Urban Agriculture

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Chapter 8

Problems Related to Urban Agriculture

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Problems Related to Urban Agriculture

Urban agriculture is commonly perceived by some as an activity that is marginal, temporary, and archaic (except within Asia). Some regard it as an activity that is actually harmful to farmers, consumers, the environment, the urban land economy, and the appearance of a city. Most concerns about urban agriculture are about the potential rather than the inherent problems (Table 8.1).

If not practiced properly, urban agriculture can indeed be both unsanitary and polluting. To cite one well-known example, vegetable irrigation with untreated wastewater from Chilean peri-urban farms resulted in a few cases of cholera in 1992 because the vegetables were not cooked. (**Fig. 8.1** and Case 8.1). This same problem was more pronounced in Peru, but now both countries have instituted water management regimes that have prevented a recurrence.

Government authorities have frequently responded to these problems by prohibiting urban farming rather than trying to resolve them. In Nairobi, for example, it is illegal to grow crops above a certain height. Lusaka, Kampala and other cities once banned maize cultivation, which was believed to spread malaria. Most North American cities ban poultry production. Lomé, Togo prohibits growing sorghum in the city because authorities think it makes the city dirty. Bamako, Mali has prohibited straw-producing cereals since 1989 because they are believed to breed mosquitoes and serve as hiding places for criminals.

It is vital for supporters of urban agriculture to confront these potential problems because they can also reinforce biases (see Chapter 9). The first step is to understand the problems, how and why they can occur, and their effects. Concerns that are genuine must be resolved if urban farming is to flourish. Those that are mere attitudinal biases and mistaken beliefs — for example, that farming is unaesthetic or that it serves as a hiding place for criminals — can be discarded.

The main problems that may emerge from urban farming occur because of its close proximity to densely populated areas sharing the same air, water, and soil. Food production in the polluted environment of cities may cause contamination. Livestock rearing and use of chemicals and waste in farming can contaminate the soil and water used by city residents. Although these problems are shared with rural farming, the population concentration in cities makes their impact more serious. Many problems are caused by poor practices through lack of information and extension assistance.

Table 8.1 Problems associated with urban agriculture

Health

- Intestinal infections from contaminated food
- Bronchial infections from insecticides
- Malaria from mosquitoes
- Tuberculosis from cows
- Trichinosis and swine flu from pigs
- Compost attracts rats
- Fish may carry hepatitis and heavy metals
- Vegetables may be contaminated by heavy metals
- Insecticide on vegetables and fruit cause stomach poisoning
- Offal contaminates water, which causes diarrhea
- Informal community markets sell unsanitary cooked food
- Raising livestock in the city leads to informal, unsupervised slaughtering
- Urban agriculture close to industry can be contaminated by hazardous toxins

Environment

- Water pollution from waste and chemicals
- Insecticide air pollution
- Damage to grassland if overgrazed
- Soil pollution from waste and chemicals
- Sometimes replaces forest cover with field crops
- Drains wetlands and reduces biodiversity, as do all urban land uses
- Some farming practices on riversides and steep slopes contribute to flooding and erosion

Social

- May cause women (often the primary farmers) to overwork, considering other family obligations
- Engages and can overwork children

Urban management

- Difficult to tax
- In some cases occupies a site that may command a higher rent for another use
- Uses expensive potable water without paying for it
- To be safe, urban agriculture requires more monitoring per unit of production than some other urban production processes

Other

- Can be unattractive, depending on how it is implemented
- In some cases, the shoulders of highways used by farmers contribute to accidents

Source: The Urban Agriculture Network

Researchers and policymakers who were contacted during this study have voiced the problems enumerated in this chapter. More research is needed to establish their extent and seriousness. Data on the problems caused by urban farming may be more scant than data on its benefits. The problems can be grouped into four categories, with the first two more significant that the latter pair:

- health and hygiene effects,
- environmental effects,
- inefficiencies, and
- aesthetic effects.

Health and Hygiene Problems

A number of activities associated with urban agriculture can cause health and hygiene problems. Farming in the city may carry higher health risks than in rural areas because the urban air, water, soil, and waste may be more polluted and hazardous for farming. The close proximity of urban farming to larger population concentrations increases the risk of spreading both communicable and non-communicable diseases. Urban farming may pollute the environment through use of agrochemicals and leaching of animal excreta, as well as increase the habitat for certain disease-carrying vectors. Examples of non-communicable health hazards potentially associated with urban farming activity include neurological damage from pesticides used in farming and from lead in crops, and infant respiratory disorders from nitrates in wastewater used for irrigation.

Pollution from industrial, commercial, residential, and other urban activities affects the soil, air, and water that urban farming uses. Pollution in urban areas can be caused by industrial solid and liquid waste, industrial air exhaust, inadequate waste disposal, and automobile exhaust. These pollutants may deposit heavy metals in the soil, air, or water, and on plants.

Heavy metals and pathogens can be harmful if consumed by humans because plants grown in cities may pick them up from the soil, air, or water and transmit them to consumers. However, the transmitted levels depend on a host of factors. Pollutants and pathogens can also be transferred to individuals coming in direct contact with the soil, water, or wastewater during farming, as well as to handlers and consumers. Children live closer to the earth and spend more of their waking hours in contact with the outdoor urban environment. They are especially endangered.

Pollutants can affect urban farming through the following means:

- pathogens and heavy metals in air and soil affecting crops;
- heavy metals, industrial pollutants, and vectors in water bodies affecting fisheries and aquaculture;
- pathogens, heavy metals, and industrial pollutants in irrigation water, wastewater used for irrigation, and the water table affecting plants; and
- heavy metals and pathogens spread through consumption of hazardous waste by livestock.

The next five sub-sections address this range of problems, their causes, links, and consequences. Solutions to all these actual and potential problems are discussed in the final sub-section.

Spread of Diseases Through Urban Crop Production and Marketing

Potential diseases that can be spread by urban farming activity include:

- vector-borne diseases that can spread through irrigation and wastewater use;
- mosquito-transmitted diseases (malaria, filariasis, dengue);
- chagas disease;
- water- and food-borne parasitic diseases;
- cholera;
- tapeworm, hookworm, beef tapeworm;
- schistosomiasis, bilharzia;
- dysentry;
- zoonoses;
- agrochemical poisoning; and
- metal poisoning.

Communicable diseases such as malaria, filariasis, schistosomiasis, and plague are usually carried by vectors such as mosquitoes, houseflies, snails, and rodents that breed and thrive in environments such as stagnant water, untreated waste, and wastewater (Table 8.2). In urban areas the threat of disease transmission may be higher because population density is higher than in rural areas. Poor communities in cities are hit the worst because living conditions are not hygienic, sanitation facilities and waste pickup services are lacking, and they may be located in environmentally hazardous areas.

The relationship of urban farming to these environments and diseases can be positive or negative. It can be a part of the solution by improving waste and land management by converting vacant spaces to farming. Or, urban agriculture can increase the spread of diseases by expanding the environments conducive to the vectors. It can also contribute to a higher incidence of diseases by putting farmers in closer contact with these risks while farming.

Petty trading and street food vending has often been singled out for criticism and targeted for elimination by urban planners, based on the belief that these activities maintain low hygiene and nutrition standards, besides being economically inefficient and charging higher prices. Formalization of the marketing system, while making use of economies of scale and improving hygiene, may not improve nutrition and may prevent families in low-income residential areas from buying the small quantities that they may need or can afford. For the past three decades, UN/FAO has been working with local governments and NGOs in countries on four continents to improve the safety of street food, with considerable success.[1]

Table 8.2 Vector-borne diseases where urban agriculture may increase risk

Disease	Vector	Habitat in relation to natural resource management
Malaria	Anopheline mosquito	Usually rural, but also urban in India and some other countries. Rural vector may find a niche in peri-urban environments.
Filariasis	Often Culex mosquito	Commonly in heavily polluted water associated with overcrowding, poor drainage, and blocked drains.
Dengue, dengue, hemorrhagic fever, and yellow fever	Aedes mosquito	Solid waste that can hold rainwater and water storage containers.
Gastrointestinal infections	Houseflies	Organic refuse
Schistosomiasis	Aquatic snail intermediate host	Irrigation channels and rivers where people bathe
Chagas disease	Triatomine bug	Association with peri-urban livestock in Central America
Plague	Rat flea	Food stores infested with rats
Other arboviruses and typhus	Hard ticks	Imported livestock

Source: Martin Birley and Karen Lock. 1999. *The Health Impacts of Peri-Urban Natural Resource Development.* Liverpool: Liverpool School of Medicine, p. 23.

