RUAF Foundation
RESOURCE CENTRES ON URBAN AGRICULTURE & FOOD SECURITY

Management of health risks associated with urban agriculture[1]

Henk de Zeeuw, RUAF Foundation

1. Introduction

Urban agriculture can have both negative and positive effects on the health of the urban population. This paper deals mainly with the (management of) health risks of urban agriculture. The positive effects on health have been dealt with in the previous module on food security and nutrition.

Urban agriculture engenders a complex mix of potential health risks, both for urban agriculturalists themselves and for their suppliers, neighbours and clients (Brown & Jameon, 2000; Flynn, 1999). Many of these health risks are similar to those in rural agriculture, some others are specific for the urban context. The geographic concentration of people and activities within urban areas can result in greater exposure of agriculturalists and their produce to physical, chemical, biological and psychosocial health hazards. Thus, UPA may be associated with greater health risks than its rural counterpart, although there are also numerous benefits derived from this activity that must be weighed against these risks.

It is essential to address the health risks associated with urban agriculture for two main reasons (Flynn 1999):

I. to protect consumers from contaminated foods and agricultural workers from occupational hazards; and
II. to secure the support of municipal and national authorities for the development of sustainable urban food production.

City authorities have often been reluctant to accept agriculture as a formal urban land use because of perceived health risks. However, prohibitive laws and regulations have proved to be largely ineffective and, despite such laws, urban agriculture is practised on a substantial scale. Hence, policies are needed that lead to an active **management** of the health risks associated with urban agriculture.

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[1] This paper was first published as one of the modules of the distance learning course developed by RUAF Foundation in cooperation with Ryerson University, Canada (see www.ruaf.org for free access version and http://www.ryerson.ca/~foodsec/certificate_0.1.html for certificate course).

The paper at present is being updated for republication (expected August 2014)

It is important that agriculture and health sectors, as well as urban planners, community organizations and others, closely cooperate to address these health risks in order to maximize the economic, social, and health benefits of urban and peri-urban agriculture, while minimizing the associated health risks.

Health is not merely the absence of disease or infirmity but a state of complete physical, mental and social wellbeing (WHO definition). The health concept initially was conceptualized on an individual basis. Nowadays it is increasingly understood to be at different levels: household, community, and city. The health status of an individual highly correlates with the health status of his/her living environment. Urban poor tend to live in those locations where living conditions are worst (high degree of contamination, poor sanitation, poor shelter, erratic water provision, high crime rates).

A **health hazard** is a danger to human health, resulting from environmental pollutants, human activities and life-style influences. If people are exposed to such health hazard there is a certain **health risk:** the probability of morbidity (illness or injury) or mortality (death) depending on the degree of **exposure** and the type of health hazard concerned.
Health hazards are often classified as physical, chemical, biological and psychosocial hazards:

- *Physical hazards* involve some direct transfer of energy to the body resulting in an internal (e.g., back pain from forward bending to weed a crop) or external (e.g. injury from an accident with a grinding mill) health impact).
- *Chemical hazards* can involve direct exposure (such as skin contact with pesticides from a leaking backpack sprayer) and indirect exposure (e.g. contamination of roadside vegetables with lead due to exposure to vehicular exhaust). Of special concern in urban agriculture are the numerous hazardous discharges by factories, hospitals and other sources and exposed in open water sources or into the air or leaking to the ground water.
- *Biological hazards* can be passed directly (such as swine fever from living with pigs), or indirectly either through media such as water (cryptosporidium in drinking water) or food (salmonella in eggs) or are vector born (e.g. malaria through mosquitos). These biological hazards are often part of a complex set of relationships with other species, both domestic (cattle and dogs) or feral (mosquitoes for malaria), which may act as vectors (carriers) of a particular illness, sometimes passing through life cycles in different media & organisms e.g. malaria and helminths (worms)
- *Psycho-social hazards*: the work involved in managing one’s household and farming activities can make for overload (long hours, multiple demands) and insecurity (e.g. unclear land tenure, adverse weather conditions) resulting in adverse psychosocial effects, particularly for women (Avotri & Walters, 1999).

The actual **health impacts** of exposure to a health hazard depends on the related **risk**, the **exposure dose,** size of the **affected population** and their **vulnerability**, which varies among others with age, gender, health status, body weight of the affected persons.
More vulnerable populations are: poor households (among others due to poor nutrition), already sick (e.g. vitamin A deficient to infection), very young and very old (e.g. pesticide effects), those with limited supports (e.g. orphans of AIDS parents). Women are more vulnerable than men (e.g. anaemia due to malaria).

