Chapter 9
Health Impact Assessment of Urban Agriculture in Kampala

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Introduction

While the Urban Harvest-supported studies described in the previous three chapters were going on in Kampala, an opportunity arose to complement them with an exploration of the health impacts associated with urban agriculture (UA) in the city. The Kampala City Council had expressed concern about the health risks associated with some forms of UA and the research team welcomed the chance to examine ways to reduce health risks and increase health benefits. A parallel research process was therefore set up, governed by a Health Coordinating Committee comprising researchers and policy-makers. Scholars from universities and research institutes in Uganda and Canada, in collaboration with local government and non-governmental organizations, were supported by the Canadian International Development Agency (CIDA) and the International Development Research Centre (IDRC). This chapter is essentially a summary of a companion book titled "Healthy City Harvests: generating evidence to guide policy on urban agriculture", which contains all these studies (Cole et al. 2008). As in that book, the research findings are translated into policy implications, not only for Kampala but also for other cities with similar conditions.

Identifying Potential Health Impacts

Urban governments have reason for their concerns about the health risks of food production in urban areas with high population density, as in parts of rapidly growing cities of the South like Kampala. Communicable (infectious) diseases from pathogens transmitted to and among people often through inadequate water and sanitation services have been compounded with exposures to potentially toxic chemicals, creating a "double health burden" among the urban poor living in informal,

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un-serviced settlements (UN-Habitat 2001). High urban population densities are accompanied by high concentrations of energy use, resource consumption and generation of waste, even with the same levels of individual consumption, leading to a different mix of risks and benefits from urban as compared to rural agriculture (Cole et al. 2006).

With increasingly sophisticated understanding of the links between human health and environment, approaches have been developed to assess benefits and risks to human health including Health Impact Assessments (HIAs) and frameworks for managing risk and promoting healthy public policy (Cole et al. 2006). In HIAs, potential hazards are first scoped out, and those of greatest concern are identified for further investigation. A potential hazard does not always mean there is a risk to health. The pathways through which exposures occur or diseases are transmitted are examined in HIA, providing a way to work out mitigation strategies (Cole et al. 2006).

HIAs on UA involving concerned local government and community stakeholders should include four steps (adapted from Lee-Smith & Prain 2006):

1. Identifying and prioritizing key hazards and benefits associated with UA;
2. Examining hazardous exposures for particular populations and developing risk-reduction methods;
3. Identifying health benefits for particular groups and considering how to enhance these benefits;
4. Formalizing outputs into health-risk mitigation and health-benefit-promotion strategies.

To start the process in Kampala, stakeholders – including policy-makers, scientists and civil society representatives – listed the main health *benefits* of UA as:

- Improved nutrition including dietary diversity, namely protein from livestock and livestock products, energy from staples, mainly *Matoke* (green banana) but also cereal and root and tuber crops, and micronutrients from fruit and vegetables, especially traditional vegetables;
- Nutritional benefits such as mitigation of effects of contaminants and HIV-AIDS, including production of medicinal plants;
- Use of organic waste to produce crops (vegetable compost and livestock manure), and raise animals (organic residues as feed); and
- Psycho-social benefits of physical labour, greening the city, bolstering self-esteem, community organizing and social capital.

The main health *risks* associated with UA were identified as:

- Bacteriological and toxic contamination from cultivation in wetlands (Lake Victoria and its channels) due to poor sanitation and uncontrolled discharges from a variety of urban industrial and other activities;
- Bacteriological and toxic contamination from cultivation in areas where soil or well water are polluted by garbage, run-off or other sources;

- Poor handling of waste and its use for farming (mixing of organic and inorganic);
- Air pollution from industry and traffic; and
- Transmission of disease from livestock to humans (zoonoses).

A Participatory Urban Appraisal (PUA) showed urban farmers' health-risk perceptions varied with location (Chapter 6 above; Lee-Smith 2008). For example, farmers in the Banda wetland slum area identified a wider range of health risks and differentiated between them, as compared to farmers in the semi-rural peri-urban area of Komamboga who perceived fewer health risks. Awareness of risks sometimes led to mitigation actions, such as community organizations forming to manage garbage. However, the very poor, while aware of health risks from UA, could sometimes not avoid them because their survival depended on getting food and water for themselves and their families. Women's and men's perceptions and mitigation strategies also varied due to the different activities in which they are involved (Lee-Smith 2006). Women were more likely than men to grow food crops on contaminated land and were more involved in multiple UA activities, yet were least protected from its environmental hazards (Nabulo et al. 2004).

Based on the benefits and risks identified and resources available, we chose to focus on food security and nutritional benefits, contaminant risks – both biological and chemical – and livestock-related benefits and risks.

Documenting Household Food Security and Child Nutritional Benefits

Aim and Methods

Although data from Kampala in the 1990s suggested that children in farming households were better nourished, based on height-for-age (stunting), than those in non-farming households (Maxwell et al. 1998), there was limited evidence in the published literature regarding not only the mechanism by which UA could contribute to the food and nutritional security of urban populations, but also the degree to which it can. Kang'ethe and colleagues (2007) called for the inclusion of adequate controls, measurement of intermediate outcomes between urban agriculture and nutrition outputs and better control of potential confounding factors.

Hence, we sought to examine relationships among kinds of urban farming, household socio-economic characteristics, household food security (HFS), food frequency, child dietary intake and biochemical indicators among pre-school children (Sebastian 2005; Yeudall et al. 2007) as per Fig. 9.1.

