, conserving natural resources, preventing soil erosion, and reducing pollution. UPH, like UA in general, has multiple functions. The main function is supplying fresh food, but emerging functions that are becoming more and more essential are economic (income generation), social (labour), cultural, living environment (open spaces and greening), environmental (recycling) and security (food and natural risks).

Although most of these species are not specific to periurban horticultural systems and can also be grown elsewhere, horticulture in urban areas minimises the transportation time for the supply of fresh produce to city dwellers. The cropping system in urban and periurban

areas is usually adapted to the specific circumstances. Many traditional crops have been adapted to better respond to the needs of city consumers. Horticulture is practised for home-consumption but very often also for the market as high-value cash crops. In such a competitive environment, a focus on profitability may lead to improper management such as the intensive use of water, land and other (chemical) inputs, and thereby pose threats to humans and the environment. This issue will be discussed later in this chapter.

Table 11.1 *Horticultural plants cultivated in urban areas*

Vegetables

Amaranth, Genius ***Amaranthus***
Beans, ***Vigna radiata*** & ***Phaseolus vulgaris***
Broccoli, ***Brassica oleracea*** **var.** ***italica***
Cabbage, ***Brassica oleracea*** **var.** ***capitata***
Cassava leaves, ***Manihot esculenta***
Cauliflower, ***Brassica oleracea***
Chinese cabbage, ***Brassica rapa*** **var.** ***pekinensis***
Chinese mustard, ***Brassica juncea*** **var. rugosa**
Choy sum, ***Brassica rapa*** **var.** ***parachinensis***
Cucumber, ***Cucumis sativus***
Eggplant, ***Solanum melongena***
French bean, ***Phaseolus Aureus***
Garlic, ***Allium sativum***
Gourd, Genius ***Cucurbita***
Indian grass, ***Brassica juncea***
Indian mustard, ***Brassica juncea***
Jaxatu, ***Solanum aethiopicum***
Kangkong (water convolvulus), ***Ipomoea aquatica***
Leek, ***Allium ampeloprasum***
Lettuce, ***Lactuca sativa***
Lotus, ***Nelumbo nucifera***
Melindjo, ***Gnetum gnemon***
Mungo bean, ***Phaseolus Aureus***
Okra, ***Hibiscus esculentus***
Onion, ***Allium cepa***
Palak, ***Beta vulgaris***
Pea, ***Pisum sativum***
Potato, ***Solanum tuberosum***
Squash, ***Cucurbita maxima***
Sweet pea, ***Lathyrus odoratus***
Sweet pepper, ***Capsicum annuum***
Snow pea, ***Pisum sativum***
Tomato, ***Lycopersicon esculentum***
Water morning glory, ***Ipomea aquatica***
Wheat, ***Triticum aestivum***
Yardlong bean, ***Vigna unguiculata sesquipedalis***

Aromatic and flowering plants

Agati, ***Sesbania grandiflora,***
Basil, ***Ocimum basilicum***
Chives, ***Allium schoenoprasum***
Horseradish tree, ***Armoracia rusticana***
Indian borage, ***Plectranthus amboinicus***
Kohlrabi, ***Brassica oleracea*** **var.** ***gongylodes***
Lemon grass, ***Cymbopogon citratus***
Mustard, ***Brassica compestris***
Pakchoy, ***Brassica camperstris*** **var** ***chinensis***
Peppers, Genius ***Schinus***
Perilla, ***Perilla frutescens***
Roselle, ***Hibiscus sabdariffa***
Tuberose, ***Polianthes tuberosa***

Fruits

Banana, Genius ***Musa***
Melon, ***Cucumis melo***
Orange, ***Citrus sinensis***
Papaya, ***Carica papaya***
Peach, ***Prunus persica***
Pineapple, ***Ananas comosus***
Strawberry, Genius ***Fragaria***

Ornemental plants

Bougainvillea (Genius)
Chrysanthemum (Genius)
Kumquat, Genius ***Fortunella***
Rose, Genius ***Rosa***

Policymakers around the world are showing an increased interest in urban horticulture, although their major focus is still on the temporary use of peri-urban lands. Periurban agriculture is encouraged in poor countries, mainly because it improves food security of poor households and the urban population's nutritional status (freshness of products and better access to fruit and vegetables, considered as a major source of vitamins and micronutrients), especially in view of the inefficient transportation and storage facilities in these countries. Policymakers also encourage UPH because it provides jobs and incomes to poor and landless urban dwellers and because it is well adapted to the urban environment where water and land are scarce.

Urban Demands for Horticulture

The proximity to urban markets often defines the production of specific fruits or vegetables, while there are also seasonal differences between rural and urban areas in terms of supply to the urban market. The case study from Hanoi, Vietnam, is an interesting example of how the horticultural market has evolved dynamically over the years in relation to social, climatic and cultural factors.

Fruits and vegetables for city markets are supplied from different areas: rural, peri-urban and urban, from within the country or from foreign countries. There is complementarity between the supply flows from the various origins, which may change over time. Products from UPH make up a very large part of the supply of vegetables to urban markets, such as in the capital city Hanoi (2.7 million inhabitants). Here, 80 percent of the vegetables (118,628 tonnes), come from the Province of Hanoi, an area of 7,095 ha of urban gardens (Mai Thi Phuong Anh 2000). In Brazzaville, 65 percent of the marketed vegetables come from its urban gardens (Moustier, 1999).

Factors such as climate, soil, access to water, insects and diseases, costs of production and, most importantly, the shelf life of the crop itself, influences the location of vegetable production. The last factor explains why, for most urban markets, leafy vegetables are produced in urban and periurban areas. In Brazzaville, the urban gardens provide 80 percent of the leafy vegetables for the urban market; in Bangui, 100 percent; in Bissau and Antananarivo, 90 percent (Moustier & David, 1997); in Dar-es-Salaam, 90 percent (Sabel-Koschella et al., 1998). Some leafy vegetables are well adapted to a hot wet season. The very short shelf life of cut flowers such as roses and chrysanthemums explains the development of these horticultural crops around Hanoi, where they are grown on 1,000 ha.

The season also influences the distribution of supply to the urban market from rural/ urban areas. In Bangui, the share of tomatoes from rural areas increases from 40 percent to 50 percent in the wet season. In Bissau, the share of tomatoes from urban areas increases from 10 percent to 20 percent in the wet season. Urban horticultural areas may also supply the urban market more regularly than the rural areas. In Nouakchott, UPH supplies the urban market during nine months of the year, whereas the rural areas provide vegetables to the city only during three months (Margiotta 1997). Around Hanoi, choysum and leafy mustard are grown year-round. In Dar-es-Salaam, amaranth is grown throughout the year. This tendency to crop year-round is increased by the UPH producers' need to derive an income from various high-value crops throughout the year. This bias towards UPH may also be due to production constraints and access to transportation infrastructure during the rainy seasons or to socio-economic causes. In some countries, however, where flooding of urban areas expand every year, it is easier to find suitable spaces to grow vegetables in rural areas (Phnom Penh, Dacca).

Even if the consumption of vegetables per person is relatively low, consumer demand remains the major driving force behind UPH. In developing countries, the consumption of vegetables is generally lower than the FAO recommendation of 75 kg/year/inhabitant (205

g/day/capita). The importance of vegetable consumption depends on the population group. Over the period 1994–1998, consumption in Vietnam was higher in urban areas (182 g/capita/day) than in rural areas (122 g/capita/day), but lower than in mountainous areas (196 g/capita/day) (Nguyen Thi Lam & Ha Huy Khoi 1999). As is shown in Table 11.2, the consumption of vegetables in Bangladesh was higher in urban areas than in rural areas (Ali 2000).

Table 11.2 *Monthly per capita consumption of vegetables (kg) in Bangladesh*

Household	Total vegetables	Leafy vegetables	Potato	Banana, papaya & eggplant	Other vegetables
Rural	6.20	1.42	1.67	0.82	2.29
Urban	5.13	1.08	1.13	0.80	2.12

Source: Ali (2000).

Urban consumption is related to the size of households, income and socio-cultural characteristics (Bicas 1998). In Africa, the most popular vegetables are tomato, onion and leafy vegetables, but there are location-specific variations. In Brazzaville, for instance, the importance of vegetables varies from one socio-economic group to another (Moustier, 1999).

Culture and festivals also have a very strong influence on consumer demand for specific products. In many countries, the main demand for flowers occurs on Mother's Day, Valentine's Day and during the Christmas period. In Vietnam, the Tet celebration is the opportunity to offer two ornamental trees: kumquats bearing mature orange fruits and peach trees in blossom. In urban and periurban areas in Hanoi, ornamental fruit-tree specialists have set up production to meet this demand, which means that they nurture young trees for a period of one year to prepare them for sale.

Table 11.3 *Most frequently eaten vegetables per socio-economic group in Brazzaville (Congo) (ranked in order of importance)*

Socio-economic group	Vegetables eaten most frequently
Congolese households	Cassava leaves, cherry tomato, pakchoy, roselle, melinjo, dry kidney bean
Non-Congolese African households	Potato, cassava leaves, cherry tomato, dry kidney bean, amaranth, lettuce
Expatriates	Potato, "European-type" vegetables

Source: Moustier (1999).

Factors Influencing Urban Horticulture

The development of horticultural systems in urban and peri-urban areas is determined by specific opportunities and constraints in the city. The constraints are mainly related to resource scarcity (water, land, labour and access to other inputs) and pollution.