2. Overview of potential health hazards associated with urban agriculture and strategies to prevent and reduce negative health impacts

Review of the available literature on urban agriculture and health (Birley and Lock, 2000) indicates that the main health hazards associated with urban agriculture can be grouped into the following categories (Birley and Lock, 1999):

a. Contamination of crops with **pathogenic organisms** (e.g. bacteria, protozoa, viruses or helminths), due to irrigation by water from polluted streams, or inadequately treated waste water or organic solid wastes;
b. Human diseases transferred from **disease vectors** attracted by agricultural activity;
c. Contamination of crops and/or drinking water by **residues of agrochemicals**;
d. Contamination of crops by uptake of **heavy metals** from contaminated soils, air or water;
e. Transmission of diseases from domestic animals to people (**zoonosis**) during animal husbandry, processing or meat consumption;
f. Human diseases associated with **unsanitary postharvest processing, marketing and preparation** of locally produced food; and
g. **Occupational health risks** for workers in the food-production and food-processing industries.

Below a short introduction to each of these health hazard is provided as well as the strategies that may be applied to prevent or reduce the health risks (risk mitigating strategies).

***3.1 Contamination of crops/soils with* pathogenic organisms** (e.g. bacteria, protozoa, viruses or helminths)

The contamination of soils, crops and fish with pathogens might be caused by:

a. *Irrigating fields with insufficiently treated wastewater or water from contaminated streams.* Wastewater contains various bacteria, protozoan parasites, enteric viruses and helminths. Liquid waste from domestic sewage is widely used for irrigation and fertilisation of field crops, perennials, trees and fish ponds. A large part of the wastewater used is untreated or poorly treated. These risks are not limited to official wastewater but often also apply to contaminated rivers and other open water sources: 45% of 110 rivers tested by Westcott (cited in Birley and Lock, 1999) carried faecal coliforms levels higher than the WHO standard for unrestricted irrigation.

   The coliform bacteria in the waste water may be transmitted to humans by eating the contaminated crops. Poorly treated sewage may contain viable stages of the hookworms may remain in moistened soils and affect agricultural workers who expose their bare skin to the soil. Transmission of pathogens may also take place by fertilisation of fish ponds with human and animal wastes (e.g. overhanging latrines, overhanging poultry cages, ducks, addition of urban night soil and use of wastewater).

   Various researchers (e.g. Furedy, 1996; Drechsel, 2006) have pointed out that perceived health risks of the re-use of urban wastes in agriculture are overstated and that regulations of waste re-use are frequently outdated or lack comprehensiveness. These research results have recently led to a revision of the WHO guidelines for the use of wastewater in agriculture .

   Important risk mitigation strategies include:

   - Establishment of more and decentralised wastewater treatment facilities with more appropriate water treatment technologies (e.g. waste stabilisation pond systems rather than sludge treatment plants - the former are cheaper to establish and maintain and retain more nutrients).

- Monitoring of the quality of irrigation water from rivers and wastewater outlets; certification of safe production areas; restriction of crop choice in areas where minimum water quality cannot be guaranteed.
- Farmer education on management of health risks (for workers and consumers) associated with re-use of wastewater in agriculture, including:
  - avoidance of direct exposure to wastewater and soils treated with wastewater, e.g. by using boots and protective clothing, and regular washing of hands and feet;
  - adaptation of crop choice in wastewater-treated land: e.g. it is not appropriate to grow fresh salad crops like tomato, lettuce, parsley, cucumber and mint in poorly-treated wastewater; these could be replaced by fodder, fibre, wood and seed crops);
  - application of drip irrigation or other localised irrigation methods (rather than sprinkler, gravity or spraying). Irrigation with wastewater must be stopped three weeks prior to harvesting
  - precautions to be taken in the management of wastewater-fed fish ponds.
- Consumer education (scraping and washing of fresh salads; eating only well-cooked crops, meat and fish from wastewater-fed crops, animals and ponds).

b. *The application of fertilization with fresh or improperly composted organic solid wastes* (especially if organic materials are mixed with human excreta from latrines or hospital waste) or animal faeces (e.g. from bird cages placed over nurseries or aquaculture ponds).

Important risk mitigation strategies include:

- Promotion of waste separation at the source; Regular collection of organic refuse; prevention of mixing household waste with waste from hospitals and non-agro industries;
- Establishment of decentralised composting sites; Securing the application of proper composting methods with right temperature and duration to ensure killing of pathogens;
- Recognition of the various informal actors involved in the processing of urban wastes and the marketing of recycled products; Provide training to the people involved in proper composting methods and other health risk reduction measures (e.g. sifting out sharp objects, removal of batteries).

c. *The unhygienic handling of the products during transport, processing and marketing* are an important source of bacterial contamination especially of fresh vegetables.