Food security means that "all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO 2002). Confronted by food shortages the primary caregiver – the one responsible for obtaining and preparing food for the rest of the household – uses the strategies of dietary change, food-seeking, household structure changes, and rationing (Maxwell 1996; Maxwell et al. 1999). Our indicator of HFS was based on four questions regarding three of

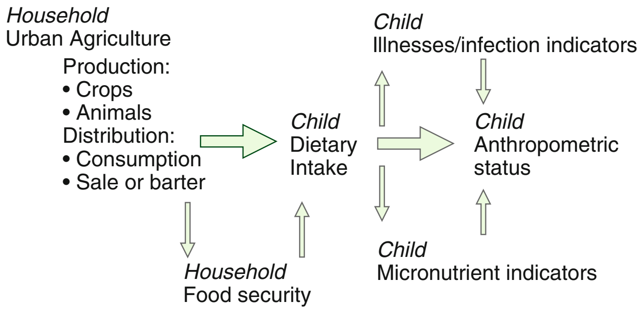

Fig. 9.1 Framework of linkages between household UA and child nutrition

these coping mechanisms, namely borrowing money or food, limiting portion size, skipping meals or eating different foods.

We interviewed 295 primary caregivers of children aged 2–5 years in randomly selected farming and non-farming households in 13 parishes of Kampala, using the Kampala City Council UA classification system of parishes on a continuum from inner-urban to peri-urban. The consent process resulted in 90–100 percent agreement, meeting the communities' need for feedback information dealing with HIV fears and providing both information on anaemia and malaria and referrals for treatment.

Anthropometrics, dietary intake and levels of vitamin A and iron were measured and underweight, stunting and wasting assessed on each child. For each household, we calculated a simple Asset Score as a wealth indicator and used Tropical Livestock Units (corresponding to approximately 250 kg animal live weight) as an indicator of livestock owned. Child-nutrition indicators included dietary quality (the percentage energy coming from animal-sourced foods and dietary diversity, the number of unique food items reported for each child in a 24 h recall), biochemical measures (haemoglobin and retinol), and the nutritional indices of weight for age Z score (WAZ) and body mass index Z score (ZBMI). Chronic infection or inflammation was assessed with C-reactive protein (CRP).

We first used multivariate linear regression analysis to model factors associated with HFS in three population subsets: all respondents (farmers and non-farmers), crop growers and livestock farmers (including those who also grow some crops). Then we used pathway analysis to explore links of these variables to child-nutrition indicators (Yeudall et al. 2007).

Findings on Household Food Security (HFS)

The main factors that improved HFS were greater wealth (assets), particularly among those with less land – land size < 0.25 acre (0.1 ha) – and livestock keeping, with more complex relationships with gender and education (Sebastian 2005; Yeudall et al. 2007). This means those cultivating more land could produce more food either for consumption or for sale, improving their HFS. Raising pigs contributed significantly to HFS, apparently related to cash obtained, since 85 percent of these farming households kept pigs only for sale.

Women were the primary caregivers of their children and generally the urban farmers as well. HFS was better in male-headed households if the woman had secondary education or higher. Her nutrition education also played a role, but it was less clear. Intriguingly, HFS was only significantly and positively associated with assets among household heads having at least a secondary education. A recent review of agriculture interventions concluded that investments in different types of human capital were needed for increased food production to improve nutrition (Berti et al. 2004).

For households raising livestock, women-headed households had greater food security than male-headed households when the size of land was a quarter acre or less. Women heading households may have fewer resources (labour time and money) to make use of land than if they receive support from the man of the household. Women farmers in Kampala have been found to grow crops requiring minimum labour time because they are also responsible for household activities such as cooking and caring for their families (Nabulo et al. 2004). Perhaps women farming larger plots of land alone may rely more on UA as a livelihood strategy than do women in male-headed households. Women's access to food for themselves and their children has been shown to be strongly associated with their control over household resources (Kabeer 1991).

Findings on Child Nutrition

In the path analyses, assets (wealth) contributed directly to children's weight-for-age status, and indirectly to nutritional security indicators such as animal-sourced-food consumption and diet diversity. We noted a significant positive relationship between HFS and subsequent animal-sourced-food consumption, which in turn was positively associated with retinol, an indicator of vitamin A status. Consumption of animal-sourced food was significantly negatively associated with CRP, which in turn was significantly negatively associated with haemoglobin. Thus infection, inflammation and anaemia were less likely in children consuming more animal-sourced foods. Haemoglobin was significantly positively associated with WAZ, highlighting the importance of efforts to increase animal-sourced foods in children's diets (Allen 2003).

Dealing with Contaminants on and in Crops

Nature of the Enquiry

To respond to Kampala City Council's (KCC) concerns about microbial and chemical contamination, it is useful to distinguish the pathogenic risks presented

Table 9.1 Differences between biological and chemical health hazards in UA

Hazard	Biological	Chemical
Type	Pathogenic[a]	Toxic
Source	Excreta, organic matter, especially in decay	Manufacturing processes & their products e.g. paints, cleaning fluids, gasoline, batteries, and combustion products e.g. diesel emissions
Main pathways of exposure	Solid waste & wastewater	Solid waste, wastewater, air
Behaviour in environment	Have limited life span but multiply	Decay slowly, if at all, but can accumulate up food chains
Disease	Infectious	Non-infectious
Conventional controls in cities of lower income countries	Composting & latrines. Sometimes sewage filtration, sedimentation, and drying of sludge for agriculture. Some water purification, local or central.	Currently limited – except for some controls at source, re-use, emission controls, and sanitary landfill burial.

[a] Some biological organisms are beneficial e.g. soil bacteria. Here we only refer to pathogenic bacteria, viruses, parasites, etc

by microbial agents that can cause infectious diseases from the risks presented by chemicals that can cause a range of non-infectious diseases (see Table 9.1). Although often lumped together as "contamination", pathogens and potentially toxic chemicals come from different sources, behave differently in different environmental media, and require different control methods to mitigate adverse health effects. A key factor is separation of the two types of contaminant wastes – analytically as well as physically.

Many UA sites in Kampala, e.g. wetlands, dumpsites and roadsides, present a heightened risk of farm household and produce contamination. Hence the first study examined pathogenic hazards, the second, metals, and the third, complex organic compounds present at these sites.