Access to natural resources and labour

Access to suitable land is a key factor in urban agricultural development. Land ownership and tenure arrangements are important (see also chapter 3). In the large and fast-growing cities of developing countries, land pressure is great and often leads to rising prices. In this context, access to land by urban or periurban producers is difficult and poses a major constraint to their activities. As they are usually not landowners, they are obliged to rent from others or to squat on public land in order to have a small plot to cultivate. This uncertainty of land tenure has a strong influence on land-use strategy and maintenance. Producers may select fast-growing plants (such as leafy vegetables) rather than perennials (such as fruit trees); and may use places regarded as unsuitable for dwellings (such as swamps), which limits the range of crops that can be grown.

Insecurity of land tenure is a major problem that often leads to two types of responses by producers, who do not always take the long-term effects of agricultural practices into account. As a result they might choose inputs with strong and quick effects, such as chemical fertilisers and pesticides, rather than improving the soil using long-acting fertilisers and integrated production techniques. Producers may even turn to soil-less production systems on diverse substrata.

Cai Gaojian

Looking after the greenhouse and picking cucumbers.

The size of plots is also a constraint. In the inner cities or periurban areas, horticultural crops are grown on very small parcels of land. This leads to the development of specific systems: intensive, high-yielding and year-round with the same or different crops. High yields require high use of inputs – water and fertiliser – combined with good light. The role of substrates to grow the crops is essential. As will be discussed later, different techniques have been developed for cases of little land or poor soil quality, such as hydroponics or organoponics.

Different sources of water are available in urban and periurban areas: potable water, wastewater, rivers, lakes and ponds. The specificity of horticultural systems is their adaptability in using these different sources, particularly the use of wastewater (see chapter 9). In all cases, this scarce source needs to be used efficiently and with precaution. Drip irrigation with different systems of micro-irrigation is possible. Use of a watering tank is more popular and is also one of the most efficient systems. The advantage of wastewater is that it provides nutrients together with the water. This saves the cost of fertilisers and labour to apply the fertiliser.

In urban areas, there is fierce competition for the use of land and water between horticultural activities and other economic activities. In a context of high economical competition, horticulture can be maintained if it generates more benefits than any other use of the resources (see also chapters 6 and 7 on this). Yet, even without intensification of production and even if it is less profitable, horticulture continues to exist, if its other functions (i.e. cultural) are valued by city stakeholders.

Another aspect of this competition comes from the many other human economic activities that occupy urban producers. In Hanoi, for instance, periurban gardeners seek jobs in industry, business and administration. Most often urban horticulture is a part-time job in this city, and different activities are combined in order to maintain livelihoods. The household members also divide their activities between production, sales and employment. The multiple

economic activities of most urban gardeners may lead to a lack of sufficient labour during certain cropping periods such as planting or harvesting or for irrigation. The urban economy and its dynamics assign different responsibilities to women and men: women are often more involved in the cultivation and marketing (West Africa) activities than in rural and traditional horticultural systems.

Environmental pollution

Industry, services, traffic and high population density in urban areas are known to cause pollution to water, soil and air and reduce light intensity. A major challenge for urban agriculture, and especially for horticulture, is to supply safe products in this often polluted environment. In urban or periurban areas, the main pollutants of horticultural crops are heavy metals, pesticide residues, and biological contaminants. Such pollution presents a risk not only to the consumers, but also to the producers who come in contact with contaminated materials, for instance in wastewater. Additionally, these forms of pollution can be major factors in limiting crop growth. The problems occur mainly in areas close to active or old industrial sites, on urban waste disposal sites, when irrigating is done with water that contains heavy metals, fertilisers or organic matter, or when contaminated soils are used for cultivation. The source of human parasites are wastewater or animal wastes that are not composted (see chapter 8-9).

Heavy metals

The main causes of soil pollution from heavy metals (including lead, cadmium, chromium, zinc, copper, nickel, mercury, manganese, selenium and arsenic) are irrigation with water from streams and wastewater contaminated by industry, the application of contaminated solid wastes and the use of former industrial land contaminated by spilled oil and industrial wastes. Toxicity from heavy metals can directly affect plant physiology and growth and many cases of toxicity from heavy metals have been reported. For example, Jørgensen et al., 2005 show that intensive horticultural systems (particularly in greenhouses) in urban areas may be threatened by soil toxicity through trace elements such as Zn, Cu, As and Pb. The soils in many cities in developing countries have very high heavy metal contents. If the concentration of these elements in human food increases, it may cause toxic symptoms and cause damage to health (carcinogenic and mutagenic effects).

Mario Gonzalez Novo

Organoponics in Cuba

The health effects and the heavy metal threshold concentration under which it is possible to practise safe agriculture have been subjects of much discussion. Puschenreiter et al., 1999 conclude that, having considered the several available pathways to reduce the transfer of heavy metals to the human food chain, urban soils with slight contamination by heavy metals can be used safely for gardening and agriculture if proper precautions are taken. However, Birley and Lock (2000) argue that little is known of the chronic health effects of consuming tiny amounts of heavy metals over long periods of time and that further research is needed. Mapanda et al., (2005) show that, in vegetable gardens of Harare (Zimbabwe), irrigation by wastewater may lead to significant heavy metal (Cu, Zn, Cd, Ni, Cr and Pb) enrichment in the soils. On the other hand, studies have shown that production in urban and periurban areas does not produce lower-quality vegetables than in rural areas (Midmore, 1998). Depending on the species and the plant parts, accumulation of heavy metals varies. Leaves can reach a high level while seeds are often less affected. It is possible

to adapt the choice of crops in relation to the degree and type of contamination. Some horticultural crops such as beans, peas, melons, tomatoes and peppers show very low uptake of heavy metals.

The risk of pollution depends directly on the location of the fields. The rate of absorption of heavy metals by vegetables seems to be linked with their levels in the soil. Lead is taken up by the plant roots and is then transported to the leaves. Lead from traffic fumes in the air settles on the leaves. It can be washed away by watering the leaves, especially when the leaf surface is waxy (cruciferous plants, Alliums). Cadmium can be taken up by plants through roots and leaves. For these two very poisonous heavy metals with no positive biological functions, their presence in plants is controlled by respecting the soil standards. The location of vegetable production, with regard to roads and polluting industries, should be selected carefully. Bio-remediation of the soil by plants and installation of mycorrizae limiting heavy metal uptake are long-term projects that might help in management of heavy metals in the future.

In addition to heavy metals, air pollution too can contribute to crop toxicity. For instance, Agrawal *et al*. (2003) show that, in the polluted environment of Varnasi, India, some physiological characteristics of bean, palak, wheat and mustard are significantly affected by the SO_2, NO_2 and O_3 O3 concentration, which are very common. These gases are very common in large cities in developing countries, especially with the fast growth of personal transport.

Pesticide residues and fertilisers
As in many forms of crop production, horticulture is confronted with pesticide residues in the plants and pesticide exportation to the environment. This can lead to major health problems for producers and/or consumers. The residues of pesticides and fertilisers originate not only from agricultural inputs used by the producers. Cultivation in contaminated areas or irrigation with contaminated wastewater, also contribute to increasing the residual levels in plants above the allowed limit.

These contaminants are absorbed on soil and are characterised by a very long half-life. Most belong to families of products that are banned worldwide. The crops containing these pesticide residues are mostly tubers and root vegetables. For instance, in the periurban cropping system in the French West Indies (more specifically home-gardens), root vegetables (manioc, yam) grown on plots where organo-chlorine has been used, even many years ago, contain some residues and may constitute a risk to consumers' health. In this case the risk is further enhanced due to the improper management of land.

Biological contaminants
The contamination of crops with pathogenic organisms by re-use of urban wastewater and organic solid wastes is an important issue associated with food safety, especially in the context of UPH (see chapter 8-9). These diseases may affect the producers who handle the contaminated material, as well as the consumers who may eat contaminated fruits or vegetables.

In horticultural systems, solid wastes are mainly used to improve the soil (household wastes, market refuse, sewerage, night soil, manure, fish wastes and agro-industrial wastes). Urban organic wastes are mainly composted; this process significantly reduces health risks.

If the compost is not properly prepared (at a too low temperature), the organic wastes can still contain pathogens (bacteria, helminth eggs, etc). The risk is greatly enhanced if organic materials are mixed with human excreta from latrines, manure or hospital waste, causing pathogens to breed. The use of domestic sewage for irrigating and fertilising field crops, perennials and trees is widespread. A large part of the wastewater used is untreated or

poorly treated and contains various bacteria, protozoan parasites, enteric viruses and helminths. Coliform bacteria are mainly transmitted to humans from wastewater via the contamination of crops irrigated with wastewater or through consumption of contaminated meat from domestic animals that have ingested tapeworm eggs from faeces in untreated sewage.

Pollution by horticultural practices

Horticultural systems may also pose a risk to their environments, and especially so in an urban context because of the proximity to people. Additional conflicts may arise between urban gardeners and city dwellers, especially when horticultural systems cause odours or, improperly, use large amounts of pesticides or fertilisers – artificial or otherwise – that urban dwellers fear may cause pollution. Although it is a general rule that inputs that affect human and environmental health must be used with care, this is more so in urban areas. The intensive use of agrochemicals (fertilisers, pesticides, fungicides) may lead to residues in crops, surface water or groundwater and cause negative effects to the health of agricultural workers.

Pesticides

All levels of cropping intensity are encountered in urban areas, from the most extensive (traditional) in developing countries and in allotment gardens, to the very intensive agriculture using high amounts of agrochemicals. Logically, the levels of pollution risk vary depending on the intensity of production.