Important risk reduction strategies are:

- Education of the people involved in food processing, street vending, transport and marketing of fresh produce on sanitation and health aspects
- Provision of clean water at processing points and markets
- Consumer education on the need of washing, scraping or cooking of agricultural produce

3.2. ***Human diseases transferred from disease vectors attracted by agricultural activity*** *(malaria, dengue, tick borne diseases, etcetera)*

Malaria occurs in many environments but particularly in areas where irrigation is practised. Malaria in relation to urban agriculture is a serious risk in Africa only. Most malaria in cities is found where temporary water pools with clean, sunlit and shallow standing water can be found e.g. in irrigated rice fields and uncovered water tanks.
Growing wet crops and application of ridge cultivation (e.g. rice, sweet potato and yams) are favourable for the breeding of malaria mosquitoes. Cassava growing is only occasionally a problem, when it is grown in cultivation ridges in wet clay soil. In contrast, maize and banana crops, as well as tall grasses, present **no** particular malaria risk (Note: in many cities authorities have traditionally justified destruction of urban crops like maize and banana by saying that mosquitos breed in leaf axils, but research clearly indicates that axils of plants are never breeding sites for any kind of mosquito).

Filariaris: The mosquito *Culex quienquefasciatus* that transfers Filariasis, breeds in standing water that is highly polluted with organic matter (e.g. pit latrines, blocked sewage drains, cesspits and septic tanks, soak pits and poorly designed sewage-treatment plants). Filariasis is spreading rapidly due to urbanisation.

Dengue: The Aedes mosquito, which is the main vector of dengue, breeds in water containers that include much solid waste (e.g. tin cans, coconut husks, rubber tyres, water storage jars).

Poor disposal of organic solid waste (animal manure, crop residues and other farm refuse) may also attract rodents and flies that may be carriers of diseases (e.g. *plague, lime*, *tick borne diseases*).

Scavenging by domestic animals (e.g. cats, pigs and rats) is associated with a range of food-borne diseases such as *amoebic and bacillary dysentery*.

Important risk mitigation strategies:

- Co-operation between the health sector and the natural resource management sector (solid waste management, water storage, sewerage, agriculture and irrigation) is essential to reduce vector-borne diseases.
- Filariasis control is not sustainable until related urban problems, like solid-waste management, are solved in an integrated way (drains are often blocked by garbage due to ineffective collection systems). Solid waste management is also essential for the control of dengue and dysentery (as well as rodent control programmes). Mosquitoes breeding in latrines and stagnant polluted waters can be controlled effectively by the use of expanded polystyrene balls.
- Water tanks and irrigation systems (especially in peri-urban areas) need to be properly designed to prevent malaria. Also slow-release floating formulations can be applied to control the malaria vector.

3.3 *Contamination of crops and/or drinking water by residues of agrochemicals*

Intensive use of agrochemicals (fertilisers, pesticides, fungicides) may lead to residues of agrochemicals in crops or in the groundwater. The risk of crop or groundwater pollution due to agrochemicals is mainly restricted to areas with intensive commercial horticulture, especially for vegetables (WHO Commission on Health and Environment 1992). In traditional and subsistence farming the risk is quite limited since urban farmers hardly apply agrochemicals due to poverty, use of wastewater and composted organic solid wastes and/or their preference for a clean product for self-consumption (Lourenço-Lindell, 1995). But even in peri-urban market vegetable farming more organic fertilizers than mineral fertilisers are applied (De Bon et al. 1997; Kouvonou et al. 1998).

Chronic illnesses have been associated to residues in foodstuffs due to concentration of agrochemicals in the food chain, including vegetables, red meat, poultry, eggs (FAO and WHO 1988).

Inadequate management of agro-chemicals may also have direct negative health impacts on farm workers. Acute poisoning due to agrochemicals can cause a range of symptoms which are often not correctly diagnosed (e.g. dizziness, diarrhoea, headache, memory impairment, convulsions, coma, liver and kidney impairment and lung fibrosis).

Important risk mitigation strategies include:

- Farmer education on the proper management of agrochemicals; introduction of cheap protective clothing and equipment;
- Promotion of ecological farming practices and replacement of chemical pest and disease control by IPM (integrated pest and disease management);
- Better control of sales of banned pesticides;
- Monitoring of residues of agrochemicals in crops and groundwater.

3.4 Contamination of crops by uptake of heavy metals from contaminated soils, air or water

The main causes of soil pollution from heavy metals (including lead, cadmium, chromium, zinc, copper, nickel, mercury, manganese, selenium, mercury and arsenic) are irrigation with water from streams and wastewater contaminated by industry[2], the pollution of crops by heavy traffic on roads nearby (lead, chromium), the application of contaminated organic wastes (e.g. by leaking batteries) or sewage sludge, and the use of former industrial land contaminated by spilled oil and industrial wastes.