In the 1980s in Harare, Zimbabwe, government anti-street food campaigns targeted a largely female group of street traders. The stated aim was to maintain hygiene.[2] Such attitudes are unproductive and do not recognize the immense importance of this informal activity in not only reducing urban poverty, but also improving nutrition and the food supply. Many such projects are on record in a score of countries. The first stage in working to ensure the hygiene of urban farming and marketing is to recognize the activity as legitimate and then work with farmers and marketers.

Mosquito-Borne Diseases

Malaria, filariasis, and dengue are the most prevalent diseases transmitted by mosquitoes, which usually breed in stagnant water. The mosquito adapts to different breeding environments such as water pools, irrigated fields, water storage jars, pit latrines, and abandoned auto tires.

Malaria infects over 100 million people every year in about 100 countries. The anopheline mosquito is the vector, and breeds in relatively clean water. Irrigated agriculture in peri-urban areas is one of the many factors that provide a habitat for this mosquito to breed. Some researchers believe that the incidence of malaria in African cities may be linked to relatively more open space, abandoned land, and cultivation than elsewhere. A study in Gambia found much lower malaria prevalence in peri-urban than rural areas, and concluded that in the former, the vectors may be breeding in garden wells and rice fields. In Brazzaville, Congo, breeding sites for the local malaria vector included wells and waterholes in small fertile valleys (Case 8.1).

Case 8.1 Peri-urban malaria in Brazzaville, Congo

In Brazzaville the two main mosquito species are *An. gambiae*, the malaria vector, and *Cu. quinquefasciatus*, a nuisance mosquito. A study found that there are seven potential breeding sites:

- banks of rivers and streams,
- wells,
- installations for irrigating vegetable crops,
- ditches and gutters,
- puddles in ruts and car tracks on roads,
- barrow pits and drainage wells at construction sites, and
- marshy hollows.

The main colonies of malaria mosquitoes are found in the small, well-watered clay soil valleys that have vegetable crops. The sites are riverbanks, adjacent hollows and the diverse installations used for watering crops. Because of their high agricultural value, these valleys have persisted as urban open space. The low marshy banks of streams, in zones of poor soils with little agricultural value, have been more rapidly built out. Rainwater collection sites, such as ditches, ruts and puddles are commonly polluted and favored by nuisance mosquitos.

Contact: See source listed in Appendix C.

The mosquito related to filariasis breeds in water polluted with organic matter such as in pit latrines, blocked sewage systems, drains, cesspits, and septic tanks. It can be linked to use of untreated sewage for irrigation in urban farming. The mosquito that transmits dengue and yellow fever breeds in rain puddles, discarded tires, and drinking water jars. Containers used in small-scale horticulture irrigation are implicated as well.

Water- and Food-Borne Parasitic Diseases

Parasitic infections are associated with poor hygiene, therefore the urban poor (and particularly youth) are more at risk. Urban farming can increase this risk through use of waste, and through increased contact by farmers and others with potential breeding environments (soil and water bodies).

Protozoa are transmitted to humans by consumption of contaminated raw or partially cooked crops, meat, or fish. Soil- and water-based helminths such as *Necator americanus* and *Clonorchis sinerisis* pass to farm workers with skin exposed to the infected medium. Others, such as Ascaris, are contracted by eating crops that were grown in direct contact with soil.

Common urban parasitic pathogens that may be associated with urban farming include round, hook, whip, and tape worms; dysentery; salmonella bacteria; cholera bacteria; and schistosomiasis (which has a particularly high incidence in Africa). Common symptoms range from anemia, diarrhea and fever, to wasting and damage to organs and nerves over the long term. All these food- and water-borne diseases are treatable through medication and body fluid replacement.

Agrochemicals

Excessive use of insecticides, fertilizers, and other chemicals in farming deposits chemical residues in crops. Agrochemicals may affect the health of farmers (occupational hazard through direct contact while spraying), neighboring communities (by inhaling, ingesting, or contact through air, soil, and water pollution), or consumers (through chemical residues in food). Airborne pesticides travel far in the atmosphere. The inactive ingredients in pesticides such as petroleum distillates may also have harmful effects on human health.

Some pesticides, especially the older types, can cause allergies, cancer, birth defects, male sterility, contamination of breast milk, genetic mutations, respiratory diseases, behavioral changes, and a variety of intestinal disorders. Pesticides can also affect the skin, eyes, liver, kidneys, and nervous system.

Pesticides and fertilizer can contaminate food. In the USA, 35 percent of marketed food is found to have detectable levels of residue, of which 1-3 percent is above legally defined tolerance levels. In India, 80 percent of food has detectable levels of residue.[3] Agrochemical use is currently lower in developing than developed countries, but is on the increase. Globally, between 1945 and 1990 there was a 42-fold increase in the use of pesticides, reaching about 2.5 million metric tons in 1990.[4] The pesticides and fertilizer used in developing countries are older and usually more harmful, their use is less regulated, and awareness of safe usage and health hazards is limited.

The level of agrochemicals used by urban farmers has rarely been researched or recorded, so it is difficult to generalize about the relative residue levels in urban versus rural crops. Indications are, however, that small-scale urban farmers in general use few or no agrochemicals, but larger-scale farmers — particularly peri-urban ones — may be using sufficient quantities for there to be health concerns. Use of inappropriate chemicals is somewhat more likely in urban than rural developing-country situations because of broader availability and greater exposure to marketing. For instance, fumigants or insecticides packaged for commercial or industrial use may be available to untrained urban farmers and then used on edible crops.

Use of agrochemicals is much higher on cash crops, market crops such as vegetables, and in intensive farming. Since a large share of peri-urban farming is city oriented, it tends to be intensive and focused on market crops such as poultry, vegetables, and fruit. Thus it is expected that there is significant use of agrochemicals in peri-urban farming.

Small-scale farmers in developing countries, including urban farmers, are particularly vulnerable to pesticide problems because they lack information on safe usage, health hazards, and economic imperatives. Up to the middle 1980s, some 50 percent of all pesticide poisonings and 80 percent of deaths occurred in developing countries, even though these regions were consuming only 20 percent of global pesticide consumption.[5]

About 40 percent of respondents in a study of urban farming in Harare, Zimbabwe used pesticides in their home gardens, except for those in the poorest groups. On illegal plots, less than 10 percent used pesticides.[6] Agrochemical runoff into surface water bodies was a concern expressed by the study, but not measured.

Forty percent of the vegetables consumed in the densely populated Upper Silesia area of Poland are produced locally, despite warnings of health risks from soil and water pollution by agrochemicals. Food safety concerns have led a group of women to begin the Tested Food for Silesia program, which is focusing on public education to promote organic and sustainable farming in the area (see Case 3.6).[7]

Chemicals released into the atmosphere by spraying are likely to affect large numbers of people when spraying occurs in or near crowded city areas. Health concerns are multiplied by sharing water and soil. The proximity of other sources of chemical pollution, such as industry, may also increase the severity of the problem.

It is therefore even more important to regulate the use of chemicals in urban farming than in rural farming, as well as train farmers in safe and appropriate application. This problem must be addressed at the national level. Monitoring systems that do not cover informal markets, however, will be unable to stem the sale of contaminated food by small-scale urban farmers.