Vegetables containing pesticide residues above the maximum residue limit have been identified in markets (Moustier 2000, Midmore 1998, Fatou Diop Gueye & Sy, 2001). In Accra, for example, a survey in 1998 of common cabbages collected from the retail market showed high residues of methamidophos, with two out of 20 samples exceeding the maximum residue limit (Sonou 2001). This occurs often, in spite of the fact that regulations for the use of pesticides and recommendations for health safety are in place. The application of pesticides on crops also endangers workers if little information is available on how to use them and when no protective measures are taken. This mainly affects low-income gardeners who cannot afford to buy proper protective clothing and equipment or are not aware of the importance of doing so.

Awareness of the risks caused by excessive use of chemical pesticides exists among all stakeholders, ranging from producers, consumers and public authorities to agrochemical companies. The UPH sector is more sensitive to this problem because of the proximity of consumer and producer. At this point in time, the penalties are not high enough to drastically reduce the over-use of pesticides. More negotiation between all players in the commodity chain might be one solution. In any case, there will be a cost, implying that the consumer must be ready to pay more to have a better-quality product and a safer environment. The development of new technologies such as integrated pest management and biological control can help in reducing pesticide use.

Nitrates

Nitrates deserve mention in pollution related to agriculture inputs. They can cause health problems to young children and pregnant women. Nitrates are also an indicator of good or bad agricultural practices. Nitrates cause eutrophication of water in combination with phosphorus. In Europe there are standards regulating the nitrate content in crops and water. In UPH systems, nitrates stem from fertilisation and from irrigation water. Some quick tests, such as Nitracheck®, appear to help producers manage nitrogen. Still, many of the methods available need to be validated for the specific urban and periurban leafy vegetables grown in developing countries. Moreover, with the aim of making better use of organic matter obtained from urban wastes in mind, specific tools need to be developed that take into account the problem of the irregular and slow release of nitrogen. If the source of pollution is close to the

water resource, as is often the case with UPH, the risk of pollution of water by nitrates is enhanced. This is particularly true in developing countries that do not have a good network of water supply and where many people depend on the local water resources for their supply.

Recommendations for safe urban horticulture

De Zeeuw and Lock (2000) suggest a number of prevention and control measures that can be applied in UPH systems to help produce safe and healthy products. Such measures should help reduce risk of pollution of crops by heavy metals, agrochemical residues, pathogens and diseases. The general principle of these 'good practices' is often based on good communication between health sector actors and urban farmers, ensuring the latter is educated to respect rules to limit/ stop contamination of the horticultural products. A summary of the major recommendations is presented below (see Box 11.1).

Box 11.1 *Major recommendations to reduce risks (see also chapters 8 and 9)*

Heavy metals

- Define norms regarding crop restrictions according to type and level of contamination of agricultural soils; test agricultural soils and irrigation water for heavy metals;
- Establish minimum distance between fields and main roads and/or boundary crops to be planted beside them;
- Treat soil to immobilise heavy metals: application of lime increases pH and thus decreases the availability of metals, except for selenium; application of farmyard manure reduces the heavy metal content of nickel, zinc and copper (but may increase cadmium levels); iron oxides (like red mud) and zeolites are also known to absorb heavy metals such as cadmium and arsenic;
- Wash and process contaminated crops to effectively reduce heavy metal content;
- Use plants such as Indian grass for biological remediation of polluted soils or streams (when planted in hydroponic beds).

Agrochemical residues

- Train of gardeners in proper management of agrochemicals;
- Promote ecological farming practices and replacement of chemical control of pests and diseases by integrated pest and disease management techniques;
- Establish better control on sales of banned pesticides;
- Introduce cheap protective clothing and equipment;
- Monitor residues of agrochemicals in groundwater.

Irrigation

- Improve inter-sectoral linkages between health, agriculture, waste and environmental management;
- Separate waste at source; collect organic refuse regularly;
- Establish decentralised composting sites; ensure the application of proper composting methods (temperature, duration) to kill pathogens;
- Identify quality standards for municipal waste streams and composts produced from them; monitor quality of soils, irrigation water from rivers and wastewater outlets, and composts; certify safe production areas; restrict of crop choice in areas where wastewater is used but water quality cannot be guaranteed;
- Establish adequate wastewater-treatment facilities with appropriate technologies;
- Train gardeners in managing health risks (for workers and consumers) associated with re-use of waste in agriculture;
- Educate consumers (scraping and washing of fresh salads; eating only well-cooked food).

Diseases

- Maintain cooperation between the health sector and the natural resource management sector (solid waste management, water storage, sewerage, agriculture and irrigation);
- Ensure water tanks and irrigation systems (especially in periurban areas) properly designed to prevent malaria;
- Apply slow-release floating formulations to control the malarial vector; use expanded polystyrene balls to effectively control mosquito breeding in latrines and stagnant polluted water.

Agronomic Techniques

Horticulture in urban areas will continue to be adapted to specific circumstances, as determined by the opportunities and constraints, and specific techniques will be developed, including combinations of practices from traditional horticulture and more modern, innovative practices.

Horticulture is practised in various agro-ecological and climatic zones, from dry areas to tropical and equatorial climates, in areas with cold seasons and in those without. Urban producers strive to grow crops year-round, to be able to better regulate delivery. However, in different parts of the world, certain periods of the year are too cold or too hot to produce crops. Or the producer faces drought in arid zones and excess of water in wet tropical areas, mainly in the rainy season. Temperatures can be regulated by using greenhouses and plastic covers. In developed countries, vegetables are grown in greenhouses with a cooling system to decrease air temperature. In developing countries, the two main difficulties faced are excess of water or lack of water.

In tropical areas, the distribution of rainfall often varies greatly between the dry season, which is usually colder, and the wet season, which is usually warmer. In the wet season, heavy rains may stop horticultural activities even though the consumer demand is high. In solving this problem, producers in some areas, such as Martinique (French West Indies) and Mayotte, use shelters as "umbrellas" to prevent an excess of water for the crops. In some areas, despite the tropical location (eg. Réunion or Vietnam), heated shelters have to be used during winter when the temperatures are low. In some other cases, an insect-proof greenhouse has to be used to protect the crops (at least in its early stage of growth) from a virus frequently transmitted by insects. This is the case of tomatoes which can be infected by PYMV (Potato Yellow Mosaic Virus) and TYLCV (Tomato Yellow Leaf Curl Virus) through the white fly (*Bemisia tabaci*). These shelters help increase yields but require significant investment and may lead to side effects, such as the soil becoming too poor to further sustain production. Producers may need to turn to new techniques as described in the next section (organoponics or hydroponics). Producers, whether rural or urban, are always willing to adapt and improve their practices based on their own experiences and new information. Most of the new techniques however require access to capital for investments and access to specific knowledge.

Gabriel Ramirez Garcia

Productive Micro Farm in San Luis Huexotla

Irrigation systems

Water is essential for the growth of plants. Water requirements are related to climatic conditions and plant species. In most capital cities of developing countries located in tropical and subtropical areas, the quantities needed vary from 0,1 to 1 l / m^2/day in very dry and hot weather. For a crop of 30 days, the quantity of water needed by a leafy vegetable during the dry season is around 15 l/m^2. The case study of Dakar, Senegal emphasises the issue of water management in a context of limited availability.

Generally, water availability in cities has been showing a decreasing trend and the forecasts predict it will continue at least in the next 30 years (see chapter 9). Water is a necessity for crop production. Depending on the climate and the yields, producing 1 kg of a crop such as

tomato requires 60–140 litres of water. Table 11.4 presents the approximate rates of water consumption of some horticultural crops.

Table 11.4 *Water consumption of some horticultural crops*

Vegetables	Cycle length (without nursery) days	Yield kg/m²	Waters need litre/m² (tropical)
Tomato	120	6	400 – 800
Non-leafy Chinese cabbage	40	2	150- 300

Different techniques are used for irrigation. Water is applied by overhead irrigation using watering cans, and also through sprinklers or perforated pipes from wells, ponds or the sewer.

Vegetables, especially leafy ones such as lettuce and cabbage, need to be watered twice a day, every day or at least every other day to obtain a good quality (freshness, tenderness) for marketing. There are two steps in watering: 1) lifting the water or bringing it to the plots, and 2) applying the water to the plants. These two steps may be merged or kept separate. For UPH in developing countries, the watering can is the most commonly used system. Each can holds 8–15 litres; one worker usually carries two cans. The water is taken from shallow wells, deep wells, "céanes" in Senegal (which are wells fed by groundwater and often located at the bottom of slopes and strongly polluted by nitrates), small cement reservoirs, drums (Ghana) etc. Reservoirs are filled by hand using small buckets, or with treadle, electric or motorised pumps. In Vietnam, people irrigate by submersing the crop or by using small hand buckets to lift water from canals to fields. The manual system is efficient because, most of the time, the gardener applies exactly the quantity of water needed by the crop. It is labour intensive, and in Senegal, this operation takes 60 percent of the total labour requirement for vegetable production.