The heavy metals may accumulate in the edible parts of crops that are consumed by people or fed to animals. Generally, the highest amounts of heavy metals accumulate in the leaves, whereas the lowest contents are located in seeds.

Plant uptake of heavy metals varies, which opens the possibility to adapt the choice of crops in relation to the degree and type of contamination. Beans, peas, melons, tomatoes and peppers show very low uptake figures. Plant uptake of heavy metals (especially of cadmium and lead) also varies with soil pH (Iretskaya and Chien, 1999).

The health risk of heavy metal contamination in urban agriculture is less conclusive as few studies have examined this issue. The risk depends primarily on the upstream sources of pollution (air and water). The extent of industrial pollution in an area is an important factor.

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[2] Important sources of heavy metals are smelters, refineries, manufacturing plants, vehicles, metalliferous mines, ceramic industry (lead and cadmium), leather tanneries (chromium salts), lignite-based power plants, aluminium industry, electronics industry, and metallurgical industry.

Puschenreiter et al. (1999) concluded, after reviewing available research data, that soils with slight heavy metal contamination can be safely used for gardening if proper precautions are followed. However, Birley and Lock (2000) argue that little is known of the chronic health effects (carcinogenic and mutagenic) of consuming tiny amounts of heavy metals over long periods of time, and that further research is needed.

Main <u>risk mitigating strategies</u> include:

- Reduction of heavy metal pollution at the source
- Periodic testing of the contamination of agricultural soils and irrigation water with heavy metals especially in areas downstream polluting industries (air and water);
- Maintaining a minimum distance of 70-100 meter between crop fields and main roads and/or planting of boundary non-food crops beside roads to reduce contamination of crops by lead and cadmium;
- In contaminated areas:
  - Shift to crops that take up less heavy metals
  - Soil treatment for immobilisation of heavy metals by application of lime (increases pH and thus decreases the availability of metals, except for selenium) or farmyard manure (reduces the heavy metal content of nickel, zinc and copper, but may increase cadmium levels).
  - Biological remediation by making use of plants like Indian grass (*Brassica juncea, L*) that take up heavy metals very easily; Iron oxides (like red mud) and zeolites are also known to absorb heavy metals like cadmium and arsenic;
- Washing and processing of contaminated crops may effectively reduce heavy metal content: good results were obtained for lead (less so for cadmium) in green beans, spinach, potatoes, whereas peas virtually showed no change;

3.5 Transmission of diseases from domestic animals to people (zoonosis)

Certain diseases (bovine tuberculosis, pig and beef worm, trichinosis, anthrax, salmonella and campylobacter) can be transmitted to humans by livestock kept in close proximity to them, if proper precautions are not taken (Kathleen Flynn, 1999).

Bovine tuberculosis is transmitted by the ingestion of contaminated unpasteurised milk from infected cows and through direct contact with infected animal material (blood, urine) and forms a main occupational hazard of livestock farmers and slaughterhouse workers. It can also spread by air-borne transmission and inhalation (e.g. in the neighbourhood surrounding a slaughterhouse).

Taeniasis and cysticercosis (beef and pig tapeworm) are transmitted by consumption of meat infected with tapeworm eggs congested by animals that scavenge on human faeces, or of crops irrigated with improperly treated sewage.
Trichinosis is transmitted by consumption of infected meat of pigs that scavenge on food waste and dead animals.

Anthrax is transmitted through a cut in the skin, by inhalation of bacterial spores or consumption of infected meat and most common in people who work with livestock or work in animal product industries (e.g. slaughterhouse, tannery).

Leptospirosis (Weil's disease) is transmitted through the contact of humans with infected animal urine or contaminated feedstuff or by swimming in or drinking from water supplies contaminated with animal urine.

Salmonella and campylobacter can be transmitted through contamination of animal feed. The wastewater discharge from intensive poultry farms can carry heavy loads of these micro-organisms and may contaminate sources of potable water.

Important <u>risk mitigation measures</u> include:
- Collection of prevalence data for the most important zoonosis;
- Consumer education regarding thermal treatment of all milk and dairy products and proper cooking or freezing of meat products;
- Restriction of uncontrolled movement of livestock in urban areas (e.g. by promoting stall feeding)
- Strict slaughterhouse regulations; Condemn pig carcasses infected with tapeworms (which is sometimes a very high percentage);
- Simple laboratory antigen-testing for anthrax infection of suspect animal products (like carcasses and hides); disinfection of wool and fur;
- Farmer education on the risks of animals scavenging on human wastes, the need to compost manure before application, the risks of self-slaughtering, etcetera

3.6. ***Occupational health risks****.*

In the above we have seen various examples of occupational health risks:
- Improper handling of agrochemicals may lead to health problems among urban farmers (Kishi et al, 1995). Similar professional health risks are run by persons involved in the handling of urban organic wastes and waste water.
- Sharp objects in composted organic wastes may cause injuries
- Persons that slaughter animals without sufficient precautions may be affected by antrax or bovine tuberculosis, if no proper precautions are taken.