Biological Hazards Associated with Crops Grown on Untreated Sewage-Watered Soils

Aim and Methods

Our aim was to measure the presence of selected bacterial and parasitic pathogens in sewage water and soils used for UA crops, as well as on the surfaces and in the tissues of crops themselves (Serani et al. 2008).

We took samples from three contaminated sites including the Nakivubo channel, where UA uses flood irrigation in the wet season and digging of canals in the dry season, and two uncontaminated sites on hilly areas not near any drains. The Nakivubo channel, built 50 years ago to carry storm water from the city into Lake Victoria, now receives a considerable quantity of partially treated and untreated industrial and domestic wastewater as sewage volumes have grown but wastewater treatment has not. The selected crops were tomato (a fruit), Doodo (or amaranth, a leafy vegetable) and cocoyam (a root crop).

In the laboratory, we analyzed for pathogens in water or soil and on and in the plant crops. These included the broad coliform group of bacteria found in the feces of warm-blooded animals (humans and livestock) and in soil, *fecal coliform* bacteria, found only in the former, and *Salmonella*. We could not analyze for viruses. We used both the flotation technique and centrifugal sedimentation examination to test for a range of parasites including: *Entamoeba histolytica* cysts responsible for amoebic dysentery, helminth eggs and roundworm larvae.

Findings

We found coliforms and *E. coli* in appreciable numbers in most samples from contaminated sites. Concentrations of fecal coliforms in water samples were much higher than World Health Organization guidelines for irrigation water. Coliform counts obtained from the analysis of plant parts also indicated fecal contamination. Tomato samples from one contaminated site had coliform contamination on the surface of the root and stem with internal contamination of tomatoes also seen, although at low levels.

Our detection of bacterial pathogens on the inside of tomatoes is consistent with other research showing human pathogens surviving in tomatoes and tomato products, both coliform (Zhuang et al. 1995; Zhuang & Beuchat 1996; Tsai & Ingham 1997) and *Salmonella* (Jablasone et al. 2004). Fecal *E. coli* was isolated both on the surface and to a limited extent on the inside of some plant tissues, including the popular cocoyam. One sample of the surface of the leaves of *Amaranthus* from a contaminated site was positive for *Salmonella*. Control sites that did not use wastewater were less contaminated with coliforms and *E. coli* compared to the sewage-contaminated sites.

Helminth eggs, amoebal cysts or larvae were not detected in any soil or crop samples. The three positive findings (out of nine samples) were all in wastewater from different sites: parasite eggs (6/ml), *Entamoeba hystolitica* cysts (24/ml) and parasite larvae (3/ml). In contrast, in Ghana, where use of chicken manure is common in urban farming, mean parasite egg levels of 1.1, 0.4 and 2.7 eggs per gram were isolated from lettuce, cabbage and spring onion, respectively (Amoah et al. 2006).

The World Health Organization (Keraita & Dreschel 2006) states that using excreta or wastewater in agriculture can result in a public health risk ONLY if ALL the following occur:

- An infective dose reaches a field or pond, or a smaller dose multiplies there;
- The infective dose reaches a human host;
- The host becomes infected;
- The infection causes disease or further transmission.

Kampala farmers handling raw sewage and children accompanying them are likely at greater health risk than consumers, because they handle soil and water directly, exposing them to infective doses. Kampala vegetable consumers who eat crops raw, e.g. tomatoes in salads, are also at risk of infection from bacteria inside the tissue of the vegetables, even though they may be able to remove bacteria on surfaces by scrubbing and disinfection. Vegetable crops that are cooked, e.g. cocoyam and amaranth leaves, should not pose such risks because bacteria should be killed with heating.

Heavy Metal Contamination of Vegetable Food Crops

Aim and Methods

Waste dumps and roadsides are common sites where poor households grow crops. Vehicle emissions are a major source of heavy metal contamination in urban areas, exposing human beings through inhalation and through ingestion of plants grown in affected soils. Lead (Pb), a neurotoxin particularly for children, is widely used in gasoline in Kampala; cadmium (Cd), a kidney toxin and carcinogen, is found in paints and motor vehicle batteries; and zinc (Zn), which is toxic to soils and plants at high concentrations, is a component of tires that is released as they wear. This research sought to measure these persistent heavy metal levels in soil from selected sites and rank vegetables and various plant parts according to metal uptake.

Soil samples from UA sites where municipal and other wastes were disposed of, including metal workshops, industries, sewage, a hospital, garages and scrap yards, as well as wastewater-irrigated wetlands, were analyzed for heavy metal content (cadmium, lead, zinc, copper and nickel) for comparison with international guidelines. Different plant parts were analyzed for heavy metal uptake.

Eleven sites along roads radiating from Kampala were also selected, based on the presence of UA, and traffic counts taken. Surface soil was taken at each site perpendicular to the road at 5 m intervals distance, using several locations at each distance and mixing them together to form an aggregate sample. The soil was air dried and passed through a 2 mm sieve to remove gravel and superfluous matter, care being taken to avoid other sources of contamination such as industrial or other waste or compost. Three samples of each selected crop, including one edible vegetable weed *Amaranthus dubius,* were taken from the roadside gardens, and bagged for laboratory examination. The soil and plant samples were analyzed for Pb, Cd and Zn using flame atomic absorption spectrophotometry (Perkin Elmer, Model 2380).

Findings

The study found elevated levels of Pb, Zn and Cd, particularly in leafy vegetables. While not all roadside sites had heavy metals above the recommended maximum levels in their soils, contamination of soils and *Amaranthus* leaves with Pb was clearly shown to be a function of traffic density. Nevertheless, all sites, including those with less traffic, had Pb levels above those recommended in vegetables for human consumption. Accumulation of Pb in soils above background levels took place up to a distance of 30 m. Lead concentrations were found to be highest in leaves, then in roots, next in fruits and lowest in seeds. Atmospheric deposition was found to be the dominant pathway for Pb reaching leafy vegetables, more than through soil up-take. Leafy vegetables were the most effective in accumulating Pb from the atmosphere (Nabulo et al. 2006).