Drip or trickle irrigation is another irrigation technique that has been promoted for nearly twenty years. It saves water by 10–20 percent compared to overhead irrigation, but requires clean water in order to avoid blocking of the emitters. The fully-fledged system includes filters, pumps and a pressure regulator, which low-income vegetable growers cannot usually afford. The advantage of this technique is that water is not in contact with the fruits and leaves. It will not, however, avoid contamination of the soil and roots of vegetables with biological pathogens. Underground irrigation provides water to the plant by capillary action. Such an underground system can limit the transmission of pathogens to the vegetables thanks to the filtrating effect of the soil. But installation (flat soil) and operation (control of the flow to the plants) are rather difficult. Some simple drip-irrigation systems have been developed, e.g. in South Africa. This system consists of a 210-litre drum, which is connected via a tap to a set of five polyethylene dripper lines, each with a length of 6 m. The drippers are constructed by perforating the polyethylene pipe with a heated nail. A piece of string is threaded through these perforations by means of a bag-needle. Knots on both ends of the string prevent it from slipping out of the pipe. When the perforations get clogged, pulling the string from side to side usually unblocks the openings. Clogging of the drippers is reduced by placing a stone and sand filter at the bottom of the drum. The filter prevents coarse particles, which may be present in the irrigation water, from entering the pipes and blocking the drippers (Khosa et al. 2003). Such a system of micro-irrigation is particularly suitable for small farms in urban areas, because it does not need a high capital investment and because it uses rainwater collected from roofs.

Fertilisation

Crops require nutrients: macro-elements such as nitrogen, phosphorus, potassium, calcium and potassium; and micro-elements such as manganese, copper etc. Intensive cropping systems on very small areas, using only solid and liquid urban wastes, are not always optimal for crops.

Two main groups of fertilisers are used: organic fertilisers and chemical (or inorganic) fertilisers. There has always been a heavy use of organic fertilisers in intensive production such as vegetables and ornamental flowers. The quantity varies from a few tons/ha to 50 or even 100 tons per year. Organic fertilisers provide most of the micro-nutrients and in addition improve the structure of the soil. Organic fertilisers can be manure from livestock or poultry, compost from vegetable wastes or wastes from urban activities: sewage sludge, night soils, household wastes etc. Over many centuries, periurban and urban farmers have managed and recycled urban wastes (Fleury and Moustier 1999). In South-East Asia, use of fresh night soil is a common practice even though it disseminates human pathogens. These practices may cause some risks to the environment – pollution of soils with heavy metals from sewage sludge, pollution of water with nitrates due to large quantities of organic manure – and also to the health of the consumer.

Robert J. Holmer

Bucket Drip Irrigation in Philippines

Solid organic fertilisers have the disadvantage that they release nutrients, especially nitrogen, slowly. Liquid fertilisers act more quickly. This explains why liquid organic fertilisers are often used on short-cycle leafy vegetables like amaranth and mustard. In Hanoi (Vietnam), liquid organic fertiliser, eg. pig urine, is used to supply nitrogen during crop growth. Research has often focused combining organic and inorganic fertilisers to enhance their efficacy. AVRDC (World Vegetable Center) is working on producing an organic liquid fertiliser that does not endanger consumer health (AVRDC, 2000). The use of organic wastes as fertiliser can lead to different forms of pollution as discussed earlier. This problem is strongly linked to recycling in the cities (see chapter 8).

Inorganic fertilisers are easier to use and allow for application of the right dose of nutrients. However, there are risks of over-application and contamination of soils and water by nitrates and phosphates, which is especially relevant in the city. Also, they could be a source of heavy metals. In Thailand, it has been shown that ammonium phosphate can release cadmium, zinc and chrome into the environment in excessive quantities (Tran Khac Thi, 1999). Urea is the main inorganic fertiliser used in horticulture, especially for vegetables. There is often a lack of phosphorus and potash, and this can lead to an imbalance in the proportion of nutrients in the soil. However, the access to fertilisers in general and inorganic fertilisers in particular still requires a fairly high investment by farmers in most developing countries.

Pesticides

Chemical pesticides have contributed to yield increases in agriculture in general for more than 50 years. Especially in periurban horticulture, easy access to pesticides (via national and international companies, retailers and wholesalers) and technical information has increased its use. However, this has also increased the negative perception of agricultural production in and around the cities. There are three major risks involved: i) health risks for consumers; ii) risks of polluting the environment (mainly water sources); and iii) risks for users. Surveys have been conducted regularly on the use of chemicals, their rate of application and the period between the last application and the harvest for marketing.

In Vietnam, low-cost pesticides (organo-phosphates, pyrethroids, carbamates) with high toxicity (classes I and II) are very commonly used with little information about how to use them. Surveys shows that application rates are much higher than the recommended rates for most of the pesticides used. This and the high spraying frequency are the causes for high pesticide residues in the marketed vegetables.

Pesticides in the city's surface and waste water does not necessary come from urban horticultural production. Still when this water is used for urban crop irrigation, it constitutes a high risk. In Bangkok, a survey has shown residues of organo-chlorine and organo-phosphate in irrigation water (Eiumnoh & Parkpian 1998).

Urban Horticultural Systems

Rural horticulture adapted to urban situations

Kessler (2003) describes the different farming systems in four West African capitals (Lome, Cotonou, Bamako and Ouagadougou). In this study, the farming systems are characterised by the crops grown by farmers. The study reveals that differences in crops and inputs of the different farming systems are due to different economic strategies adopted by the farmers. Mixed vegetable farming with watering cans and/or with pumps to cultivate short- and long-cycle vegetables like lettuce, cabbage, carrots, onions, etc. is an example.

Similar systems are also described in Asia. Farming systems in the peri-urban areas of Hubli-Dharward (India) comprise vegetable production, agroforestry systems, Napier grass (fodder) production and small-scale livestock production (Bradford et al., 2002). In Hyderabad (India), the predominant system is paragrass production, which like Napier grass is used as folder. Green leafy vegetables are grown here on small sections for subsistence needs and for sale. Other crops include rice, fruit trees and flowers. There is also coconut and banana as well as livestock (water buffalo) keeping (Buechler et al., 2002). In Cagayan de Oro (Philippines), urban types of agriculture are characterised by home gardens as well as aquaculture and other specialised food crops (banana, cereals, vegetables etc.,usually as mono-crops). Production can be for home consumption as well as for market sale. Peri-urban agriculture is often dominated by irrigated vegetable production, as is the case in Vietnam or Malaysia. Other systems that can be counted are commercial and domestic livestock production, flowers and seldom agroforestry (Potutan et al., 2000; own observations). Major systems mentioned for Shanghai are cereals, vegetable and livestock production (Yi-Zhang and Zhangen, 2000).

F. Arroyo

Organoponics in small buckets

Many additional types could be named using the major crops grown or animals raised as a criterion. A study under the Urban Harvest Programme (www.cipotato.org/urbanharvest/home.htm) in Cameroon identified three major types of cropping systems:

1. mixed crop systems dominated by open-pollinated varieties (OPVs) of improved maize in the upland areas (vacant lots, unused municipal lands);
2. mono-cropping systems of OPVs of improved maize grown in valley bottoms; and

3. intensive horticultural systems in valley bottoms, primarily for the production of traditional leafy vegetables (TLVs).

In addition, they observed that there is widespread use of small home garden plots for growing leafy vegetables and stands of banana, plantain, avocado, African plum and other fruit trees around homesteads. Within these cropping systems, the research identified two types of agricultural units: "commercial" and "household food" producers based on the criterion of producing for sale, at least, half of the output from one of their products. The study found that women are the main producers for both household food and for sale, accounting for 87 percent of the total sample (see also the case of Yaounde).

Moustier in chapter 7 summarises the different descriptions found in literature of cropping and farming systems in 5 major types of urban agriculture:

- Subsistence home intra-urban farmers (intra-urban and peri-urban areas)
- Family-type commercial farmers (intra-urban and peri-urban areas)
- Urban and peri-urban agricultural entrepreneurs (intra-urban and peri-urban areas)
- Multi-cropping peri-urban farmers (peri-urban areas)
- Urban residents with speculative strategies (intra-urban and peri-urban areas)

Although quantitative data on the importance of each of these types are scarce, available figures for West and Central Africa suggest the dominance of family commercial farmers in terms of number and of importance in urban food supply (Moustier, in chapter 7). In Dakar, out of 5025 urban farmers, 70 percent were family commercial farmers, 25 percent were entrepreneurs and 5 percent were subsistence farmers (Mbaye and Moustier, 2000). Households may move from one category to another, for instance when products are being sold in the market. The (semi) commercial households' main aim is to have a regular income and a regular food supply for securing their livelihoods. Therefore the cropping system is based on crops that add high value and that are less risky to grow on small parcels of land. Leafy vegetables with short cropping cycles that enable regular cash generation are a typical example.

New Urban Horticultural Systems

New horticultural practices have been developed to maximise the use of space, to optimise the use of inputs and to minimise impacts of horticulture on human and environmental health. Some of the new techniques described here are: growing horticultural crops on urban built-up land with various types of urban substrates (eg. on roof tops, organic farming and hydroponic production), to save water in highly populated areas, to produce pesticide-free vegetables year-round with a low content of heavy metals and human pathogens, and to control wastage and leaching (fertilisers, pesticides, organic matter, water) into the urban environment.

These techniques take into account the specific constraints of UPH systems, but are more demanding than traditional or conventional techniques in terms of new knowledge and/or investments.

Hydroponics

Hydroponics is a technology characterised by the absence of soil. It needs less space, labour, external inputs and time, but needs proper management and often higher investments. As mentioned earlier, it is often difficult to control or quantify nutrient availability in the soil. Hydroponic systems provide a convenient means to control plant uptake of nutrients. An additional advantage of water culture is its secondary effects such as accumulation of soil

toxins are likely to be reduced (Lissner et al., 2003). Another advantage of growing without soil is that it reduces some soil-borne diseases.

The basic concept of hydroponics is that roots suspended in moving water absorb food and oxygen rapidly. Of special concern is the availability of oxygen. The grower's task is to balance the combination of water, nutrients and oxygen with the plants' needs in order to maximise yield and quality. The use of water and inputs is optimised: the exact amount needed by the plants is provided. For the best results, a few important parameters need to be taken into account: temperature, humidity and CO_2 levels, light intensity, ventilation and the plant's genetic make-up. In order to fix the crop roots in the required position, some inert substrata may be used (sponges, artificial mineral marbles, rock wool etc).