<u>Risk mitigating strategies:</u>
- Education of farmers and labourers at composting plants and slaughter houses on health safety aspects of their work
- Proper regulation and control of slaughter houses

4. Health impact assessment

In order to be able to better manage the health risks associated with a specific type of urban agriculture or a planned policy or intervention it may be needed to implement a Health Impact Assessment.

A Health Impact Assessment (HIA) is a tool for estimate the magnitude & severity of the likely health impacts of a certain health hazard or a certain UPA practice (or of the change in health risk (positively or negatively) that may be expected of a planned project or policy".

A number of HIA guidelines have been developed, usefully reviewed in Birley (2002). The WHO website provides international examples of HIA practice (case studies, toolkits, etcetera) (http://www.who.int/hia).

The main steps involved in an HIA are:
a. Identification and characterization of the related potential health hazards
b. Assessment of potential health impacts
c. Planning and implementation of risk mitigating measures

ad a. ***Identification and characterization of the related potential hazards*** *(also named: scoping exercise)*

The first step of an HIA is to identify potential health hazards: a broad scoping exercise aimed at examining all potential health hazards related to the practice or intervention under study and narrowing the possibilities to those of greatest concern.
This scoping process may involve discussion with multiple stakeholders to draw on their knowledge and perceptions. Identification of each of these hazards usually builds on a combination of the perceptions of those exposed to them, what is known about the health hazards of particular practices in UPA (literature and expert knowledge) and direct observations of particular situations.

Often rapid qualitative methods are used (see Scrimshaw and Gleason, 1992 for an overview) including:

- Focus group discussions: semi-structured discussions with a small group of people with particular characteristic(s) i.e. a selected number of UPA farmers that use pesticides in a particular community. Focus group discussions involve a facilitator and a recorder.
- Key informant interviews: semi-structures interviews with individuals that you think have specialized knowledge about a particular area, making use of open-ended questions about a number of topics following a general outline and allowing additional subjects to be incorporated as they arise.
- Observations: Carefully document events and behaviours that you observe in the daily socio-cultural context of a household or community.
- Narratives: The participant provides a step-by-step description of a particular event they experienced, such as a recent illness.
- Tools that involve drawing, mapping, diagramming, etc. i.e., cards with pictures representing illnesses and participants group together those cards that they feel are related, which may reveal ideas about causation.

A good example of integrating sources of data into a profile of potential hazards was that conducted for irrigated vegetable production and marketing in Accra, Ghana (Sonou, 2001). Group interviews were conducted with farmers about the source of water for irrigation – as many as 60% confirmed using wastewater, with 23.3% using pipe-borne water, and 17% using piped water stored in a ground reservoir. Other interviews with market women found that all reported washing vegetables prior to bringing them to the market to sell. In addition to documenting practices, the interviews found that neither group associated their practices with any potential health hazards. Parallel data collection efforts measured bacterial counts in irrigation water and on vegetables from two different market sites in Accra. High levels of contamination of market vegetables by *E.coli, Pseudomonas, Salmonella*, and nematodes were observed. Based on these observations suggestions for training and education campaigns for farmers and market women were developed as well as a proposal for designing a water quality certification program based on levels of contamination.

Ad b. ***Assessment of health risks/impacts***

The next step will be to define the potential health impacts of these hazards by:

- ***Exposure assessment****: Identifications of the (potentially) affected populations and their degree of exposure: who are the people that are affected by this hazard and in what degree are they exposed?*

  We do so by clarifying:

  a. the <u>exposure pathways</u> of the hazard: how is the potential disease transmitted from the source to human beings (through vectors, by air, water, the soil, through consumption, etcetera)?

  b. <u>behaviour</u> that links humans to these pathways: Working with animals or toxics can lead to exposure to occupational hazards (ILC, 1998). Playing close to parents irrigating with wastewater or in yards where animals defecate exposes children to biological hazards. Consumption of chemically or biologically contaminated foods is likely one of the major ways people are exposed.