Contamination from Heavy Metals

Urban environments that are farmed may contain toxic substances such as heavy metals, including lead, zinc, copper, tin, mercury, and arsenic. Although some levels of metals are good for plant growth, excessive amounts may lead to reduced plant growth, phytotoxicity, or health problems for consumers.

Chemicals are particularly harmful to pregnant women and children, and may result in maternal and peri-natal mortality. Health problems that may occur include dizziness, blurred vision, weakness, or coma caused by acute pesticide poisoning; heart and lung diseases; various cancers; and fetal damage. Lead and cadmium may be the most harmful and most researched of the heavy metals. Children with high levels of lead in their blood may suffer from anemia, encephalitis, behavioral problems, lower IQ, and neurological impairment.[8]

The main sources of metals in urban soils are from natural occurrence, pesticides, emissions from factories, automobiles, and sewage.[9] Certain plants are more resistant to metal absorption than others. Studies indicate that green leafy vegetables such as spinach are the most vulnerable to heavy metal pollution (especially aerosol lead), followed by root crops. Fruit trees are the most resistant. Cabbage is the least vulnerable among leafy vegetables because it has tight heads and grows from the inside. Plants with hairy leaf surfaces retain more aerosol lead than those with smooth surfaces. Fast-growing leafy vegetables, if washed before consumption, may not be a health threat.

Metal poisoning is a potential hazard in farming that is undertaken in specific areas where heavy metals are likely to accumulate. These include:

- areas adjacent to streets,
- waterways with wastewater discharges,
- industrial zones and areas that were previously in industrial use,

- downstream from polluted areas, and
- waste dumps.

There is a global need to identify vulnerable areas and regulate farming in these locations to ensure food safety. Standards have been set by UN/WHO, EU, and several nations.

Soils near roadways may suffer heavy metal pollution from airborne lead and cadmium from gasoline exhaust. Automotive emissions are the main source of lead. About 75 percent of the lead in fuel is emitted into the air, with the balance going to the soil or remaining in the engine and engine oil. Airborne lead, which is absorbed by surface tension of leaf and fruit surfaces, is not removed by wind. Washing may remove only 50 percent of the lead.[10]

Sewage sludge produced by wastewater treatment contains heavy metals in varying quantities depending on the waste source and the level of pollution and industrialization in the city. Excessive zinc, copper, or nickel in sludge can cause phytotoxicity.

Metal poisoning from farming on contaminated urban soils and use of sewage sludge in farming first became an issue in the early 1980s in the USA. Considerable research was undertaken to estimate the levels of heavy metals found in soils in various cities, ascertain the impact of lead on human health, and develop guidelines and standards on the level of heavy metal accumulation considered safe for farming.

The general conclusion was that in most cities and in most parts of the city in the USA, farming is safe from metal poisoning. Research found that sewage sludge, especially if low in heavy metals, can be safely used when growing vegetables.[11] Guidelines were provided on land and crop planning (depending on the vulnerability of different lands, plants, and edible crops). Food safety measures were proposed to monitor the levels of heavy metals in food for sale, as well as to prevent ingestion of any metals that may persist.[12] Technology was also developed to ensure removal of heavy metals from sludge.

An early study in New York City in 1976 measured the lead and cadmium content in vegetables from 17 urban gardens. The study concluded that the metal content in the vegetables was not high enough to have a negative impact on most healthy people. However, children, pregnant women, and adults with metabolic problems may not be able to metabolize and excrete the lead, and thus may be at risk.[13]

Even where soils have significant levels of metals, they may not necessarily increase accumulation in the bodies of consumers, as was learned in studies in Zambia (Case 8.2) and elsewhere. In a survey in the Netherlands, lead levels in blood of people who consumed vegetables from gardens along highways were compared to levels in people who ate produce from gardens located away from highways. No significant difference was found between the two groups, despite a 2-3-fold variance in the lead content of the vegetables.[14] A study in Russia found cabbages and tomatoes could be safely grown in an area where soil cadmium levels exceeded acceptable levels.[15] Food and consumers of food from vulnerable areas need to be tested to assess whether there is indeed a health hazard before expensive control systems are instituted.

Case 8.2 Quality of produce grown in gardens on former garbage landfills on the outskirts of Lusaka, Zambia

Gardens on former waste disposal sites potentially bear a risk of toxic wastes and heavy metal pollution. Such sites are popular for farming due to the high fertility of the waste-enriched soils. The potential threat to human health from consuming food grown in such gardens was studied just outside Lusaka, where vegetables are grown in the wet season. One garden was 1,400 square meters, and the woman farmer grew vegetables and perennial fruit as her main cash crop (banana, mango, and papaya). She earned the same income as a night guard in town (US$ 20-25 per month), while also contributing significantly to the family food supply. She used no fertilizer and few pesticides.

Soil testing revealed a significant presence of heavy metals at the waste disposal site, with high variation in levels of concentration. Some of the samples had lead, zinc, or cadmium levels that were above international thresholds for vegetable farming. Sewage sludge bought by commercial gardeners also had cadmium and copper levels that exceed European thresholds.

Uptake of heavy metals by vegetables, however, was found to be within permissible levels. There was no cadmium uptake, a low level of copper uptake was found in maize, and some zinc in cucumbers. The relatively high pH value (7.7) and organic matter content (5.7 percent) of the soil seem to have helped reduce plant uptake of metals, as in many other studies.

The researcher expressed concern that metal uptake might be a problem in other gardens. Soil monitoring, as well as advice to farmers on managing soils on former waste dumps, was considered to be critical to healthy food production.

Contact: Axel Drescher (see Appendix F for complete address).

It is difficult to estimate the level of health hazard from heavy metals in the urban environment in developing countries because urban farming is usually unregulated and soils are rarely tested. There tends to be little awareness among farmers or consumers about the health implications of heavy metals and pathogens, or guidance to farmers. Urban farming is frequently observed in areas that may be highly contaminated with heavy metals or pathogens.

The level of heavy metals in urban areas of less industrialized countries is generally far lower than those in industrial countries, and more likely to be within a safe standard, although specific areas may pose a health threat. There is very little data on the health impact of heavy metals in cities in developing countries, or the contribution of urban farming to this health problems.

The data that do exist are mixed. Examination of vegetable quality (spinach, kang kong, romaine lettuce) in various parts of Jakarta revealed that the content of lead, copper, zinc, tin, mercury, and arsenic was below the threshold defined by Jakarta Municipality.[16] A recent study on the use of wastewater from a paper mill to irrigate coconut in India found concentrations of copper, lead, zinc, nitrogen, cobalt, and cadmium exceeding WHO guidelines.[17]

In the Msimbazi Valley in Tanzania, toxicology tests on the river water have shown heavy metal concentrations higher than standards set by the Water Utilization (Control and Regulation) Act for all but one of the rivers in this valley. River-bank levels of lead, cadmium, and possibly zinc were also reported to be high.[18] In contrast, soil testing for heavy metals in Dar es Salaam found levels of heavy metals to be well below safety standards for all metals, although there were warnings of potential accumulation in the expected locations (roadsides, streams).[19]

Domestic and Municipal Waste

Using waste as a farming input can have many positive benefits. Composted organic solid waste and treated household sewage contain nutrients that benefit soil fertility and crop yields, as well as help recycle urban wastes and save freshwater. Crops grown in soils with a high content of organic matter accumulate lower levels of heavy metals. There are, however, several potential health hazards from using waste in farming, which have become more serious with the increasingly hazardous content of urban waste.