Water quantity and quality are key factors in hydroponic systems. Water quality depends mainly on the source used. Growers use water from different sources, such as surface water (lakes, natural and artificial ponds), groundwater (wells), municipal tap water, rainwater and combinations of these. Rainwater has a low ionic strength and usually low micro-organism and algal densities; it conforms to water quality guidelines and is often better than other sources. A common practice is to collect rainwater from greenhouse roofs into ponds. However, as these ponds are fed by atmospheric precipitation, they are vulnerable to changes in the environment, eg. eutrophication and acidification. Rainwater is not always available for use in irrigation because of technical problems in collection and storage. Therefore, the grower must find other water sources, eg. rivers or lakes, but, in many cases, such sources are polluted (Schwarz et al., 2005).

Hydroponics allows production in abundance of healthy fresh vegetables, ornamentals, aromatic and medicinal plants and suits the requirements of poor urban farmers. When the technique is well controlled, the productivity generated by hydroponic systems is greater than that from traditional gardening systems. It is a perfect technology for urban or periurban areas where the soil is poor or polluted. In many countries of South America, hydroponics is a technique that is fast gaining importance (Tabares, 2003; Rios, 2003).

Small hydroponic units can be operated by families. This may help in meeting their food needs and in getting an additional income. Some special hydroponic techniques have been developed, especially for limited spaces and to suit people in developing countries. Such simplified hydroponic systems often use recycled materials and are easier to understand, learn and implement (Caldeyro-Stajano 2004). Simplified hydroponics is a technology incorporating soil-less culture techniques without using mechanical devices or testing equipment. This technology was developed in the early 1980s in Colombia and is propagated by FAO. It is accessible to people with limited resources and is optimised to use minimal inputs of land space, water, nutrients and grower infrastructure (See Box 11.2). A Family Economical Unit (FEU) of 20 bed-growers of 2 m^2 each (40 m^2) is designed to produce crops that bring an income estimated at USD 3.33 per day in Colombia (year 2000 figures). Simplified hydroponics is well suited to fresh vegetables and fruits (with a high water content) such as lettuces, tomato, bell pepper, basil, celery and radish.

Box 11.2 *Cost estimation of a simplified hydroponic system*

In data gathered from the Colombia project, the results of garden productivity were averaged and the commercial values were estimated. The cost of building 20 bed-growers for the FEU from recycled wood is estimated to be USD 12.84 (6.42 m^2). The annual costs for operating a garden, using the same crops as in the Colombia project, will average about USD 355. This includes costs for medium replacement, seeds, nutrients and water. The annual net income from this garden is estimated to be about USD 1210.00 (USD 101/month). Water is applied to the bed-growers and the excess water is collected underneath them and recycled to the growers the next day. The average water use for a grower is 2–4 litres/day/m^2 or at most 160 litres per day. The annual water requirement for each garden is estimated to be 60,000–120,000 litres.

Another interesting process is hydroponics with floaters, where plants are fixed on polystyrene beds that float over a tank. The water surface is completely covered by the floating bed which permits a very limited growth of algae. The tank's nutritive solution is oxygenated, eg. by a pump. This hydroponic system is characterised by a large volume of nutritive solution, no losses of water, minimal evaporation and the possibility to use the solution for many crop cycles. It is a low-cost method needing little maintenance. It is used in Martinique (French West Indies), an island with high constraints of space in periurban areas, for production of lettuce or onion (Langlais, CIRAD, pers. comm.). Hydroponic systems also present interesting solutions in combination with the recycling of water, and has been studied in water hyacinth, reed and flower (roses) production systems. Another possible future development of hydroponics is the production of bio-energy crops using wastewater as a nutrient solution (Mavrogianopoulos et al., 2002).

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A large variety of crops can be grown on a small area

The use of wastewater in hydroponic systems requires monitoring of the water quality. The Gravel Bed Hydroponic system (GBH) developed by the University of Portsmouth, UK, includes a rock filter in gabions for primary treatment, GBH beds for secondary treatment and a pond for tertiary treatment. It reduced the biochemical oxygen demand (from 350 to less than 20 mg/l) of the output water in a bed planted with narrowleaf cattail (*Typha angustifolia)* in Colombia (Stott et al., 1999). Williams et al., 1999 also show that the use of GBH in Egypt permitted a significant removal of parasite eggs from domestic wastewater.

Organoponics

Organoponic systems grow crops on organic substrata to replace unavailable chemical inputs. The crops are sown in holes or furrows filled with an organic substratum, the concentration allows maximisation of its effect. The origin of the substratum can be diverse, including compost or organic residues from other sources (faeces, wastewater residues etc). The technique is widely used in Cuba and Venezuela.

Organoponics is particularly suited to soils of very low fertility; in the long term, it helps restore the soils by increasing the soil organic matter content. It is also well suited for vegetable production in urban and periurban areas because it maximises the use of space and water. However, in an urban context, the supply of organic substrata can be limited. Depending on the origin of the substratum, some pollution and sanitation problems may be increased, especially when solid waste compost that could contain heavy metals is used. Linking horticultural organoponic systems with ecological sanitation (as described in the Urban Agriculture Magazine no.10) or use of manure, could increase the productivity of organoponic systems.

Green buildings

In developed countries, covering buildings with plants (green building strategy) is part of the ecological design of urban landscapes and is becoming increasingly widespread (Calkins 2004). To be a nutrient capture system, to recycle organic waste and to provide employment, rooftop growing must be profitable. Wilson, G., (2002) shows that in the medium-term urban cropping systems may generate a positive net gross margin. In developing countries, horticulture on buildings, mainly on rooftops, is gaining in importance and allows production of various vegetables, fruits or flowers. For instance, in Senegal rooftop gardening, based on bricks or wooden box beds filled with compost, allows growing a wide variety of crops, including: fibrous roots crops, tomato, hot pepper, eggplant, etc. (Deesohu Saydee and

Ujereh, 2003). Such cultivation is characterised by its high level of intensity due to very small spaces available on the roof of buildings. They use either hydroponics or organoponics (often in containers, boxes, pots or cells). A positive effect of rooftop gardening is that planted roofs improve the thermal performance of a building. They block solar radiation and reduce daily temperature variation and thermal ranges between winter and summer (Eumorphopoulos and Aravantinos 1998). The effect of rooftop gardens on reducing the energy consumption of commercial buildings was measured to be up to 14.5 percent in Singapore (Wong et al. 2003). Singapore has developed a project of greening by planting trees, shrubs and grass in the city in order to maintain a pleasant living environment. Roof gardens, though not a new concept, increase the percentage of greenery in urban built-up areas and bring back the vanishing urban green space. Sprucing up the originally under-utilised portion of the buildings, they can 'create a new network of vegetation linking roofs' and increase the ratio of greenery to people.

Due to being located outdoors, these systems face natural attacks, e.g. of insects and birds, and some crops would therefore need protection. The issue of the crop residues produced by such systems is also a consideration in the urban context and could be a limiting factor in the development of agriculture, if not accounted for in urban planning.

Permaculture

Due to the limited area for cultivation and the constraints this poses, agricultural activities within the city have to be efficient and with minimal impacts on the environment. Some integrated systems called 'permaculture' have been developed to meet these requirements. They combine growing fruits, vegetables or grains with keeping livestock by creating a symbiotic ecosystem, with an ethical foundation in sustainability and copying nature, and a scientific basis in ecology. Permaculture (for permanent agriculture) is particularly relevant in the context of UPH because it is a flexible option that suits city conditions due to the local recycling of energy and resources. The variety of production limits the risk and gives financial security. It is well suited to the developing countries because external inputs (chemical fertilizers, pesticides etc) are limited or absent.

Permaculture can be considered as one ultimate cropping system concept that uses a wide range of techniques and concepts: rainwater collection, excrement composting, reusing and recycling resources, saving energy, green building and planning, developing the local economy. For example, in London (UK), Becontree Organic Growers in Dagenham develop the local economy through a local exchange trading scheme (Sherriff and Howe, pers com.). In Havana (Cuba), permaculture has been encouraged (Lazo and Barada, pers com.), where it has not only permitted the production of food, medicinal plants, spices and ornamental plants, but also resulted in a knowledge network by including a range of interested actors through periodic workshops, courses and conferences in environmental education and other related topics.

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Simple Hydroponics at a school in Peru

Conclusion

In many expanding cities in developing countries, UPH is already a large contributor in supplying fresh produce to city markets and is expected to remain so in the near future. On the one hand, the available land will decrease because of the need for industrial development and urban housing. On the other, the demand for fruit, vegetables and flowers will increase

with rising standards of living and growing populations. Horticultural production units will evolve and adapt to new environments as cities continue to develop. In the future, vegetable production will remain essential as a source of high income and healthy food for growing cities.