Certain plants, such as the *Brassica oleraceae* acephala group, commonly known as *sukuma wiki*, were found to accumulate heavy metals (such as cadmium) more than others, while the outer leaves of cabbage had higher concentrations than the inner leaves. Washing was found to reduce Pb and Cd levels in many of the vegetables studied. Previous studies have found that heavy-metal levels in soil and vegetation decrease with increasing distance from the road that is the source of vehicle emissions. This study similarly found the lowest concentration of 28 mg/kg (ppm) of Pb was at 30 m away from the road edge, allowing the growing of leafy vegetables with relatively lower health risk (Nabulo et al. 2006).

Risk Assessment for Children Exposed to Incomplete Combustion Products

Aim and Methods

Children experience higher relative exposures to contaminants because they consume more food and liquid and breathe more air in proportion to their body weight than adults. Further, their less-developed metabolic pathways hinder their ability to metabolize, detoxify and excrete toxicants. Children also have longer to develop diseases triggered by exposure to toxic contaminants early in life (Suk et al. 2003) and early life exposures are more likely to perturb sensitive ontogenetic processes.

Polycyclic aromatic hydrocarbons (PAHs) are semi-volatile, persistent organic pollutants emitted through incomplete combustion of organic matter such as gasoline, wood, coal or oil for domestic use and industrial power generation, with smaller amounts coming from printing industries and barbequed foods. Domestic cooking is a major source of PAH in dense urban areas of lower-income countries. Approximately 95 percent of Ugandans use wood or other biomass as their primary domestic energy source. Vehicle emissions are also important contributors. This research sought to measure PAHs on surfaces, to estimate children's exposure via air, soil, water and food, and to scope potential health risks attributable to PAHs among UA households (Yamamoto 2005).

We first assessed the concentrations and spatial patterns of five PAHs in surface soils and atmospherically derived surface films: phenanthrene (PHE), anthracene (ANT), fluoranthene (FLA), pyrene (PYR) and indeno[*1,2,3-cd*]pyrene (ICDP). Samples were collected from 10 households engaged in UA that had already participated in the earlier nutrition study. The households, from different areas of Kampala, with a range of high to low traffic, industrial and population densities, also provided information about agricultural activities, smoking habits, fuel used, kitchen location and the time children in the household spent indoors and outdoors.

These data and those from the literature were then used in a risk assessment to quantify the pathways of PAH exposure and to estimate likely health impacts among children aged 2–5, using the Multimedia Urban Risk Model (MUM-Risk) designed by Diamond and co-workers at the University of Toronto and modified into the MUM-FAMrisk model (Multimedia Urban Model, Family Risk) also used in Toronto by researcher Heather Jones-Otazo (2004). The most sensitive health endpoint for three PAH contaminants, anthracene (ANT), fluoranthene (FLA) and pyrene (PYR), were chosen from the five measured, based on levels detected, potential health effects, and availability of reference dose data. Hazard quotients were calculated and comparisons made to established risk levels.

Findings

PAHs were found in most surface and soil samples and ingestion was found to be the most important pathway of exposure to PAHs, consistent with findings in other cities. Overall, the most urban areas tended to have the highest total estimated daily intake (EDI) for all compounds and one peri-urban area was consistently the lowest. The dominant risk pathways for anthracene were the ingestion of below-ground vegetables and the inhalation of indoor and outdoor air for all age groups and both sexes. For pyrene the dominant pathways were ingestion of below-ground vegetables and cereals and grains and for fluoranthene, the ingestion of fish and shellfish.

We found that all the hazard indices (HI) fell below the conservative action level chosen for MUM-FAM risk for the compounds studied, as well as the levels set by the U.S. EPA and European Commission (2002). This suggests their contribution to nose, throat and lung irritation, increased carboxylesterase activity and the decreased ability to fight diseases, as well as kidney problems among children in Kampala, should be small. But if they are considered as part of complex mixtures including other PAHs and organic compounds, there could be additive effects of multiple exposures resulting in the action levels being exceeded. There are a number of things that should be noted as cautions when dealing with risk assessments in general. Risk-assessment models involve numerous assumptions that provide conservative estimates of the hazards posed by exposure to certain chemicals and the data used can be associated with a high level of uncertainty (Vostal 1994). For this study in particular, it is hard to tell if our findings are conclusive given the small subset of PAH compounds which we were able to test. Regardless of our findings, we suggest that policy-makers need to consider biomass burning and vehicle emissions as important sources of pollution in Kampala.

Managing Urban Livestock for Health

Nature of Inquiry

We engaged in a multifaceted examination of livestock related practices, potential health risks and current mitigation strategies among households keeping cattle and chickens, the two most common types of livestock in Kampala. For both types we purposively selected 10 of Kampala's 98 parishes, to give a range of urban and peri-urban livestock-keeping conditions.

Dairying

Methods

Preliminary focus group discussions (FGDs) were held with, on average, seven livestock-keeping households per parish. A household sample of 150 cattle keepers was then selected based on information gathered, and 50 neighbouring households not keeping cattle were also selected for comparison. The cattle keepers reported the age, sex and breed details of 713 bovines they kept, including 357 adult cows. Biological testing for four health hazards was done using blood and milk samples from sample cows from each household:

- *Brucella abortus* in milk, the cause of undulant fever in humans;
- Total bacteria in milk, a rough indicator of milk hygiene and cow health;
- *E. coli* O157:H7, a cause of gastro-intestinal disease and sometimes of kidney disease and blood disorders;
- Anti-microbial residues in milk, which may disrupt normal gut bacterial function that acts as a barrier to infection and may occasionally cause allergic reaction in susceptible people.