Unregulated urban farming leads to discretionary treatment and use of waste by farmers. When city farmers use uncomposted solid waste to fortify soils or untreated wastewater to irrigate crops or feed livestock, potential food contamination is a serious concern. In many cities in less-industrialized nations, sewage is simply discharged to waterways from which farmers use water for irrigation. Many farmers also tap directly into sewage systems to get fertile irrigation water. Pathogens, heavy metals, and harmful chemicals in waste used in farming may lead to a host of communicable and non-communicable diseases, and act as an occupational hazard for farmers and farm workers (Table 8.3).

Human and animal fecal matter, if improperly treated, can be sites for pathogens and vectors to breed.[20] Sewage sludge and improperly treated, composted, or stored solid waste may all contain pathogenic organisms. Some worms and protozoan parasites entering the food chain through the use of waste may live long enough to be transmitted to the consumer.

Primary pathogens include bacteria, viruses, protozoa, and helminth eggs, which usually enter the waste through fecal matter, and can be transmitted to consumers orally or through the skin, causing a host of diseases including diarrhea, dysentery, hepatitis, schistosomiasis, cholera, and hookworms. There are also less dangerous fungi and bacteria that are called secondary pathogens, which grow during the biological decomposition of waste and can cause infections and respiratory problems among people working with the compost.[21]

Intestinal helminths such as Ascaris are frequently found to affect poor communities in developing countries. Hookworms are more likely to enter children, farmers, or workers exposed to the soil. Irrigation with wastewater, seepage of wastewater, or leachate from solid waste can produce hazardous concentrations of chemicals and heavy metals in soils.

Pests such as flies, other insects, and rodents attracted by waste can also act as disease vectors. Diseases associated with rodents are the plague, endemic typhus, and rat-bite fever. In 1998, fear of a potential plague outbreak from rats in waste piles in cities in Gujarat, India caused a national panic.

Table 8.3 Summary of health links to recycling and waste reuse

Waste material	**Links to communicable diseases**	**Links to non-communicable diseases**
Solid waste	Attraction of rodents, poor composting and refuse disposal, lack of hygiene when handling, smoke and dust, vector breeding sites	Accumulation of hazardous chemicals, smoke and dust, leachates, skin contact when sorting
Fertilizer, soil additive, animal feed	Poor composting and refuse disposal, vector breeding sites	Accumulation of hazardous chemicals, plant uptake, leachates
Liquid waste	Level of treatment, retention time of domestic sewage waste, contamination of drinking water supplies, occupational exposure	Mixing domestic and industrial wastes, contamination of drinking water including groundwater, plant uptake, chlorination
Sludge	Poor composting, vector breeding sites	Plant uptake, groundwater contamination

Source: Martin Birley and Karen Lock. 1999. *The Health Impacts of Peri-Urban Natural Resource Development*. Liverpool: Liverpool School of Medicine, p. 91.

Waste consumed by livestock may transfer pathogens and metals to the animals and then on to the human consumer. Cow and pig tapeworms are examples of latent pathogens that use livestock as an intermediate host, and are transferred to humans who eat meat from beef grazed on wastewater-irrigated areas and pigs fed on domestic waste.

Excreta from intensive (factory) livestock farming can be responsible for leaching nitrates and phosphorus into water supplies, soil contamination with acids and ammonia, and heavy metals in slurries. Nitrates are linked to nervous system impairment, cancer, and blue baby syndrome.

Fish grown in wastewater or in bodies of water contaminated by waste may also be contaminated. Pathogens that use snails in waterways as intermediate hosts include hepatitis and schistosomiasis. An outbreak of hepatitis in Shanghai in the late 1980s was linked to consumption of coastal water shellfish (not urban aquaculture). Consumption of fish with excess nutrients may lower oxygen-carrying capacity in infant blood, and is possibly carcinogenic.[22]

One-third or more of the vegetables consumed in Asmara, Eritrea are irrigated with wastewater.[23] In Yaounde, Cameroon, irrigation water for salad plants often contains rubbish and sump oil or sewage. Squatters in Lusaka, Zambia irrigate their crops with wastewater illegally channeled from a neighboring sewage lagoon.[24]

It is critical that all waste be suitably treated before use in urban farming, and that the levels of heavy metals and the persistence of pathogens be tested before the waste is used. With adequate treatment, organic solid waste and sewage are very good soil additives — they are less costly and more sustainable than chemical additives, as well as contributing to a far more sustainable waste management system. While use of untreated or inadequately treated waste is a health hazard, properly composted waste does not pose the health threats of pathogens and pests created by untreated waste. An improved waste collection system in Mexico City decreased the rate of cholera by 20-40 percent.[25] A similar development took place in Santiago (Case 8.3).

Case 8.3 Raw sewage in urban agriculture — an outbreak of cholera and typhoid in Santiago, Chile

Cholera returned to South America in the early 1990s, appearing first in Santiago, Chile in 1992. Investigations discovered that tainted vegetables, grown in metropolitan Santiago using irrigation water polluted by raw sewage, were partly to blame. They found that 60 percent of the irrigated area used water with over 10,000 fecal coliforms per 100 milliliters.

Although Chile had enacted laws regulating sewage irrigation in 1941, they were not enforced. Following the outbreak, the government bulldozed thousands of hectares of vegetable crops and since then has prevented such crops from being planted where they will be irrigated with wastewater. It then instituted restrictions on crops, along with certification programs, which led to a reduction, not only in cholera, but also hepatitis and typhoid.

Santiago had suffered for decades from typhoid outbreaks. Rapid growth of squatter communities had led to an increase in effluent in streams, without a comparable increase in treatment. Although the supply of vegetables dropped the first year after the government action, it recovered once horticultural zones were relocated to lands that could be safely irrigated. Confidence that the vegetables no longer posed a health risk contributed to a doubling of their prices. Unfortunately, prices have stayed high, denying the benefits of fresh vegetables to a large share of the low-income population. Many small-scale farmers were unable to get certification and went out of business.

The cholera control measures have had far-reaching consequences. Greater Santiago is one of the most fertile regions of the country, providing 40 percent of Chile’s agricultural exports and 10 percent of its total exports. The handling of sewage-based irrigation therefore has national economic repercussions, which explains why the government reacted swiftly and why it is now seeking a more enduring solution to the problem. The World Bank supported studies, and solutions that have been considered to date are costly — US$ 750 million for wastewater treatment, a per capita annual cost of $7.00 to $7.50 per year.

There is a significant lesson to be learned — enforcement of existing regulations could have prevented the outbreak. But because there are a dozen regulatory agencies, coordination of monitoring and enforcement is difficult. A new partnership among farmers’ associations, NGOs, local government, and the national government may be the key to solving the problem. Potential solutions include improved irrigation methods, regulation of crops (rather than prohibition), cost recovery from the farmers who benefit as well as from residents, modified food preparation, and institutional reform.

Contacts: Carl Bartone and Klas Ringskog (see Appendix F for complete addresses).

Considerable testing was undertaken in the USA to assess if wastewater was safe for irrigation and to define adequate treatment and standards. Sewage sludge, especially if low in heavy metals, was found to be safe for use in growing vegetables.[26] The United States Department of Agriculture (USDA) in 1980 developed technology to ensure complete pathogen kill and proper stabilization of sewage sludge for use in agriculture.

Sludge application in the USA has been regulated by the Environment Protection Agency (EPA) since 1979.[27]

While treatment of waste for reuse in farming is well researched and standards and guidelines are available, in reality formal treatment in less-industrialized countries is often inadequate and rarely monitored. City farmers in poorly managed cities frequently use untreated wastewater. Such use is a potential health threat, especially because most farmers are not aware of the problem or the means to prevent health hazards.

The most sustainable solutions for urban waste management may be those that combine urban agriculture with waste recycling, requiring source separation and waste treatment at the community level. Current, centralized waste management systems in most cities are not designed for such a strategy. Solutions focus on:

- appropriately scaled, decentralized local treatment systems,
- adequate participation in some form of treatment by urban farmers,
- monitoring practices and the resulting crops for safety, and
- farmer and community education.