Box 11.3 *Allotment Gardens in Cagayan de Oro, Philippines*

By R. J. Holmer

Cagayan de Oro, a city of about 600,000 people, is located on the central coast of Northern Mindanao in the Southern Philippines. It is representative for the numerous secondary cities that have rapidly emerged all over Asia in the shadow of the so-called megacities such as Manila, Jakarta or Bangkok. Out of its total land area of 48,885 ha, about 2,300 ha are under agricultural production, mainly for production of corn, fruits, root crops, rice and vegetables with eggplant, squash, string beans, bell pepper, horse radish tree leaves and bitter gourd as the most popular ones (Potutan et al. 1997). Apart from these commercial farms, other forms of urban horticulture also exist. The City Agricultural Office estimates that about 40 percent of all households (94,672 in 1997) maintain backyard gardens and produce mainly leafy vegetables, fruits and ornamental plants. 96 percent (75 out of 78) of public elementary schools in Cagayan de Oro maintain a school garden. This activity is pursued by pupils as part of the school curriculum and supervised by the principals and teachers. The size of these gardens ranges from 500-1000 m^2. The pupils usually plant leafy vegetables, fruits, ornamental and herbal plants. In some schools, parents are involved in maintaining and safeguarding these gardens. School administrators have adopted bio-intensive gardening, designed for pupils to learn about urban agriculture through both formal and informal approaches to education (Potutan et al., 2000).

Since 2003, a special type of community gardens, so-called allotment gardens, was established in four highly urbanised areas of Cagayan de Oro, particularly to benefit urban poor families. Allotment gardens are characterised by a concentration in one place of several small land parcels of about 200 to 400 m^2 that are assigned to individual families, who are organised in an association. In allotment gardens, the parcels are cultivated individually, differing from other types of community gardens where the entire area is tended to collectively by a group of people (Holmer et al., 2003). The production practices for vegetables in allotment gardens are similar to those in rural areas, but differ mostly in the choice of suitable cultivars and the reduced application of agrochemicals due to the proximity to populated areas (Guanzon et al., 2003). The perceived benefits of the allotment gardens in Cagayan de Oro are many (Urbina et al., 2005). While 25 percent of the vegetables produced is consumed by the family or given away to friends, 75 percent is sold to neighbours or walk-in clients who come directly to the gardens as they appreciate the freshness of the produce, the convenience of proximity as well as the lower price compared to the public markets. The gardening activities, a secondary occupation for all its members, have augmented the available income by about 20 percent while the vegetable consumption has doubled for 75 percent of its members. This is especially notable since the average vegetable consumption in Cagayan de Oro is only 36 kg per capita and year, which is half of the minimum recommended intake of FAO (Agbayani et al., 2001). In addition to these benefits, the gardeners particularly appreciate the strengthening of community values, which they have experienced by engaging in allotment gardening. The gardens are also essential for the successful implementation of the city's integrated solid waste management programme. The segregated bio-degradable waste from the neighbouring households is delivered to the allotment gardens where it is converted into compost. The amount of residual waste delivered to the landfill site from these areas has thereby been reduced by more than one third. The city government of Cagayan de Oro is presently mainstreaming this concept into its overall city planning and development, which will also use participatory GIS-based approaches to identify suitable areas for future allotment garden sites.

Vegetable production provides regular and high incomes to the various actors in the commodity chain and provides food to urban dwellers. For instance, in 1999 in Jakarta (Indonesia), UPH fruit production supplied almost 20 percent of the city's demand. Worldwide, about one quarter to two thirds of urban and periurban households are involved in agriculture. In the coming decades, fruit and vegetable production will continue to play a

key role in feeding cities and providing activities and incomes to farmers. To answer consumers' demand and to produce healthy fruits and vegetable in a manner that respects the environment and producers, it will be necessary to combine agro-technical solutions with urban planning. Many specific techniques have been developed or adapted specifically for urban areas but there is still some research needed in order to better understand these complex anthropised agro-systems. Systems such as permaculture that combine various forms of production can be very complex ecologically. It is therefore important to undertake agro-technical studies that could provide more in-depth on the conditions required for obtaining good-quality vegetables. Urban planning should help to provide optimal conditions for urban gardeners (See chapter.3).

So, with a view to current and future technology transfer, all stakeholders in the commodity chains have to be involved in developing better conditions for integrating fruits, vegetables and flowers as part of UPH. Supply of inputs and materials, management of crop residues and linkage between activities are key points that need to be taken into account early in the urban planning process. It involves all aspects of a city's organisation and requires commitment to provide goods and services to agricultural activities and people (Pinderhughes 2004), (see also chapter 1 and 2). The case of PROVE (chapter 7), also shows that additional income can be gained by (poor) urban producers if less intermediaries are involved in getting their products to the consumers.

Various functions of UPH have been mentioned in this chapter. The food supply function remains the most important, even though economical, social (labour), cultural, living environment, environmental (recycling) and security (food and natural risks) functions appear to be essential too. More than any other agricultural system, UPH has a multifunctional role that should be taken into account by researchers and policy makers. Implementation of an urban planning policy that includes the sustainability of this form of agriculture is a necessity for well-balanced urban development. UPH plays a substantial role in the development of local (micro)enterprises, including input supply, processing and marketing. It also reduces the distance that fresh food needs to travel from producer to consumer.

If well managed, urban horticulture can play an important role in reducing socio-economic and environmental problems in cities. Planners and policymakers should develop and support community-wide plans to improve poor people's incomes using urban organic waste, to improve urban food safety and to create sustainable food systems.

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Dry and aquatic peri-urban and urban horticulture in Hanoi, Vietnam

Hubert de Bon

In Hanoi (2.8 million inhabitants, 921 km^2), horticulture is practised all over the city. Hanoi Province is divided into seven urban and five periurban (or rural) districts. The mean farm size varies from 1600 m^2 in urban districts to 3200 m^2 in peri-urban districts. The average household labour involved in horticultural production is around one person in urban districts and 1.5–2 persons in periurban ones. Hanoi is surrounded by rivers which flood during the wet season from June to November, and is a significant constraint to horticulture. Despite the humid subtropical climate, all crops are irrigated.

In urban districts, the main crops are leafy vegetables (kangkong, Chinese water spinach, water morning glory and choysum), flowers and ornamental citrus tree (*quat*). Kangkong is grown in the Hanoi area, in the two urban districts of Than Xuan and Dong Da, as well as in the Thanh Tri southern peri-urban district. Kangkong (water convolvulus) is grown in water and in a dry system. The aquatic production occurs in lowland areas and canals filled by rainwater and sometimes domestic wastewater from the surrounding houses. In the urban districts, the main sources of wastewater are city drainage and households. Whatever the quality of the water, kangkong grown in water is considered to be the best. The growers are essentially older women. In the two urban districts, only five families are occupied with this production, which contributes only part of their household income. Harvesting is done every two or three weeks; the young shoots of 30–40 cm are cut and sold by the bunch. Sometimes, pesticides are applied on the foliage. The produce is sold directly in the street markets or, during the main harvesting period, at the wholesale night markets in bulk.

Nguyen Thi Dieu Phyuong

Water mimosa production

Ornamental plant production has developed in connection to the Tet (Vietnamese New Year) celebration. Citrus kumquat with orange fruits and blossoming peach trees are traditional gifts for the Vietnamese New Year. All around the lake Tay Ho, just before Tet, there is tremendous activity in sales of ornamental potted trees and blossoming peach-tree branches. Usually, the potted trees come from nurseries with a nine-month cycle in the inner districts of Hanoi. The young trees are brought from areas further away in the eastern provinces, such as Hai Dung, and transplanted in the nurseries of Hanoi. The Hanoi cycle demands large quantities of soil which are brought every year, between the Tet harvest and the time of transplanting. Many lorry loads of soil are dumped around the lake in order to replace the 10-cm layer of soil removed by the production of trees for the Tet festival. Uniformity in the size of the orange fruits is obtained by applying hormones. The pyramid shape of the trees is gained by tying up the lateral branches with wire.

In the five peri-urban districts, vegetable production is very diverse with many specialised niche markets. Around 100 vegetable species are grown. For instance, the wax gourd (*Benincasa*) is grown mainly for small enterprises that produce crystallised fruits also sold during the Tet festival. Gherkins are grown for pickles. Recently, rose production for the local market and for export to China during the winter season has developed very quickly

to reach around 1000 ha of production in the Tu Liem District. Thus, there is horticultural production that feeds the processing and export sectors which take advantage of the city infrastructure (railway station, roads, access to power and services). On the other hand, there is also the cultivation of species that require short marketing chains from harvest to consumer, such as choy sum, Indian mustard, garland chrysanthemum, amaranth, lettuce and young shoots of squash. In this type of production, the grower tends to apply diverse chemical pesticides in order to obtain a good green leaf free of insect and disease damage. Thus, it is necessary to develop techniques that will reduce the use of chemicals. If chemical spraying is chosen, it is necessary to identify clearly the pest and the disease to be able to use the correct and most efficient chemical among those that are officially authorised. A recent on-going project (SUSPER: Sustainable Development of Periurban Agriculture in South-East Asia) has proposed the development of a physical barrier method. To protect the leafy vegetable crops, mainly crucifer, from insect attacks, farmers are advised to place tunnels of nylon nets with 500-micron stitches (or 32 mesh) over the crops. The mesh is small enough to keep out the diamond back moth cabbage worm (*Plutella xylostella*); a chemical treatment could be applied under the net if needed. For maximum efficiency, the net should not have any holes. To combat the stripe crucifer flea beetle (*Phyllotreta striollata*), the soil should be flooded 48 hours before sowing in order to kill all the pupae in the soil.

The political authorities are very concerned about the inappropriate use of chemicals. For instance, the Hanoi People's Committee has encouraged the development of a better-quality vegetable industry. One of the most successful initiatives is the setting up of safe vegetable production for specific markets, such as for school canteens, restaurants and high-income consumers. In comparison to the standard production, safe vegetable production is a good opportunity for maintaining vegetable production in the periurban area. Reducing the use of pesticides is a response to the risks of damaging human health and polluting the environment.