  The degree of exposure can be estimated by:

  - Interviews with affected persons
  - Source/destination flow models and maps
  - Systematic observations on activity patterns e.g. urban horticultural practices, inorganic waste disposal practices or activity patterns of the populations of interest (e.g. children's movement around the farm during a day/week in order to identify the number of times and duration that they played in locations where they are exposed to the health factor under study)
  - Assessment of dietary intake (if the health hazard is related to consumption) and the source of different foods in the diet, as well as documentation of food preparation practices by particular populations (e.g., boiling of milk to reduce bacterial contamination prior to consumption).
  - Laboratory analysis to define contaminant levels (e.g. of metal levels in soils and crops, e.g. Nabulo, 2002)

  However, obtaining more detailed and quantitative information on a very wide range of potential hazards can pose considerable technical challenges and entail substantial expenses to obtain accurate analytical results.

  The challenge of assessing exposure to chemicals in UPA lies in identifying the numerous chemicals involved, the multiplicity of sources, uncertain emission rates and diverse population behaviours. Nevertheless, based on current knowledge, metals such as lead and cadmium, combustion products such as PAHs and dioxins, and pesticides applied in UPA such as organophosphate and organochlorine insecticides such assessments are regularly undertaken.

For many health risks associated with UPA, exposure is likely to be chronic, though **fluctuations** may occur due to UPA practices occurring **seasonally** e.g., insecticide application to vegetables during the growing season. Similarly, levels of contaminants in soil and the uptake of contaminants into vegetables may vary markedly **across UPA localities**, possibly due to distance to industry and location in relation with main wind direction and wastewater stream, site soil characteristics, or differences between particular crop species. Also the **contaminant bioavailability** for humans ingesting UPA crops highly varies.

- ***Risk assessment:***

  In order to be able to define the health risk related to the above estimated exposure to a certain hazard one needs to know:

  - What is the **probability** that the people that are exposed to the health hazard get a certain disease (and the **severity** of such disease) or die?
  - How does that probability relate to the **dosis** received and the **vulnerability** of (certain sub-categories) of the affected population?
  - What **factors** play a role in the local conditions that may reduce or accelerate the development and severity of the illness or death?

  The vulnerability / susceptibility of a certain category of the population vary among others with:

  - *life stage*: Small children have underdeveloped detoxification systems for chemicals; Women and men of *reproductive age* can be affected by a variety of exposures that impair fertility.
  - *poverty*: the urban *poor* are more vulnerable than the rich due to poorer housing and sanitation in slum areas, reduced access to nutritious foods, and more difficult access to health care (WHO, 2002).
  - *existing health conditions;* people with a poor health condition are more susceptible, e.g., asthmatics' greater response to vehicular air pollutants and anaemic children's greater susceptibility to lead exposure, particularly important for roadside plots.
  - *Gender* differences may combine several of these ways of considering greater vulnerability. Women are more commonly victims of assaults in urban plots, they are more often responsible for environmental management and therefore more exposed to health hazards associated with waste, and they are more susceptible to malaria than men due to their greater role in reproduction (see also Lee-Smith, 2006)

  The risk assessment may involve epidemiological work: the study of the distribution and determinants of diseases and injuries in populations and factors that influence this distribution. Epidemiology involves the measurement of disease outcomes in relation to a 'population at risk'; this is a group of people, who are healthy or sick, who would be counted as cases if they had the disease being studied. However, a population can represent a very large number of people, thus observations are usually made on a study sample, which is selected from the target population. (see Coggon, Rose and Barker, 1997).
  A very useful epidemiology computer software package, available for download from the Internet, that is a valuable tool in creating questionnaires, entering data, analysing data and presenting results is called Epi Info. Details about Epi Info including the package for download, tutorials and training that provide detailed directions for use, resources, as well as information on compatibility and system requirements, can be found on the CDC website at

:http://www.cdc.gov/epiinfo/. Epi Info can also be used for nutritional assessment and surveillance (see Fichtner et al. 1989)

Data on morbidity and mortality related to certain diseases may be available from health service records (e.g. malaria incidence in areas where UPA is practiced), but additional data collection may be needed via surveys. A good example is the complex set of vector density and parasite load measures mapped geographically that may assist in identifying variations in urban malaria prevalence (Robert et al, 2003) and hence marginal attribution to UPA through examination of distance from irrigation sources and nature of those sources (Afrane et al, 2002; and Klinkenberg et al).

Concentrations for chemical, radiological and biological hazards found in foodstuffs, can be directly compared with regulatory media benchmarks that already incorporate general elements of **dose** (exposure) **– response** (health outcome) **relationships** and health impacts e.g., Codex Alimentarius of FAO for pesticide residue limits.

In other cases and for more detailed and specific analyses, estimated exposure dose should be compared to a toxicological benchmark for the maximum tolerable levels in e.g. irrigation water and soils. Best estimates should be obtained from systematic reviews of dose-response relationships via searches of the literature on toxicological studies and epidemiological studies. (e.g. PubMed), if available. Alternatively, synthesized and peer reviewed estimates across species and types of studies are available via websites such as the United States Environmental Protection Agency's (USEPA) Integrated Risk Information System (IRIS) (www.epa.gov/iris).
It is important to note that human toxicity benchmarks are generally developed for healthy Caucasian adults though efforts are underway to develop benchmarks for children. Most benchmarks and toxicity assessments do not address ethnic/racial variability nor other sources of differential susceptibility such as population illness prevalence, except around air pollution and cardio-respiratory illness.