Farming is but one of several ways in which pathogens and chemicals from waste may enter human systems. In most cities (particularly in low-income areas), it is difficult to isolate the health hazard specifically created by the use of waste in farming because inappropriate waste management practices expose communities to the same health hazards. Adding to the challenge is the question of how to assess the potential negative health effects of recycling waste in agriculture against the potential positive environmental effects from the practice.

Rearing Livestock, Poultry, and Fish in Cities

Evidence on the threat to health caused by rearing livestock in the city remains relatively limited. Nevertheless, keeping livestock in the city is criticized as creating health and environmental hazards — making neighborhoods unhealthy through offal, odors, and noise, and clogging the sewage system.

Many cities manage their livestock responsibly. Properly handled animal refuse is valuable as manure to fertilize soils and fish ponds. Cow dung is also dried for use as fuel and to sanitize walls and floors of houses. However, pathogens can be transmitted directly or indirectly (through zoonoses) to human consumers. Livestock in the city can negatively affect human health through their meat and other products, excreta, and direct contact during farming (Table 8.4). Populations at risk are livestock farmers and abattoir and factory workers, consumers of animal products, people living in areas where there are significant numbers of livestock, and people living in areas where animal waste is discharged.

Table 8.4 Summary of livestock links to health

Livestock use	Links to communicable diseases	Links to non-communicable diseases
Live animals		Inhaling dust and allergens
Slaughtering	Inhaling dust	Inhaling dust and allergens
Products	Unpasteurized dairy products, consumption of contaminated meat	
Drug residues	Misuse of antibiotics	Metabolites in animal products
Animal feed contamination	Contamination by infected feces of animal feeds and animal products	Agrochemicals and hazardous chemical contaminants of feed
Wastes	Discharge into water supplies, application of slurries to land, contact	Heavy metals in slurries
Tanneries	Handling infected hides	Exposure to a range of process chemicals

Source: Martin Birley and Karen Lock. 1999. *The Health Impacts of Peri-Urban Natural Resource Development.* Liverpool: Liverpool School of Medicine, p. 82.

Zootonic diseases from livestock reared in the city can be spread through:

- dung in public places;
- consumption of contaminated meat;
- consumption of unpasteurized dairy products;
- direct contact with infected animals or animal matter (urine, blood);
- transmission through contaminated animal feed;
- spread of other pathogens by animals scavenging on waste;
- unhygienic conditions in abattoir;
- inhalation of airborne dust and allergens, especially in and around abattoirs;
- discharge of livestock waste into waterways;
- leaching of nitrates and phosphorus from animal waste into water supplies, especially from pigs and poultry;
- soil contamination with acids and ammonia; and
- heavy metals in slurries.

Roaming livestock can increase the threat by spreading a disease in the environment. Uncontrolled livestock production has led to flies and bacteria thriving in animal dung in public places. Rearing cattle and buffalo in cities carries the risk of transmitting bovine tuberculosis to humans, particularly through drinking untreated milk.[28] Animal excreta can carry germs that can cause diseases — tuberculosis, brucellosis, meningitis, salmonella, and diarrhea.

Livestock waste can transmit any pathogens carried by the animal, as well as discharge heavy metals in slurries. This is an occupational hazard for those working with urban livestock, and the problem can be spread through inadequate disposal or reuse of waste, and by dung from roaming animals.

Starting in the late 1980s, doctors in Dar es Salaam became convinced that dung rotting on city roads was contributing to the spread of tetanus. Urban livestock were reported to have exposed people in that city to zootonic diseases such as tuberculosis, leptospirosis, anthrax, salmonellosis, and brucellosis, although a definitive correlation between urban livestock and the prevalence of these diseases was not established through actual site testing.[29] Three quarters of poultry and livestock keepers in that city left dung at agreed locations along roadsides for collection by horticulturists.[30]

The problem is exacerbated by dense populations in urban places, which increases the threat of spreading diseases. The health threat also depends on the amount of vacant and green space available in the city — more space reduces the threat.

Intensive livestock production (factory farms) and processing facilities in the city may become centers of disease and pollution from animal waste. The air around abattoirs is particularly susceptible to spreading brucellosis. Anthrax threatens abattoir workers, animal product processors, and consumers of inadequately cooked meat. Animals may pick up tapeworm eggs from unhygienic environments and from scavenging on waste, feces, or dead infected animals. Abattoir workers in the Netherlands are 1,500 times more likely to contract meningitis from salmonella infection than other workers.[31] Urban livestock may be behind some non-communicable diseases as well — asthma, allergies, and lung diseases. Workers in intensive urban livestock and poultry farming are particularly vulnerable.

Animal feeds of animal origin (whether urban or rural) can carry pathogens such as *Salmonella* and *Campylobacter*, and can spread them to humans through the animal. Feeds that contain plant products may also contain harmful agrochemicals as well as heavy metals. In an industrial poultry farm in Alma Ata, Kazakhstan, 6 percent of hens and 12 percent of ducks tested for salmonella were found to be infected. Poultry bred in intensive environments is particularly susceptible to aflatoxins.[32]

Aquaculture is useful for fish and vegetable production, waste management, and habitat management. It can reduce mosquito breeding in low-lying and marshy areas if the correct range of fish species is included. But urban aquaculture may increase the habitat of some pathogens and provide a transmission route through the fish to humans, as well as putting farmers and workers at risk. Aquatic snails in aquaculture ponds using sewage can also serve as host for pathogens that cause schistosomiasis or bilharzia.[33]

Livestock farmers often ignore animal diseases. Because the testing infrastructure is typically inadequate and the cost of animal treatment high, animals are usually not tested for diseases. Meat and hides can be tested for presence of the anthrax bacteria with a simple laboratory test, but this test is not usually available in developing countries.[34] Farmers can fairly easily evade the public health system.[35] For instance, in urban Nepal, where sewage systems are poorly developed and sewage flows freely, pigs and cattle eat human waste.[36]

Solutions to Health Hazards

Family and small-scale farmers want to produce food that is safe for their children and their neighbor's children. In the preceding sub-sections, we have described some of the health risks of urban agriculture. Safe food from urban agriculture begins with educating the farmer at the community level and providing her or him with an extension service and technical assistance that enables safe practices. As a second line of good management, CBOs, NGOs, and government at many levels may monitor urban agricultural practices to ensure compliance with health and safety regulations.

The goal of a healthy city and urban population will be helped by safe urban agriculture. Our objective is to have as many farmers in as many places within the city as feasible. The solution to health hazards, after education, extension, and monitoring, is to identify the most hazard-prone places — for example, near 'dirty' industries (such as tanneries), adjacent to highways where vehicles use leaded gasoline, or adjacent to garbage dumps — and impose legal controls that limit farming in those places.

Good practices in urban agriculture abound in history and today. Singapore, the Netherlands, and Canada offer excellent examples of current good practices. The solution to safe food from city farming, however, will usually not be found in methods being applied in wealthy European countries or in a study of history. Rather, safe urban agriculture will emerge by empowering community-based groups, farmers' associations, NGOs, and local professionals to create solutions using scientific methods and applying adaptations of best practices.

In some developing countries these types of controls overlap traditional controls. This dual system has been best studied in China. Collaboration between farmers' associations and municipal corporations based on traditional methods and modern science has worked well for 30 years.

Some measures to prevent urban food production from contributing to the spread of diseases in industrialized countries include:

- farmer and consumer education by extension agents;
- land-use planning, zoning, and regulation;
- monitoring food safety;
- vector control;
- management of heavy metals;
- control of poultry production and processing; and
- monitoring solid and liquid waste treatment and reuse.

This sub-section presents the range of possible solutions to the problems described in the previous sub-sections.