Findings

In Kampala, both rich and poor urban households kept an average of four cattle, most confined in stables and brought fodder crops, household waste and concentrates, although some were tethered or graze on vacant land and roadsides. We roughly estimate there were anywhere from 50 000 to 168 000 cattle in Kampala at the time of our surveys in 2003–2004, supporting Muwanga's similarly rough estimate of about 74 000 in 2001 (Muwanga 2001), of which 73 percent were high-yielding cattle. Agriculture was the main occupation for most cattle keepers (64 percent) and over a third of participants said keeping cattle was their main occupation (consistent with findings from Nakuru in Chapters 11 and 12). Only 13 percent of our respondents were in waged employment, with employment stated as an important subsidiary benefit of urban dairying. Still, income from cattle made up less than a quarter of total household income for half the respondents, while only 15 percent obtained more than half their income from dairying, indicating a diversified portfolio of livelihood strategies.

Milk was stated to be by far the most important benefit of dairying, with manure, sale of cattle and employment occupying subsidiary roles. Dairy cows were mostly milked by hand twice a day, giving an average milk yield of 10 l per cow per day, compared to 1–2 l per day reported for indigenous African cattle. Milk and dairy products are important sources of protein and micronutrients, some of which are found only in animal products. Milk consumption in Uganda has doubled in the last decade to around 30 l (or kilograms) per capita annually (40 l in urban areas).

Milk samples from the surveyed households indicated the cows had been exposed to brucella (*Brucella abortus*) by infection or vaccination (though we did not test directly for Brucella organisms), indicating it is likely common among cattle. Some of our milk samples also had unacceptably high levels of bacterial contamination (as defined by the East African community standards), which could be due to poor milk hygiene, mastitis (inflammation of the udder) or other factors. Of the 165 samples examined for *E. coli* O157:H7, 18 out of 69 isolates were suspect when cultured, but only two of these were serologically confirmed as positive. In the absence of information about the most important exposure routes, it is difficult to estimate globally the risk of *E. coli* O157:H7 infection from dairy cattle; but given the seriousness of the disease, it certainly warrants further investigation. Other studies in Kenya and Uganda have indicated unacceptably high bacterial counts in formal sector pasteurized milk as well, with smallholder milk comparing favourably in terms of compliance with standards (Lukwago 1999; Omore et al. 2005).

A total of 165 milk samples were tested for presence of some broad-spectrum anti-microbials in milk and 14 percent tested positive for residues above the recommended maximum residue limits. Milk samples positive for residues were re-tested for beta-lactam drugs (popular antibiotics related to penicillin) and 13 percent were positive at levels above maximum residual limits.

We then developed a pathway model describing the movement of milk from the cow to the consumer and identified critical control points where interventions may prevent or eliminate a food safety hazard or reduce it to an acceptable level (FAO and WHO 2001):

1. Contact between cow and hazards in the environment;
2. Contamination of milking shed with cow excreta and secretions;
3. Contact between milk and containers or the environment;
4. Handling of milk by processors;
5. Storage and transport;
6. Practices of food processing pre-consumption.

The average of 17 risk-mitigation strategies on the pathway from stable to table showed a rich variety of farmer and consumer risk-management strategies in place (see Table 9.2). Some of these strategies are completely effective, such as boiling milk for managing risk from *B. abortus* (this is also widespread as 93 percent of consumers boil their milk) or observing milk withdrawal for managing risk from antibiotic residues, while others reduce but do not eliminate specific risks, such as keeping only one type of livestock or selling milk within six hours of milking.

We then used a linear regression model to investigate what influenced farmers to practice risk mitigation strategies. Access to services, belief that UA was legal, and a wealth and productivity orientation were associated with higher use of mitigation strategies, while those reporting cattle disease incidence had lower use of mitigation strategies. Clearly access to services (water and electricity) makes the use of

Table 9.2 Critical control points and actors carrying out mitigation strategies (%) at each step on the pathway from stable to table

1. Mitigate exposure of cow to environmental hazards	
Keep only one type livestock	29%
Zero-graze	38
Cut and carry from own land only	41
Avoid common grazing	56
Treat cattle often (last 3 wks)	31
No calves on farm	39
Artificial insemination	44
Vaccinate against brucellosis	1
Keep local breeds	27

2. Mitigate milk shed contamination	
Feed/water trough present	94
Concrete/stone floor	96
Waste disposal strategy	96
Use bedding	41
Stack manure	11

3. Mitigate environmental milk contamination	
Hard/washable wall to shed	100%
Metal/timber roof	96
Store containers off the floor	29
Keep milk bar dry	45
Use just metal/glass containers	19
Use piped water	75
Good hygiene of premises	51
Dispose waste >5m away from dairy	38

4. Mitigate contamination of milk by personnel	
Use hot water in cleaning	18
Use soap in cleaning	81
Protective clothing	1
Wash hands with soap before handling milk	59
Good personal hygiene	49
No discharges or wounds in those selling milk	97
Hands clean	79
Nails clean/ short	81
Latrine available	98

5. Mitigate growth during storage/transport	
Refrain from consuming unsold milk	10 %
Refrain from storing and selling unsold milk	90
Treatment of milk by vendor	50
Sell milk quickly (<=6 hs)	82

6. Consumer risk mitigation	
Avoid drinking raw milk	93
Check milk quality with visual/olfactory test	48
Don't consume milk until withdrawal period passed	64

hygiene-related mitigation measures easier, while farmers may invest more in risk mitigation when they feel more secure through believing their activities are legal. Wealth, measured by a proxy index, makes it easier to invest in resources for better hygiene, suggesting special supports may be needed for lower-income producers. Farmers producing greater quantities of milk more intensively showed an increased likelihood of using mitigation strategies, probably both because these farmers were better skilled and because intensively kept animals, being more vulnerable to disease, require increased care. It may seem paradoxical that farmers reporting more cattle disease were less likely to use mitigation strategies, but the lack of resources to do anything about the risk can create a feeling of helplessness, resulting in more cattle disease.