For comparisons across risks, quantification to a common metric is often useful e.g., quality- (Ponce et al, 2000) or disability- (WHO, 2002) adjusted life years. These measures take into account when an adverse health impact occurs during a life, as well as its impacts on the quality of life experienced. Alternatively, in retrospective assessments health economists have estimated economic burdens of illness, both indirect and direct, e.g., lost workdays, transport, and clinical and treatment costs associated with pesticide poisoning among farm households (Cole et al, 2000). Labour economists have used existing cross-sectional and prospective studies to estimate productivity impacts of risk reduction e.g., improvements in work capacity among farm workers with treatment of parasitic infections and concomitant anaemia (Horton et al, 2001). Comparison of risk arising from multiple disparate factors is difficult, though of particular importance to UPA and has been identified as an important area for method development in food safety (Taylor et al, 2003)

Detailed regulatory guidelines and handbooks for conducting human health exposure and risk assessment are available from several sources. These include Health Canada's "Handbook for Exposure Calculations" and the United States Environmental Protection Agency's (USEPA) "Risk Assessment Guidelines for Superfund".

Whereas the methods are general, the assumptions made and data used (e.g., intake rates) need to be specific to UPA, the particular location and the specific populations being considered. The specificity of the analysis to UPA must be consistent with details specified in the scoping exercise. Among the issues in scoping is the fact that health risk assessment is largely limited to consideration of single chemical or biological hazards. This is an important limitation, particularly for UPA, since we are often dealing with complex chemical mixtures and multiple, non-chemical hazards.

Ad c. ***Planning and implementation of risk mitigating measures***

Results from health risk assessments can provide important information for the planning and implementation of risk mitigation measures. The results can aid in prioritizing which risks to mitigate, and also to suggest ways to mitigate them.

However, although a health risk assessment provides a "best estimate" based on empirical data, these estimates of risk may not coincide with ***perceptions of risk*** among exposed communities. In particular, different social groups have different perceptions of the intensity of risks (Elliott et al, 1999; Boischio and Henshel, 2000) that, in turn, differ from actuarial risk estimated by a risk assessment.

Documentation of perceptions or social constructions of risk can provide an additional important input to the risk management process and guide education efforts. For example, a group of South African farm women thought that storage of pesticides was risky, but not linked to health, and that pesticide containers were not a health risk if the pesticide container was washed before being reused (Rother, 1999). This demonstrates that knowledge of both perceived and actual risk must feed into a risk management framework, particular when health impacts may be occurring that farmers are not aware of, as in neurotoxic effects of pesticides (Cole et al., 1997).

Even when actual risks are known, ***willingness to take on or assume risks***, both in production and pesticide use decisions, varies across farming styles as was found among small-holder potato farmers (Paredes, 2001).

Such variation is most apparent in cases raised as human rights issues, such as the construction of large dams in India and China which are opposed by many in the rural population who are forcibly displaced. Similar human rights concerns are raised by efforts of municipal authorities to clear urban farmers away from hazardous sites such as roadside verges or near wastewater channels. Hence, activities that work with communities to foster dialogue on risks and explicitly discuss different points of view are key to initiation of sustainable health risk management strategies.

Trade-offs or balancing of health benefits and risks also occurs. Among those urban households experiencing recurrent hunger, "food on the table" to allay hunger has higher priority (see Lee-Smith, this volume) than the longer term risk of chronic diseases such as cancer due to PAH exposure from air pollutant contaminated vegetables. Sometimes adverse effects may not be perceived. Often, win-win situations can be encountered. For example, reduction of neurotoxic insecticide use among potato farmers was estimated by agricultural economists using a Trade-offs Analysis tool (Antle et al, 1998) to produce increased farmer neurobehavioural scores and farm productivity. At other times, constraints may generate inter-group trade-offs. In Kumasi, Ghana use of cheap poultry manure for vegetable production is common. However, manure producers faced such heavy demand that they shortened storage times prior to sale to the point that pathogens were no longer killed, thus exposing vegetable farmers and eventually consumers to potential pathogens (Drechsel et al, 2000).