Education and Extension

Safe food from urban agriculture must be taught to every farmer through the established education and extension systems. Educating farmers and promoting sustainable farming practices can include a range of issues already mentioned. Recognizing urban farming as a valid activity and including it in agricultural extension efforts is necessary. Education should begin at the primary level and involve parents with their children's school gardens. Active city farmers may be part of the educational system, teaching best practices. Public health professionals may train agricultural extension workers.

The agricultural extension service in most places will need to partner with waste management services, the health department, food marketing services, as well as educational institutions. In Berlin in 2000, there were 14 agricultural schools where every elementary class had its own garden plot. The 'Tested Food for Silesia' program in Poland is an example (see Case 3.6). The Developing Countries Farm Radio Network (DCFRN) provides advice to farmers using radio programs.

Land-Use Planning and Zoning

Different land areas in the city have different levels of vulnerability to pollutants, and different crops have different uptake rates for contaminates. A geographic information system can be useful to identify the potential areas where heavy metals and other pollutants may pose a health hazard. These areas can then be further tested and zoned to either ban farming or ensure that planned cropping and farming methods reduce health hazards. In some cases organic material can be added to the soil. In others greenhouses may be permitted but not open row crops. Additional monitoring of these hazard-prone areas may be appropriate.

The urban management programs of several international development agencies are promoting increased monitoring and environmental management practices. Strategies that focus on awareness and knowledge of crop choices, farm planning, or food safety measures to minimize health hazards are more likely to be successful.

Food Safety Monitoring and Crop Certification

Monitoring food sold in markets (testing for metals and pathogens) is one way that food hygiene is controlled in industrialized countries. Food safety monitoring is currently limited in less-industrialized countries in part because much of the food is traded in the informal sector or is raised for home consumption. In many cities monitoring needs to be moved to roadside stands and not be limited to restaurants and wholesale city markets. FAO has a decades-long history of improving the quality of street foods.

A good food safety monitoring system includes food safety regulations, standards, testing facilities, and public institutions to monitor safety and enforce standards. Such a program would also include monitoring livestock rearing, greenhouses, fish ponds, orchards, and field crop areas.

More and more countries are adopting and enforcing food safety standards and developing a monitoring capacity. Much of this effort is focused on exported food (in order to ensure compliance with importing-country standards) rather than protecting domestic consumers. Crop certification focuses on the producer rather than the consumer level. FAO's Codex Alimentarius provides standards and the FAO Technical Assistance Program on Food Quality and Safety provides technical assistance to developing countries.

Preventing Diseases Spread by Vectors

Preventing the spread of diseases by vectors can be done by expensive methods such as aerial spraying, or by inexpensive methods that might be labeled as 'good housekeeping'. Control strategies logically begin at home and in primary school. The first teaching tool is awareness, followed by best practices.

Some plants and animals absorb, retain, and transmit pathogens more readily than others. For example, tree fruit that can be peeled transmits fewer pathogens than a leaf crop such as lettuce. Crops that are used as livestock feed are an extra step removed from human consumption and therefore usually present fewer health risks.[37]

Curative and preventive measures to avoid vector breeding include:

- regulating and controlling selected farming activities and methods;
- altering farming practices through education;
- reducing the number of intermediate hosts through habitat management;
- managing solid waste adequately;
- designing sewage, water storage, and irrigation systems to reduce breeding grounds and environmental contamination;
- eliminating breeding sites by reducing standing water, keeping streams and rivers clear flowing, and periodically allowing irrigated fields to dry; and
- using chemical and biological controls in potential habitats, including Bt (microbial insecticide) or neem tree extract (biological control).

For many cities, the solution will lie in the interaction of CBOs and NGOs with best practices in similar cities.

Managing Farms to Prevent Heavy Metal Hazards

Soil characteristics affect the level of metal absorption by plants, and hence can also be a factor in managing for heavy metals. Metal uptake by plants is reduced by addition of phosphorus to the soil. Moisture in the soil can be managed to reduce the uptake of chromium, iron, and arsenic. Salt amendments reduce uptake of cadmium and arsenic in certain crops.[38]

An excellent solution to the problem of heavy metals is to add one part organic matter to three parts of contaminated soil to lower soil acidity. Acidic soils increase the absorption of metals, so by lowering the acidity, minerals are more readily available to the plant. A soil pH level above 7.5 prevents lead uptake by plants, and also reduces cadmium uptake. When organic matter is added to soils, lead sticks to it rather than plant roots.

Lead in soil is not particularly mobile and is not easily taken up by plants. In vulnerable areas such as near major roads, leafy vegetables can be eliminated or grown away from the road. Lead levels fall logarithmically with distance from the road.[39] One expert recommends that where leaded gasoline is used, green leafy vegetables should be planted a minimum of 7.5 meters from roads.[40.] More resistant crops, such as fruit trees or cassava, or an intervening row of trees, particularly those that are good absorbers of aerosol lead (e.g., white pine), can act as a hedge and protect more vulnerable crops from exhaust fumes.

Most of the lead found on leafy plants is in aerosol form rather than lead from the soil, which makes it possible to wash it off the crop.[41] Root crops should be peeled before cooking. It should be noted that vegetables marketed in urban areas, whether urban- or rural-grown, also pick up some airborne lead.

Lead can be removed from soil by running a high voltage through the soil between two poles. The lead will then line up and can be removed by trenching. Lead can also be removed from soil by growing crops that absorb it readily, and then destroying those crops.[42]

Waste is a major source of both heavy metals and pathogens. Waste management systems that separate waste at its source, identify sources of hazardous waste, and decentralize management and recycling are more attuned to managing the presence of metals in waste used in farming.[43] Where sewage sludge is used, the level of metals in the sludge needs to be monitored and maintained below safe levels. Standards for safe levels of metal in sludge are available, including those defined by the United States Department of Agriculture.[44]

Where soils are already highly contaminated with metals or chemicals, crops can be planted in media brought from outside the affected area. This practice is particularly feasible with techniques such as shallow-bed gardening, container farming, and hydroponics (see Cases 5.2 and 5.3). Where fish and other seafood are contaminated by toxins in urban waters, the water can be treated biologically (see Case 5.4). In Poland, a zoning system was developed for farmland near industrial areas, with different crops allowed in each zone.

The greatest danger from heavy metals in urban farming is not consuming food grown on contaminated soil, but rather contact with the soil. Workers can wear gloves to protect themselves, but access by children should be prevented so that they don’t put contaminated fingers in their mouths and noses.

Monitoring Waste Treatment and Reuse

Research on the safety of using waste for food production has been conducted by several institutions, including WHO, FAO, the World Bank, the U.S. Environmental Protection Agency, and the Asian Institute of Technology. Appropriate guidelines for use and treatment standards have been created by some of these institutions, including WHO and USEPA.[45]

To reduce the risk of contamination, it is necessary to create local waste recycling and reuse programs, institute treatment and application standards, and ensure adherence to standards. Different scales of technology are already available for waste treatment and reuse. To reduce public expense, it may be feasible to move some of the management and monitoring to the community level through decentralized waste management systems,[46] which will require monitoring by public authorities.

An approach that may have wide application is to study the overall areas of discharge, treatment, and use of waste in farming, identify potential areas of health hazards, and then concentrate treatment, crop restrictions, and certification efforts on problem areas. At the same time, it may be useful to identify areas where farming is safe and promote it in those areas.

Reuse of Solid Waste

Composting can occur in the backyard, at a community or neighborhood level, or as a centralized system. It can be an open or closed system. Composting processes include simple composting, composting two or more complementary materials together (such as organic waste and animal waste), and anaerobic digestion (by restricting the oxygen supply).

Solid waste and sludge treatment usually involves composting, which destroys pathogens and helminth eggs by generating heat. High temperatures for a determined period of time are essential for proper treatment. Composting does not remove heavy metals.

There is considerable research on composting guidelines, and standards that define acceptable levels of heavy metals and pathogens are available, such as the CCME guidelines and NSDOE sludge and compost guidelines.