Chicken Rearing

Methods

Focus group discussions in each parish were followed by selection of a sample of 142 households rearing chickens for sale and 50 neighbouring non-chicken-rearing households. The latter underwent questionnaire-based interviews about practices and potential health effects.

Findings

As in many other towns and cities in Sub-Saharan Africa, chicken rearing was the most common form of livestock production (Chapters 4, 6, 11, and 12). Past work found that urban poultry producers met 70 percent of the city's needs (Maxwell 1994). Women played a central role in our research, attending and contributing to FGDs and being the primary respondents in both chicken-rearing and non-chicken-rearing households. Generally they were the primary caretakers of the chickens, mostly self-taught or guided by friends or relatives. Only 14 percent were taught how to raise chickens in a rural area, and interestingly 42 percent had received some form of training or upgraded their management skills after they began raising chickens.

Chicken-rearing households were mainly high and middle income (66 percent), reflecting our focus on commercial farmers. Their non-chicken-rearing neighbours were mostly middle income as well (84 percent). It has been observed that urban livestock keeping is a response of middle-income households to growing urban demand and markets (Guendel & Richards 2003). Chicken production accounted for 38 percent of all household income, with more revenue (62 percent) coming from other business or employment. The sale of broilers brought the most income (40 percent of the chicken-rearing household income), eggs brought 34 percent and the sale of off-layers, local chickens and manure lesser amounts. Income generation was the primary reason for chicken rearing (92 percent), with half the households (52 percent) also stating it was to provide additional food and 38 percent stating that it was also to provide a source of manure. About half the chicken manure was used to fertilize household crops, 14 percent was sold and the rest thrown on waste dumps.

The typical input and marketing structures emerging from our study are shown in Fig. 9.2.

Most households raised exotic layers and broilers as well as local indigenous chickens and some raised other livestock such as cattle (24 percent), pigs (21 percent) and goats (19 percent) in addition to the chickens. Fifteen percent of rearing households said that chickens interacted with other livestock including contact with neighbouring chickens, household and neighbouring cattle, pigs, turkeys and goats. Local free-range chickens were usually kept for household consumption and exotic chickens (usually housed and fed concentrates) for commercial purposes. Almost all broilers and layers (97–100 percent) were housed (Dimoulas et al. 2008).

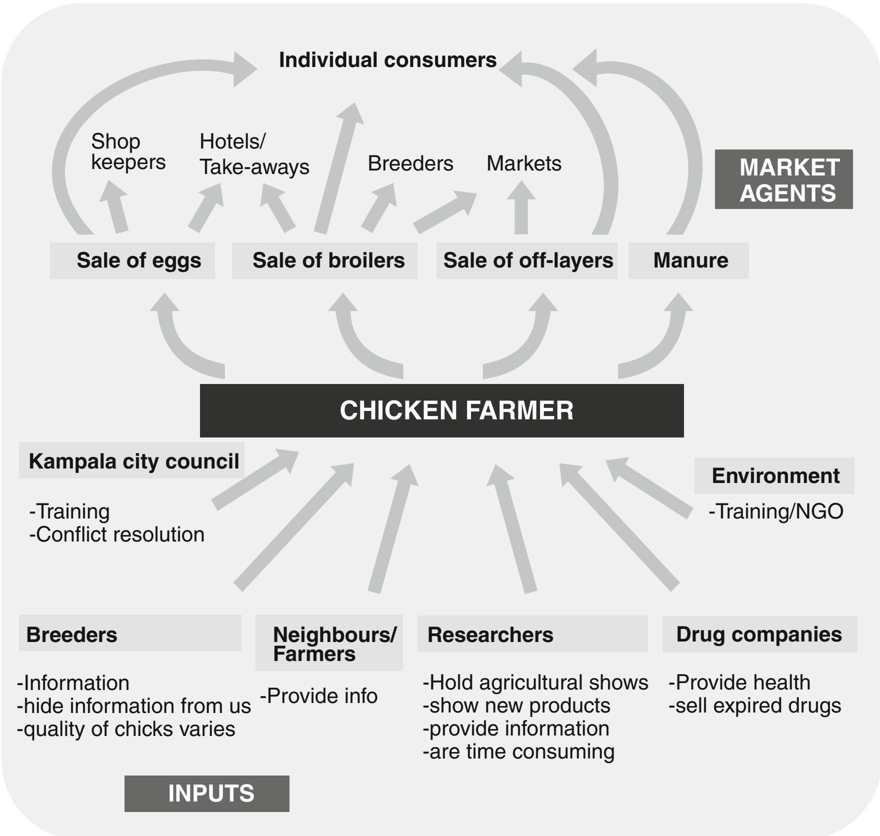

Fig. 9.2 Farm inputs and marketing pathways of chicken producers in Buziga parish, Kampala (based on focus group discussions)

Seventy percent of non-chicken-rearing households said that they benefited from farmers raising chickens in Kampala, allowing for easy access to chicken meat or eggs and manure for their gardens, although 40 percent also complained of conflict with neighbours and smell. Other benefits noted included development of the area, especially improved transport routes, and as one person said, “Friendship is formed because chickens scavenge on my land”.

Nearly two-thirds of chicken keepers had bird that died within the 30 days prior to interview and 39 percent of them did not know why they died. The chicken carcasses were either disposed off in the garbage (37 percent), buried (33 percent) or their remains used as feed for other household animals (21 percent). About half of both types of household were aware that chickens could transmit influenza-like diseases directly to humans. Fewer chicken-rearing households (40 percent) and non-chicken-rearing households (28 percent) were aware that humans could acquire diseases from eating chicken meat or egg. Only 8 percent believed that chickens could be a cause of diarrhoea in people and only 4 percent of chicken-rearing households thought that consuming infected chicken meat or eggs could cause diarrhoea. One respondent did say, “When one eats raw eggs or dead birds where the cause of death is unknown, one is bound to get an infection”. Another commented that her household does not share living quarters with chickens and they do not eat dead chickens or those being treated for disease, to reduce health risks. Non-chicken-rearing households expressed the following sentiments: “I try as much as possible to avoid those (chicken-rearing) houses” and “I advise farmers on proper garbage disposal”.