Peri-urban production is a successful example of market-oriented agricultural development that emerged after the 1988 and 1993 reforms. With 79 percent of the areas around Hanoi cultivated with rice, horticulture has a number of other functions than bulk food production: providing an income, protection against flooding, supply of fresh leafy vegetables (80 percent of leafy vegetables consumed in Hanoi come from Hanoi Municipality), providing specific vegetable and ornamental crops for processing and for export, maintaining the cultural identity around the villages, and the creation of an open space in a very densely inhabited area (this is of course together with the rice fields).

Case of Horticulture in Dakar, Senegal

Hubert de Bon

Dakar (2 million inhabitants, 550 km^2) is located in the far west of Africa and has a sub-Canarian climate, which is excellent for horticultural crops: an annual rainfall of 300–500 mm during the short wet season from June to October, followed by a dry season from November to May with relatively low temperatures due to the influence of maritime trade winds. In the area called Niayes, a large number of vegetable, flower and fruit crops such as strawberry, cabbage, tomato, lettuce, radish, French beans and Irish potatoes are grown. The large variety of vegetables grown is mainly for the local market but some of it also goes to the European market. The name Niayes is derived from the local word 'niaye' which means a depression between parallel sand dunes. Garden areas range from 1000 to 10,000 m^2. Horticulture is practised mainly with irrigation during the dry season, but is also rain fed during the wet season.

The traditional irrigation systems in the low-lying areas use water from the water table just below soil level. The soil is very peaty in the lower parts and becomes more sandier up the dune slopes. The fields are watered by hand from tanks twice a day. Manual irrigation demands up to 60 percent of the labour used for production. Sometimes, small electric or fuel pumps are used, which enables increasing the size of the plots. If domestic or urban water is available, vegetable farmers can negotiate a special price with the water companies to use this water for agricultural purposes.

IAGU-RUAF

Roof top gardening in Dakar, Senegal

Production during the wet system is limited by different factors. The areas for horticulture shrink because the low-lying areas between the dunes fill up with water during this season. Only a few vegetable varieties are adapted to the high temperature (around 29°C) and high humidity: hybrid tomatoes, eggplant, hot pepper, okra, watermelon, bissap (Roselle) and jaxatu can be grown during this season. Numerous pests and diseases have been identified on the different species: mainly insects (thrips on onion, fruit flies on solanaceous fruits, borers on cabbage, leaf miners on leafy vegetables etc) during the dry season; and fungi and bacteria (Phytophthora rot, bacterial spot on tomato) during the wet season. Throughout the year, everywhere in the sandy soil of Niayes, the root knot nematode (*Meloidogyne)* causes severe damage to various crops: tomato, lettuce, cucurbits, eggplant, okra etc. Different methods are used to control the development of this nematode: flooding during the hot wet season, using non-host crops such as cereals, and fallowing the land for several months.

In Dakar and in the Niayes area, a main constraint is the scarcity of water. The large size of the city limits the amount of water that can be used for agriculture. It is now forbidden to dig new wells to gain access to the ground water. Most of the horticultural growers complain that the water scarcity limits their production. The growers therefore have to increase the efficiency of water use and improve the profitability of production. There are two ways to deal with the shortage of water: 1) increase the efficiency of the irrigation system and 2) use wastewater. Improved irrigation systems have been developed: drip irrigation, hydroponics with water recycling, sub-irrigation by capillarity. These new systems have been tested by different projects with successful reduction in water use, but very few of these have been adopted by farmers. The use of wastewater seems to be a promising alternative. Wastewater

is used after a first treatment in a purification station. An advantage of wastewater is that it contains some of the nutrients required for the growth and development of the plants, mainly nitrogen and phosphorus. This reduces the use of organic and chemical fertilisers on the crops. The risk of plant contamination and transmitting human pathogens can be increased by watering of the crops during cultivation and just before harvesting. Several low-cost systems have been tested in Dakar to improve water quality: waste-stabilisation ponds in the traditional form or with plants such as cattail (Typha) and water lettuce (Pistia). Another solution is not to apply the water directly to the crops but rather to use sub-irrigation and hydroponics. See also chapter 9.

Thus the main problem for sustaining horticultural production in Niayes area is the water requirement of the crops. The competition between agriculture and other urban activities (mainly the development of buildings) is very high. At present, there is still a place and a function for agriculture as long as access to water, whatever its source, is not too expensive, and as long as urban citizens recognise horticulture as a way of managing urban spaces and getting cheaper and fresher food.

Micro-technologies for Congested Urban Centres in Ethiopia

Yilma Getachew

Addis Ababa sustains 2.5 million people on a total area of 50,000 hectares of land, of which the concrete and asphalt build environment takes up around 20,000 hectares. In this congested city, the availability of land for food production is becoming very scarce.

The Government of Ethiopia had begun to promote urban agriculture. It is included in the research agenda of the Ethiopian Agricultural Research Organization (EARO), in the teaching agenda of Addis Ababa University, and in the development agenda of GOs, NGOs and CBOs in Ethiopia.

Organic agriculture emphasises diversity and provides both quantity and quality of food which in turn generates income to purchase other food. Ethiopia is blessed with natural resources conducive to organic food production. Its soils are fertile and living, and its water is hardly polluted by salts and pesticides. There is also an abundance of traditional knowledge.

Bio-intensive gardening is a method that capitalises on the forces of nature in all phases of plant development: growing, fertilisation and pest control. The method has four important components: production techniques; natural fertiliser techniques; natural pest and disease control techniques; and small-scale water harvesting techniques.

Yilma Getachew

Training of trainers in Addis Ababa

Production Techniques

The Biodynamic French Intensive Method

This method, according to Jeavans (1982), is a combination of biodynamic techniques developed in Germany and the French intensive techniques developed in France. The Biodynamic French Intensive method is a form of organic agriculture comprising three basic principles. The first principle is to grow plants so close to each other that when they mature, their leaves just barely touch. This creates a situation in which the microclimate and the living mulch reduce weed growth and conserve moisture. The second principle is the use of raised planting beds (60 cm deep). These plots have loose soil that allows for air, moisture and warmth together with sufficient organic nutrients that help roots to properly penetrate the soil. The third principle is to feed the soil (and not the plant) by using organic fertiliser and natural methods of pest control. In short, the method is less dependent on expensive external inputs, is space intensive, water conserving, depends on family labour only, and creates minimal pest problems. Families practising the method are likely to have well-balanced nutritious food and a better income from products that are grown without risks.

The FAITH garden method

There are numerous organic wastes in our kitchens and gardens that are not recycled to produce more food. Such wastes include: weeds, grass, leaves, kitchen waste (peels, organic refuse, egg shells), livestock manure, ash, hedge clippings, hair trimmings, chewed sugarcane, etc. The FAITH method includes basket gardening that makes use of these wastes to

produce food. This technique requires bottomless baskets to be placed on the top of a hole (30 cm diameter x 30 cm depth) dug into the ground. All kitchen and garden waste is dumped into the hole. At the same time, desired vegetables and fruits are planted about 20 cm away from the basket. Through their root systems, the plants extract moisture and nutrients from the fermenting waste. This method produces organic food and fertiliser, conserves water and protects plants.

The Barrel garden

Imagine producing over 25 plants of Swiss chard or strawberries in a space less than one square metre? The materials needed to do this are a 200-litre barrel, a corrugated iron sheet, soil mixture (preferable 2 parts soil to 1 part aged manure or compost and 1 part sand), and manure tea.

Several incisions of about 12 cm each should be made around the barrel. The upper lips of the incisions are hammered inward and the lower lips outwards. The incisions should be made in intervals of 15 cm horizontally and 20 cm vertically. The barrel top is open while the bottom is perforated with about 10 holes. A rolled corrugated iron sheet is placed in the middle of the barrel and filled with sand. The space between the inner wall of the barrel and outer wall of the corrugated iron is filled with the soil mixture described above. Vegetables or fruits of choice are planted in the space between the two lips of the incisions. Regular watering is done through the sand in the middle. Manure tea is applied on a weekly basis through the sand in the middle. The barrel should be maintained over gravel for better aeration and drainage.

The benefits of this technology is that it enables families to increase the availability of micronutrient food and encourages the reuse of old barrels and trashcans (which are freely and cheaply available), the composting of organic solid waste, and using livestock waste as manure tea.

The Trench Garden

The trench garden method is interesting in situations where malnutrition (of macro-nutrients) and excess of livestock manure go hand in hand. The technology requires seed potatoes, aged manure and mulching material. To develop the trench garden, one needs to dig a 30 cm wide, 30 cm deep and 6 meters long trench. At the bottom of the trench, the soil should be cracked to a depth of another 30 cm to allow better aeration and drainage. After planting the seed potatoes at intervals of 30 cm, the trench is completely filled with aged manure in between plants. After two months each potato plant will yield one or two tubers per week, or about 2 kg per week, per trench, for duration of two months. After two months, the trench is refilled as before, which will continue to supply the family with potatoes for another two months. Depending on the availability of garden space the family can build several such trenches..

Yilma Getacheu

Trench Garden

Management of Bio-Intensive Gardens

Apart from the production techniques, the bio-intensive garden practitioner needs to fertilise his plots, apply pest control and use water efficiently. Sustaining soil fertility in the natural

way is the most important component in the organic farming/gardening strategy. There is a basket of choices of organic fertilisers that can be categorised as manure-based, legume-based or biomass-based. Additives like wood ash, bone meal, egg shells, etc. contribute greatly to organic fertilisation, by producing potash, phosphorus, calcium and iron if the soil micro-organisms are allowed to work on them.