Informal waste management systems have been extensively studied in Dar es Salaam (Tanzania), Curitiba (Brazil), Bangalore and Calcutta (India), Manila (Philippines), and Mexican cities.[47] In all these cases, urban poor communities play a critical role in managing waste to improve practices that improve sanitation. A common means to improve practices is to focus on organized waste pickers who work in cooperatives and run buy-back depots where consumers can purchase waste. All decentralized systems require monitoring and regulation, which has often been a shortfall in the system.[48]

Reuse of Wastewater

Wastewater can be treated biologically by an intermediate plant or animal, such as algae or duckweed, which is later used as organic fertilizer or animal feed.[49] A second approach to managing pathogens in wastewater is to grow crops that are less susceptible to contamination.

Many cities use wastewater only to grow non-food crops, including livestock forage, forest crops for fuel and construction, and plants for ornamental horticulture. Australia and Mexico, for example, limit the use of wastewater to irrigating crops not intended for direct human consumption. In Zimbabwe, sewage water is used to irrigate cattle pastures run by municipal authorities that make millions of dollars in profits through cattle sales.[50] WHO guidelines defining acceptable levels of fecal bacteria and nematode eggs were published in 1989 (Table 8.5).[51]

Table 8.5 WHO/Engelberg standards for wastewater that can be used for irrigation

Reuse condition	Exposed group	Intestinal nematodes (arithmetic mean no. of eggs per liter)	Fecal coliform (geometric mean no. per 100 ml)	Wastewater treatment expected to achieve the required microbial quality
A. Irrigation of crops likely to be eaten uncooked, sports fields, public parks	Workers, consumers, public	≤1	≤1,000	Series of stabilization ponds designed to achieve microbial quality indicated or equivalent treatment
B. Irrigation of cereal, industrial, or fodder crops, pasture and trees	Workers	≤1	No standard recommendation	Retention in stabilization ponds for 8-10 days, or equivalent treatment
C. Localized irrigation of crops in category B if exposure of workers and the public does not occur	None	Not applicable	Not applicable	Pretreatment as required by the irrigation technology, but not less than primary sedimentation

Source: World Health Organization. 1989. *Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture*, S.I.T. 778. Geneva: WHO.

Alternatives to the large-scale, post-World War II sewage systems have recently been developed to treat and reuse wastewater, including bucket latrines, cesspits, and composting toilets.[52] Decentralized systems with their own treatment plants at the catchment level are being promoted, and include reuse of wastewater in local farming. Aerobic and anaerobic biological processes are used to reduce pathogens and recover nutrients.[53] Separating waste at its source, such as keeping kitchen and bath water separate from toilet waste at the household or community level, facilitates reuse.

Solar-based treatment technologies use algae, plants, and bacteria in the effluent to degrade biological components and pathogens. Land-based aerobic-, anaerobic-, and biogas-based technologies are available at various scales.

Water-based treatment systems include wetland treatment systems using aquatic macrophytes, water hyacinth, duckweed, water lettuce, or salvinia to break down sewage. The crop can also be harvested for sale as animal feed. Water hyacinth, however, promotes mosquito breeding, therefore habitat management is important. The problem can be prevented by keeping oxygen levels low, frequently trimming plants, maintaining fish varieties such as mosquito fish, and using some chemical agents. Duckweed, on the other hand, prevents mosquito larvae from developing because it covers the entire surface (see Case 5.4).[54]

Separating urine and feces can provide two safe products, a so-called ‘ecological sanitation’ technique. Ecological sanitation is typically a decentralized operation, so families and communities can recycle their own wastes.[55]

In China, integrated resource recovery systems that combine waste management with rearing livestock, aquaculture, and soil-based agriculture use local natural resources for an ecologically balanced food production system.[56]

With appropriate monitoring, the health of urban citizens can be improved while minimizing risk. Inappropriate use of wastewater and inadequate composting of solid waste can be partially resolved by retraining and assigning some government staff who run the sanitation system to advise neighborhoods or communities to manage their own ecological sanitation processes. Communities that use their urine to fertilize parks and gardens and compost their feces to improve soil are much less likely to use waste in a damaging way.

Rearing and Processing Poultry, Fish, and Livestock

Small livestock are the most common livestock that are reared in cities, particularly larger ones. Rabbits, goats, guinea pigs, swine, chickens, and fish are ubiquitous. Less noticed are bees, silk worms, snails, pigeons, quail, and others, including dogs and rats. The most critical health hazards in this farming sector are in large-scale facilities rather than backyard and rooftop production. As in all city farming, reducing risk begins with education and extension. Strict standards are necessary for operations that exceed a certain number of animals. Extension workers, CBOs, and NGOs need to be aware of best practices and warning signs of diseases in animals that can transmit them to humans. For instance, in Chile CET found that it was safe for chickens to eat worms that fed on fetid garbage, but not for them to eat the garbage itself.

Measures to prevent communicable diseases from animals in urban areas include:

- vaccinating the human population for tuberculosis and anthrax;
- monitoring the sale of meat,
- heat treating milk and dairy products,
- controlling and eradicating diseases where animals live,
- improving hygiene in abattoirs (ventilation, protective clothing),
- vaccinating animals grazing in areas with endemic anthrax, and
- vaccinating workers at occupational risk for anthrax.

These measures are expensive, institutionally complex, difficult to establish, and can ultimately increase the price of protein to consumers. Health regulations comprise two-thirds of the total cost of pig production in Mexico.[57] Regulations should be flexible and targeted as monitoring systems identify the likelihood of risk.

Environmental Problems

Resources such as land and water are used more intensively for agriculture in dense urban areas than in rural areas. The close proximity of all phases of agriculture to a concentrated population increases risks proportionately, thus problems caused by chemical contamination can have even more serious implications. A number of strategies are available to respond to these problems.

Environmental Risks

The use of agrochemicals in urban areas may persist in the soil, air, water, or food. They cause pollution through:

- accumulation in runoff, horticultural crops, and soils;
- seepage into aquifers;
- accumulation of heavy metals and organic compounds in aquatic life;
- direct contact; and
- airborne chemicals.

Agriculture in the city can have a negative impact on green space and biodiversity if it replaces forested land, wetlands, or other biologically rich natural environments. Farming near waterways of all types can increase erosion and silting if care is not taken. Waste from urban agriculture frequently contaminates and degrades the environment where urban children play. While urban agriculture can enhance urban biodiversity in some ways, it also has the potential to do serious harm and reduce biodiversity.[58] When urban farming practices pollute, as does modern shrimp production, it reduces biodiversity. Urban forestry has too often introduced exotic varieties in monocrop patterns.

The introduction of exotic (non-native) plant species can reduce biodiversity. A prime example is non-native garden plants that invade natural areas. Replacing a tree canopy with a vegetable garden can not only reduce vegetative diversity, but also the bird and insect populations, particularly if insecticides are applied. The use of antibiotics in fish and livestock rearing has been particularly damaging in urban areas.

Leaching of solid and liquid waste from intensive livestock farms into soil is a major environmental problem in urban and rural areas. In Holland, Thailand, and the USA, surface and groundwater contamination from intensive, large-scale poultry and shrimp production has been reported since the 1980s (Case 8.4). The main source of ammonia contamination in Dutch soils is ammonia discharged by livestock producers, not industry.[59] Dairy farming around Madison, Wisconsin, USA is said to result in high concentrations of nitrate and atrazine in drinking water, as well as phosphorous that is causing eutrophication in area lakes.[60]

In coastal bays near Rio de Janeiro, agricultural and sewage runoff dumps excessive nutrients in waterways, leading to massive algae growth and eutrophication of the marine ecology from reduced oxygen levels. Costly mitigation programs and controls have been placed on farmers in some peri-urban situations. Singapore temporarily prohibited intensive livestock farming in the 1970s, while both Taiwan (province of China) and the Netherlands imposed new restrictions in the 1980s as a result of environmental degradation caused by rearing pigs.