Within chicken-rearing households, 13 percent of respondents claimed that household members had at one time or another suffered from a disease or illness due to their involvement in raising chickens. When asked if diseases acquired from chickens had any negative impact on household members’ health, around a quarter of both chicken-rearing and non-chicken-rearing households thought they did, while around one-third were unsure.

Household members always washed before preparing meals in 84 percent of non-chicken-rearing households and in 96 percent of chicken-rearing households.

In the 2 weeks preceding the survey cooked eggs were eaten more often than chicken, which was eaten by over half the households. Interestingly, a number of respondents said they ate raw eggs for medicinal (67 percent) and nutritional purposes (25 percent). The practice was more common among the neighbours than the chicken keepers themselves (16 compared to 9 percent). Anecdotal information suggests that raw eggs are used in the region as a home treatment given to children with respiratory health conditions (as one respondent remarked) and are also used after excessive alcohol consumption (Nasinyama 1996).

Around half the neighbouring households bought their eggs and chicken from the local market and somewhat fewer bought directly from chicken farmers. Non-chicken-rearing households tended to consume fewer leftover eggs (5 percent) and more leftover chicken (69 percent) than chicken-rearing households. Beef and fish were more popular foods in both types of household, both having been eaten by over 70 percent in the 2 weeks prior to the interview, more often by the non-chicken keepers (90 percent).

Overall we found that enteric illness was associated with consumption of left-overs and raw eggs, as in earlier work in Kampala (Nasinyama et al. 2000), and with the interaction of chickens with other livestock. Consumption of animal-sourced foods, including chicken, was associated with less enteric illness. Zinc, an essential mineral found in beef and chicken meat, has been shown to affect human resistance to infections (Black & Sazawal 2001; Bhan et al. 1996; Bhutta et al. 1999). Eating beef and local chicken in the 2 weeks preceding the survey was consistently found to be protective for enteric illness. It can be hypothesized that local (free range) chickens consume higher levels of zinc from soils. These findings may contribute to curbing general fears of zoonotic disease acquisition relating to chicken production in Kampala but continuing epidemiological studies, combined with appropriate diagnostic assessments, are needed to further assess which production practices can reduce health risks and so be incorporated into guidance provided by those assisting urban livestock producers.

Integrating Findings into Policy and Practice

Here we summarize what has taken place so far in Kampala in the process of evidence gathering and its translation into public health and policy messages. It is important to stress that findings from elsewhere have also played a part.

In 2004 the committee overseeing the research described in this chapter transformed itself into a policy advisory body, the Kampala Urban Food Security, Agriculture and Livestock Coordinating Committee (KUFSALCC), aimed at formulating policy guidelines and public health messages based on research. At the same time, Kampala City Council (KCC), a member of KUFSALCC, led a review of legislation governing UA, for which it received inputs from the researchers. As a result, new bylaws on urban agriculture, livestock, milk, meat and fish production, processing and marketing, were passed by the City Council and gazetted in 2006. The new research and policy body continued to monitor implementation of the bylaws in collaboration with KCC (Hooton et al. 2007) and later projects in the city have also made use of the findings.

In the companion book to this one, published a little earlier (Cole et al. 2008), the findings of the studies summarized in this chapter have been reviewed and translated into policy and public health guidelines. This involved examining the research results in the light of other evidence and policy-relevant materials including the literature on urban governance and international legislation on human rights. Based on an expert panel review, the outcome sets some policy parameters and directions. It is not the last word on the subject, and directions for future research – meaning the questions still to be answered and the methods of finding those answers – are also outlined. Here we present a few of the main points emerging.

Guidelines on Promoting Food Security and Nutrition from UA

Household food security and, thus, child nutrition security, depends largely on wealth, but urban farming moderates this relationship through other household assets including the availability of land and its size, presence of livestock keeping, and household members' education, particularly that of the primary caregiver, who is almost always a woman. Because of international legislation on the Right to Food, it is wrong for national and local governments (or anyone else) to prevent people with insufficient wealth from producing food needed for their survival. This is often the case with urban agriculture, which can be an important strategy in alleviating hunger and poverty and improving the lives of slum-dwellers (three of the Millennium Development Goals). In fact, governments can help people meet these goals by supporting UA, including promoting increased consumption of animal-sourced foods through urban livestock keeping. Greater education of farming households, particularly women, may increase the benefits for household food security.

To increase the benefits of UA, our studies suggest that further research is needed on the complex interactions of gender with other variables for their impact on household food security and child nutrition, as well as on the potential for different UA practices to contribute to the alleviation of major child health challenges, including vitamin A deficiency and anaemia. Better measures of household food security and more extensive research on its relationship to UA are needed.

Guidelines on Reducing Contamination of UA Crops

The Right to Food and the Right to Health have to be balanced by policies addressing contamination of food produced by UA. Frequently both biological and chemical hazards exist and the two types have to be treated distinctly in policy, regulation and management.

Kampala is probably typical in having high levels of *biological* contamination in water and soils used for crop production, meaning improved sanitation is a high policy priority. Meanwhile, the following public health messages need to be shared and actions need to be taken around biological contaminants, especially since farmers are aware of the high value of nutrients for improved crop production using wastewater:

- Direct contact with contaminated water presents a health risk to farmers and to children accompanying them, and protective clothing needs to be worn, especially boots;
- Crops normally processed by heat or drying before human consumption (grains, yams, oilseeds, sugar beet) are recommended for growing in contaminated areas because any biological contamination would be killed by prolonged cooking;
- Growing crops that may be eaten raw, like tomatoes, lettuce, cabbages and onions, should be avoided in sewage-watered areas;
- A common pathway of food contamination with pathogenic microorganisms is the use of contaminated water to "refresh" market produce, and the provision of clean water in markets or where this process occurs may be a critical factor in preventing pathogenic contamination of food;

- Cooking of vegetables that were grown using pathogen-contaminated water should destroy most bacteria and the majority of parasite larvae, making them relatively safe to eat. Alternatively, the public should treat produce with blanching or disinfection with bleach, vinegar or sufficiently high salt concentrations to reduce bacterial loads.