Gender differences are another factor that influences the distribution of health benefits and exposure to health risks in a community and family (Watson, 2003). A gender approach in health, while not excluding the biological factors, considers the critical roles that social and cultural factors and power relations between women and men play in promoting and protecting or impeding health *(*WHO, 1998*)*. Women tend to take on UPA activities next to their household chores and have a risk of physical overload. Women often have less access to education and training and therefor may be less informed on e.g. safe handling of pesticides (or not able to read the label with prescriptions) and proper management of household wastes (while she is often responsible for these tasks) so that women tend to be more exposed to related health risks. Women tend to have less access to credit and inputs, meanwhile they are often hold responsible for feeding the family which may cause strain and to other more risky activities (e.g. prostitution).

The kinds of health hazards identified, the extent and appraisal of health risks among different populations, differential valuation of health risks and benefits, and differential distributions of trade-offs, may all influence risk management.

In addition, the ***viability and impact of mitigation strategies*** are relevant, as discussed in an e-conference on options for health risk mitigation for different disease risks associated with UPA (Lock and de Zeeuw, 2001). For example, disease screening and treatment of UPA livestock might a better method of reducing public health risk (whilst improving benefits to urban farmers and to urban consumers) than inspection of produce, which may be uneven and ineffective in controlling risk for neighbourhood consumers? Or is use of partially treated wastewater for irrigation of UPA crops and providing clean water for washing market produce more feasible than trying to provide clean water for all activities, leaving considerable gaps in coverage? Discussions on the pros and cons of risk mitigation options should also be ‘part and parcel’ of risk management decisions.

Sustainable and effective risk management strategies should be based on joint health risk assessment and planning of risk management strategies processes involving scientists, managers and active communities. Such “***multi-stakeholder” approaches*** strive to ensure that risk management is based on an acceptable *process* (procedural justice) through community participation and achievement of acceptable *outcomes* (distributive justice) (Cole et al, 1998b). Such community participation is exemplified by participatory urban appraisals and multi-stakeholder consultations including discussions on the perceived and actual health risks of UPA that were implemented in Kampala as part of the formulation process of new Kampala ordinances on urban agriculture and livestock (David et al, 2003; Twazebe et al, in this volume). During focus group discussion on health and UPA, women UPA farmers spoke eloquently about their concerns with food contamination from human excreta and industrial pollution in wetland farming. However, they were less clear about the nature of exposure to chemical and biological contaminants. Environmental, health and social scientists from the research team discussed the different possibilities of exposure from their perspectives as part of plenary dialogue.

Increasingly, risk management is **moving "upstream" on presumed causal pathways of health impacts** and location of responses to broad determinants of health such as the way UPA is managed and carried out (Corvalan et al, 1999: WHO, 2002). For example, better household, community and industrial waste management can obviate the practice of depositing waste in drainage channels, which reduces blockages and flooding during the rainy season and, in turn, reduces levels of faecal bacteria in water and diarrheal disease morbidity and mortality. Grappling with the 'driving forces' and 'pressures' leading to environmental degradation may be the most effective way to control potential health hazards associated with UPA. In urban design terms, **dealing with "driving forces"** leads us to consider; revised urban forms e.g., designated safer locations for UPA; infrastructure provision, e.g., wastewater treatment; transportation design, e.g. more collective transport to reduce air pollution; and better stewardship of city resources and resource consumption e.g., recycling of organic wastes into UPA as is conceptually laid out in urban metabolism studies (Sahely et al, 2003). Such aspects are often central to concerns of multi-sectoral healthy public policy movements such as "**Healthy Cities**" (www.who.dk/healthy-cities) and the **Ecohealth approach** (Lebel, 2003) that seek to improve human health through better management of the urban ecosystem, taking into account multiple determinants of health, including considerations of environment, social and economic factors.

Conclusion

To arrive at reduction of health risks associated with urban agriculture achievable health gains by the affected population we need to take several steps. First, the valuation of health outcomes is required by communities suffering health impacts, UPA producers and consumers, in conjunction with trans-disciplinary teams of health and agricultural waste management experts and urban planners. Second, the relative contributions of different types of UPA to morbidity and well-being must be distinguished from the contributions of other aspects of urban living conditions e.g., poor general waste disposal and sanitation that are likely to contribute to a huge burden of existing gastrointestinal infectious disease in poor urban communities that is not directly attributable to UPA. Third, priorization of hazards specific to UPA for mitigation must be conducted through multi-stakeholder processes involving communities engaged in UPA, municipal policy makers that must manage cities for the benefit of all urban citizens, and trans-disciplinary research teams. Fourth, is the need to jointly construct feasible risk mitigation strategies of better agricultural practices and urban conditions where risks would be minimized and benefits maximized using different approaches. Fifth, more systematic monitoring and evaluation of such risk management strategies are needed to generate effectiveness and efficiency data that would improve persuasiveness with communities engaged in UPA and policy makers interested in engaging in "evidence-based practice".

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