Case 8.4 Problems and control of nutrient runoff from poultry farms around the Chesapeake Bay, USA

Rich in nitrogen and phosphorous, poultry litter is much favored as fertilizer. But those same nutrients can nourish environmental ills when they wash into waterways and spur the growth of algae that rob fish and other aquatic life of oxygen. Many scientists also believe nutrient pollution fuels the toxic microbe *Pfiesteria piscicida*, which blossomed in 1997 and 1999 in several tributaries of the Chesapeake Bay, which lies west of the mid-Atlantic coast before flowing into the Atlantic Ocean. Its watershed is nearly 64,000 square miles, including the Washington-Baltimore metropolis.

Agricultural runoff has been blamed for the growth of fish-killing microbes in some rivers. The Environmental Protection Agency and Department of Agriculture have drawn a Draft Unified National Strategy For Animal Feeding Operations (AFO), which is a blueprint for dealing with surface water pollution from all AFOs, including large-scale, confined animal factory farms with more than 1,000 birds, pigs, etc. If adopted, this draft will limit how much manure farmers may apply on their fields near vulnerable waterways.

Tightened state and federal environmental rules have rendered manure less of an asset and more of a liability. Poultry companies can be liable for fines of as much as US$ 25,000 per day if they don't follow the rules. The Maryland Agriculture Department and the Nutrient Management Advisory Committee are drafting regulations to enforce a 1998 law aimed at reducing nutrient runoff from farms into the Chesapeake Bay and its tributaries. Regulations tie a company's state operating permit to its success at preventing manure runoff.

Perdue Farms Inc., the largest poultry producer in Maryland, will relieve some of its contracted farmer/growers of the disposal burden of excess chicken manure. Perdue Farms will gather as much as 120,000 tons of poultry litter each year and turn it into pellets that can be sold as fertilizer in areas less susceptible to water pollution. The 120,000 tons is more than one-third of the manure generated by the 240 million birds the company annually processes in the immediate Chesapeake Bay watershed. Perdue will pay farmers, who grow their chickens under contract, for the manure.

Several European and American industries have learned that some polluting by-products of their operations have commercial value. This case suggests that the poultry industry is waking up to a missed opportunity. They might well be able to make profit *and* solve an environmental and public relations problem.

Contact: See source listed in Appendix C.

Overgrazing and destruction of plantation areas by animals can lead to increased erosion, as well as destroying grasslands. When ignored, such behavior can even contribute to urban desertification, negating the environmental gains that urban greening offers.[61]

Intensive livestock farming can also lead to odor and noise pollution. In a survey in Dar es Salaam, about 80 percent of respondents reported bad odors from urban livestock as a problem, and two-thirds reported noise as a problem.[62] There may be, however, a double standard inherent in some of these opinions. Odors and noise caused by livestock are often no worse than those caused by some other urban activities, such as manufacturing and vehicular traffic.

Managing Environmental Risks

Each and every urban agriculture methodology has some environmental risk. Managing these environmental risks, as with any significant urban activity, is complex. Such management may need to be founded on some or all of the following steps:

- scientific description of the problem,
- research,
- defining and establishing indicators,
- finding ‘best practices’,
- providing information and incentives, and
- establishing and enforcing penalties.

There are a number of more or less successful approaches that can be tapped for techniques and other solutions to help manage urban farming’s environmental consequences. Some of those referred to elsewhere in this book include agroecology, permaculture, the Natural Step, edible landscape, regenerative agriculture, and edible buildings. A number of biologically based sustainable practices, including organic, regenerative, and biointensive agriculture, as well as integrated pest management (IPM), are less damaging to the environment than agriculture using chemical fertilizers and insecticides. Supplying compost and treated sewage to farmers is effective in reducing the amount of chemical fertilizer needed by urban farmers. Multicropping practices can substitute for some insecticide applications.

Each offers safe alternatives to some polluting practices, and current research can be expected to yield improved solutions. We can also look to other places and times for lessons. China has a long history of coping with the risk of urban farming. Urban areas — from ancient to pre-20th century — had viable ecological risk management procedures, some of which may be applicable today.

Intensive use of animal waste on soils can cause nitrate pollution in as short a period as 5 years.[63] It is critical to monitor and regulate the use of manure and other organic waste, as well as chemicals, in urban farming. Such nitrate and phosphate leaching can be prevented through the proper treatment and reuse of animal waste as fertilizer. In Malaysia, UNDP and FAO are researching technologies to treat pig waste. Some farmers are growing worms to treat pig effluent lagoons for conversion to fish feed.[64]

Animal-related pollution can be reduced through changes in rearing practices, for example, by discouraging intensive rearing of a single species in one area. There is also a need to institute proper animal waste management practices to close the nutrient loop. Improving land and water tenure security and creating a legal system that makes farmers responsible for the land they farm will result in better farming and soil and water management practices.

Inefficient Use of Resources

We have shown throughout this book how urban agriculture is particularly adept at transforming urban waste in the broadest sense (idle lands, untapped human resources, solid refuse, soiled water . . .) into resources. There is a potential, however, for resources found in urban areas to be wasted or abused through urban farming.

A significant percentage of urban farming is conducted informally or illegally. Farmers simply expand onto unused public or private land or work out an informal agreement with the owner. While this often puts idle land into productive use, in other cases, farmers take over land planned or set aside for other purposes (such as forested areas) or encroach on land that should be conserved for environmental reasons (such as wetlands). Where the use of land is not managed and an economic rent is not paid, urban farming may be an economically or environmentally inefficient use of land.

The same is true of water used by farmers for irrigation. If farmers are not charged a fee, they may use water designated for other purposes or follow inefficient irrigation practices. Some urban farmers divert water from the potable municipal water supply, which can create water shortages in the city. A survey showed that although 4 of 10 households active in gardening in Amman, Jordan use some gray water for irrigation, most households (86 percent) rely on the public water network for at least part of their irrigation needs.[65] Overuse of surface or groundwater can reduce the city water supply. The Savanna region of Bogotá, Colombia is experiencing a water crisis due to heavy pumping of groundwater to irrigate export flower crops. This crisis can be mitigated by reuse of Bogotá's wastewater for irrigation.[66]

Regulation and pricing of land and water for farming use ensures that these scarce resources are not abused and are allocated optimally. However, charges for land and water may drive some poorer, less efficient farmers from the market. A system of subsidized land and water allocation may be needed to enable poor farmers who are growing food for family food security to continue farming.

Negative Aesthetic Impacts

The image of a cattle corral, pigs at a town dump, poorly tended vegetable patches in a community park, or chickens in a front yard is offensive to many. Food and fuel production tends to be more visible than many other urban production activities, such as making furniture or bread, which take place inside buildings. Because urban agriculture is more exposed to public view, it may be appropriate to place it under greater control and measure each urban agriculture activity not only for its health and environmental impacts, but also for its aesthetic impact.

Agriculture in the city need not be ugly if it is well managed and in appropriate places. Sweet potato growing on the roadside, fruit trees in the park, sheep grazing on a hillside, and fish in a pond may be acceptable images. But if urban agriculture is unregulated and temporary, it is less likely to be neatly maintained.[67]

Urban farming is illegal in most cities in Africa and Latin America. Where it exists despite the law, it is unregulated and its safety is therefore not ensured. Banning urban agriculture outright is not an effective solution to potential problems — whether real or imagined. If health, environmental, and other problems are to be prevented, urban agriculture must be legalized and the institutional capacity to regulate it created or reinvented. As a first step, cities need to undertake the research and cost-benefit analyses necessary to decide what types of urban agriculture are appropriate in which parts of the city.

Notes

1. Renata Clarke, FAO, personal communication, 1999.

2. (Drakakis-Smith, 1992) Is this the same as No. 6 ??

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