Chemical contaminants present a potential health risk through various pathways associated with UA in Kampala and, again, these are not untypical. A policy priority is to regulate and prevent to the extent possible the discharge of potentially harmful quantities of heavy metals and combustion by-products into air, soil and water. Throwing batteries into pit latrines is a widespread practice that may contaminate the water table and which can be curtailed through public information. Regulation of vehicle emissions and the introduction of unleaded fuel are recommended as part of a long-term solution. Discharge of chemicals into wastewater and solid waste, where their treatment only deals with biological contaminants, must be curtailed, as these are likely to enter the food chain through re-use in agriculture. In Kampala, work on public and policy awareness has already begun, through conferences, workshops and meetings with various stakeholders including industrialists, government officials, policy-makers and farmers, and some provisions were included in the UA Ordinances and Guidelines passed by KCC in 2004.

Leafy vegetables are the most susceptible to absorption of lead (Pb) from the atmosphere and should not be grown within a 30 m distance from the edge of the road, regardless of traffic density. Some indigenous leafy vegetables are, however, safer than *brassicas,* including the popular kale or *sukuma wiki*. Crops recommended for roadside farming include those where the edible part is protected from aerial deposition, such as root crops like sweetpotato and cassava, coarse grains like corn, and legumes like pulses, beans and peas. Those vegetables that bio-accumulate heavy metals in their skins or pods, such as tubers and beans, should be peeled or the pods discarded. All vegetables should be washed thoroughly in clean water before consumption as washing was found to reduce the lead and cadmium content on the surface of many of them. Soapy water should also remove some combustion by-products from vegetable surfaces.

Further research is needed to improve and quantify risk assessments of neurotoxic and other health outcomes among children, and to assess the risks of exposure to mixtures of various organic compounds.

Guidelines for Managing Healthy Urban Livestock

Although a formal risk assessment was not carried out, our study of urban dairying and chicken raising identified current risk-mitigation practices by farm households which can be supported and improved upon. This is particularly important because of the benefits that we found to households consuming animal-sourced foods, as well as the primacy of the Right to Food. Providing infrastructure and legitimizing urban agriculture may be effective strategies for improving practices and decreasing risks. However, poorer farmers and those using less-intensive farming methods will need special support to improve their practices. Adoption of risk mitigation varied from farm to farm, suggesting a role for farmer-to-farmer extension. Livestock farmers did not appear to implement specific disease-mitigation strategies with a clear understanding of disease risk and pathways of transmission. It is suggested that public health messages be broadcast emphasizing the common pathways of disease transmission from animals to humans, and how to mitigate the risks. For example:

- Boil milk (including as tea) to destroy pathogens and protect health;
- Do not use raw eggs as a medication or as infant food because they may carry pathogens;
- Fresh human and animal feces carry microorganisms that can transmit disease. Keep hands, home and livestock sheds clean;
- Avoid cross-contamination of disease in different types of livestock by keeping them from interacting;
- Do not feed your livestock with damp or stale feed or supplements. Avoid feed being sold off cheaply from unknown sources;
- Store food in refrigerators or closed containers to protect from pathogenic organisms;
- Avoid cross-contamination from manure to milk. Avoid handling manure without protective gloves and clothing and keep these clean and away from milk, food and drinking water;
- Wash hands, cows' udders and milking utensils with detergent and warm water before milking;
- Avoid traditionally fermented milk and cheese produced from non-boiled milk;
- Keep sufficient distance between residence and livestock sheds (preferred < 10 m);
- Use protection when handling aborted foetuses (e.g. gloves).

Considering strong local preference for free-range chicken consumption and its potential association with health protection, further systematic research is needed to establish actual risks and benefits to public health.

Conclusion

Because of its history and circumstances, Kampala more than many other cities has developed a particularly strong relationship to UA. It is one of the few urban local governments with a whole department dealing with agriculture, and it is almost certainly the only one anywhere in the world that has developed a typology of urban and peri-urban farming systems to apply to what goes on within its boundaries (see Chapter 6 above). While many of its circumstances – favourable agro-climatic conditions and a surviving culture of farming-based kingdoms – differ from those of other towns and cities, there is no doubt that there are useful lessons that can be drawn from its experience in developing an evidence-based approach to managing urban agriculture.

These lessons are about both process and substance. Regarding substance, Chapter 6 has demonstrated that as Kampala expands with a high rate of urban growth, the proportion of the urban population farming (and, as a result, the absolute numbers) appears to grow also. This dynamic may have as much to do with the relationship between low levels of employment and corresponding poverty levels as it has to do with agro-climatic conditions. We suggest that growing cities in dryland climates – Khartoum is an obvious example – may also have high proportions of their populations engaging in crop and livestock farming. Given the corresponding lack of urban infrastructure, gender inequalities and divisions of labour and other similar conditions, then many of the lessons learned in Kampala may be transferable.

Regarding process, the social learning and institution-building that continues to take place in Kampala does not have to be started from scratch in every other town and city government but could usefully be copied with adaptations, as is already happening in Nakuru, Kenya, as described below in this book. Nakuru has adapted one particular aspect – legislative review – in which it was already engaged. It simply examined and modified some parts of the Kampala model.

As public health practitioners and researchers, and as the Kampala and Toronto co-leaders of the health work from 2002 to 2005, we feel strongly that UA can play an important role as a determinant of health, and that urban farmers and municipal policy-makers can make a difference in improving the health of urban populations. We suggest that some of the lessons we learned in this process may well be appropriate for use and adaptation in other places.

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