There are three approaches to keeping pests and diseases at bay, the natural way. The first step is to have strong healthy plants growing in healthy living soil so that they can build resistance. The second is to fight harmful insects through beneficial insects and animals such as ladybirds, praying mantises, wasps, lizards, birds, etc. The third is to apply natural pesticides such as pepper, tobacco, pyrethrum, stinging nettle, etc.

Three major categories of activities aimed at the efficient use of water can be mentioned. The first is harvesting water during the season of plenty, for use when there is less water - roof water harvesting, ponds and artificial lakes are some examples. The second is to conserve the available water by mulching, shading, precision planting, etc. The third is recycling water or reusing it for a second and third time depending on the previous use.

Promoting Bio-Intensive Gardening in Ethiopia

Relying on the natural resource base, simplicity, affordability and productivity are the features on which training on these techniques is designed to respond towards greater sustainability, replicability and equity. To date, 800 families have participated directly in the training programmes on bio-intensive gardening in Ethiopia. Replication of the technologies amongst the communities is reported to have reached 8,000 families. The trainees are a mix of male, female, urban and rural dwellers. A typical module for a demonstration training plot is about 70 m^2.

Opportunities and constraints in Ethiopia

Illegal land occupation, use of contaminated downstream city rivers and the absence of urban agriculture in city planning are forces that have discouraged this approach in Ethiopia. However, through years of campaigning by environmentalists and agriculturalists, urban agriculture is now recognised by policy-makers and has been included in the master plan for more than four cities and towns, with others to follow.
The market is a real problem in the Ethiopian rural setting as far as vegetables and fruits are concerned. Traditional diets being predominantly cereal-based and fruits and vegetables being perishable are the main reasons. The overall poverty situation contributes to poor consumption and production of food rich in micronutrients.

Training in the bio-intensive approach to urban agriculture began in Ethiopia ten years ago. Since then, training sessions have included youth clubs, women's clubs, pensioners' associations, extension agents, farmers, school teachers and students, NGO workers, etc. In all these cases, the training sessions had limited hands-on practical sessions due to a lack of permanent demonstration plots. Thus the need for establishing a school of urban agriculture has surfaced, and is supported by several NGOs and governmental offices.

Recommendations

Urban agriculture is accepted as a policy by the Addis Ababa city administration and the city planning has set aside land for the purpose. What is not well understood by the authorities, however, is the potential of the organic option to urban agriculture and the available technologies. Seminars, workshops and publications need to address this issue. The poverty

eradication strategy of the country needs to include urban agriculture as one among the important tools in the fight against poverty in urban areas.

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Vegetable production in Yaoundé, Cameroon

L. Temple *O. David*
Lekane Kembou Hubert *Isaac R. Tchouamo*

Yaoundé, the capital city of Cameroon, has around 1.5 million inhabitants with a population density of 5691 persons/km^2. Situated at an altitude of between 700 to 1200m, 60 percent of the administrative area of Mfoundi is devoted to agriculture. This choice is reinforced by the geography of the land: swampy and flooded lowlands, hills and steep slopes. In the equatorial climate of South Cameroon with four seasons (1600 mm annual rainfall), peri-urban production has the advantage of providing a regular year-round supply of fresh and perishable products, independent of the condition of the roads. The horticultural sector includes fruit-tree nurseries and orchards, ornamental plant production, vegetables and staple foods. Peri-urban production takes place within the administrative borders of Yaoundé municipality at a distance of less than 50 km from the city centre. It develops steadily following the axes of urban development (roads, rivers and canals) in the numerous lowland areas where water is easily available and no building is permitted. Agronomic conditions in the lowland areas favour vegetable production. In total, there are 14 streams that could be sources of water for horticulture within the municipality.

According to a survey carried out in 2002, most of the periurban farming households (71 percent) have a second, non-agricultural source of income. More than 60 percent of the farmers are women. The non-agricultural income is derived by an occasional job (worker, joiner, bricklayer etc) or a permanent job (employee or civil servant). Only in 20 percent of the cases did the non-agricultural income predominate in this type of periurban agricultural household. On the other hand, farms larger than 5 ha require full-time workers to maintain operations. The average acreage of farms is 0.49 ha. More than half of the farms use external supplies of organic matter. Around 40 percent of the farmers also keep livestock (poultry, pigs, goats, or fish).

The two main vegetable-growing systems are the lowland system and the upland (or plateau) system. Various vegetables are grown: the "fruit" types such as tomato, chilli pepper, sweet pepper, okra and eggplant; the large leafy types such as leeks, lettuce; the more African-type vegetables; and the aromatic types such as basil, parsley, celery, mint, black nightshade, amaranth and jute mallow. Tomato and chilli pepper are more frequently grown in the uplands; leafy vegetables are the most common in the lowlands. Pests and diseases of vegetables are major constraints, mainly in the case of leafy vegetables of indigenous and exotic species, for instance, septoria spot and fusarium rot on celery, septoria spot and nematode on parsley, and damping-off and leaf miners on jute mallow. Insecticides and fungicides are very often used to protect vegetable crops.

In the plateau system, the cultivated crops are mainly staple foods (eg. yam, tannia, plantains and banana, maize, cassava etc) and fruit trees. Around one third of the upland farmers also grow some vegetables. One third of the farmers grow only African-type vegetables, while 10 percent are specialised in European-type vegetables such as tomato, eggplant and leek. The vegetable producers are located mainly in the lowlands and on the lower parts of the slopes.

Peri-urban horticulture in Yaoundé has different functions: i) supply of the local markets as well as home consumption, ii) land development, iii) employment and income generation for vulnerable people, and iv) use of urban animal and plant wastes as well as city waste. Integration of horticulture, livestock rearing and agro-industries is favoured by their geographical proximity within the peri-urban area as well as the proximity between research institutions, development agencies and farmers. Integration decreases the costs that local councils, industries or farms would make for recycling organic matter. It reduces costs to be made by the horticultural producers and contributes to the sustainability of periurban horticultural production. Recycling waste could be a way to maintain and develop horticulture in and around the city in the future.

Resources

Agroecological Innovations
Norman Uphoff (ed.). 2001. London (UK): Earthscan. 328 pages. ISBN: 1 85383 857 8 (paperback); 1 85383 856 X (hardback).
This volume presents both key concepts and operational means for reorienting agricultural efforts towards more environmentally friendly and socially desirable path approaches to the pressing problem of food security. It is a vitally important guide and resource for professionals and policymakers involved in agriculture and food production. Website: www.earthscan.co.uk

The Origins of the Organic Movement
Philip Conford. 2002. Edinburgh (Scotland, UK): Floris Books. 287 pages. ISBN 0-86315-336-4.
Organic production receives increasing attention from governments, scientists, retailers and producers. This book gives detailed explanations about the basic principles of the organic concept, and presents the most important dimensions of organic food production. It is interesting for reasons of history, state-of-the-art or simply to gain a better understanding of the subject.

World Markets for Organic Fruit and Vegetables. Opportunities for Developing Countries in the Production and Export of Organic Horticultural Products.
FAO/ITC/CTA. 2001. 317 pp. CTA number 1055.
This is a comprehensive guide that explains almost all that an interested trader, exporter or producer needs to know: What are the requirements for producing and exporting organic products to major markets? What are the characteristics of the individual markets of countries in the EU, in the USA or Japan? Who certifies what, which labels mean what, what is local competition? This publication is based on a study commissioned by FAO, CTA and the International Trade Centre (comprising UNCTAD and WTO). It contains a significant amount of useful facts (by CTA).

Home Hydroponic Gardens and Simplified Hydroponics (Hidroponia Simplificada).
2000 (Spanish Translation 2002) P Bradley & C Marulanda. Global Hydroponic Network. 2000.240 pp GHN, PO Box 15, Corvallis, Oregon 97339, USA,
Hydroponics reduces land requirements for crops by 75% or more, and water use by 90%. Simplified hydroponics is a vegetable production method that utilises modern-day hydroponic technology adapted for areas with limited resources. The technology is explained in this book, accompanied by careful and detailed texts and superb step-by-step coloured illustrations. It gives methods and construction techniques for building hydroponic gardens on waste lots in towns, in backyards, on rooftops, with experiences from Zimbabwe, Senegal and Colombia.

www.cirad.fr/en/pg_recherche
The site of the French organisation CIRAD contains a wealth of information on fruits and horticultural crops, and provides and links to projects and other institutions.

www.puvep.com
This is the site of the PUVeP (Urban and Periurban Small and Medium-Sized Enterprise Development for Sustainable Vegetable Production and Marketing Systems) on periurban vegetable production, consumption and marketing in Cagayan de Oro (Philippines), Ho Chi Minh City (Vietnam) and Vientiane (Laos).

www.avrdc.org
The World Vegetable Center provides documentation and seeds in order to improve production and consumption of vegetables.

www.carbon.org
This is the website of the Institute of simplified hydroponics, which links several projects and presents detailed techniques and examples of applications.

www.uwex.edu/ces/wihort
This site of the University of Wisconsin-Extension is a very complete source of information on gardening and horticulture.

www.reddehuertas.com.ar
The Network on Gardens in Argentina "Red de Huertas" (in Spanish) produces an electronic bulletin "INFOHUERTAS" aimed at linking community development and organic gardening. It is a meeting place of many different gardeners, and it is linked to the national programme: ProHuerta.

www.hydroponictech.com/
Hydroponic Tech is a site is for those who want to grow hydroponically but have found the cost of commercially available hydroponic equipment prohibitive.

www.permacultureactivist.net
The Permaculture Activist is a North American periodical. The website includes general information on permaculture; e.g., a list of sites on permaculture technologies, and a virtual library on permaculture.