

Healthy city harvests: Generating evidence to guide policy on urban agriculture

Editors: Donald Cole • Diana Lee-Smith • George Nasinyama



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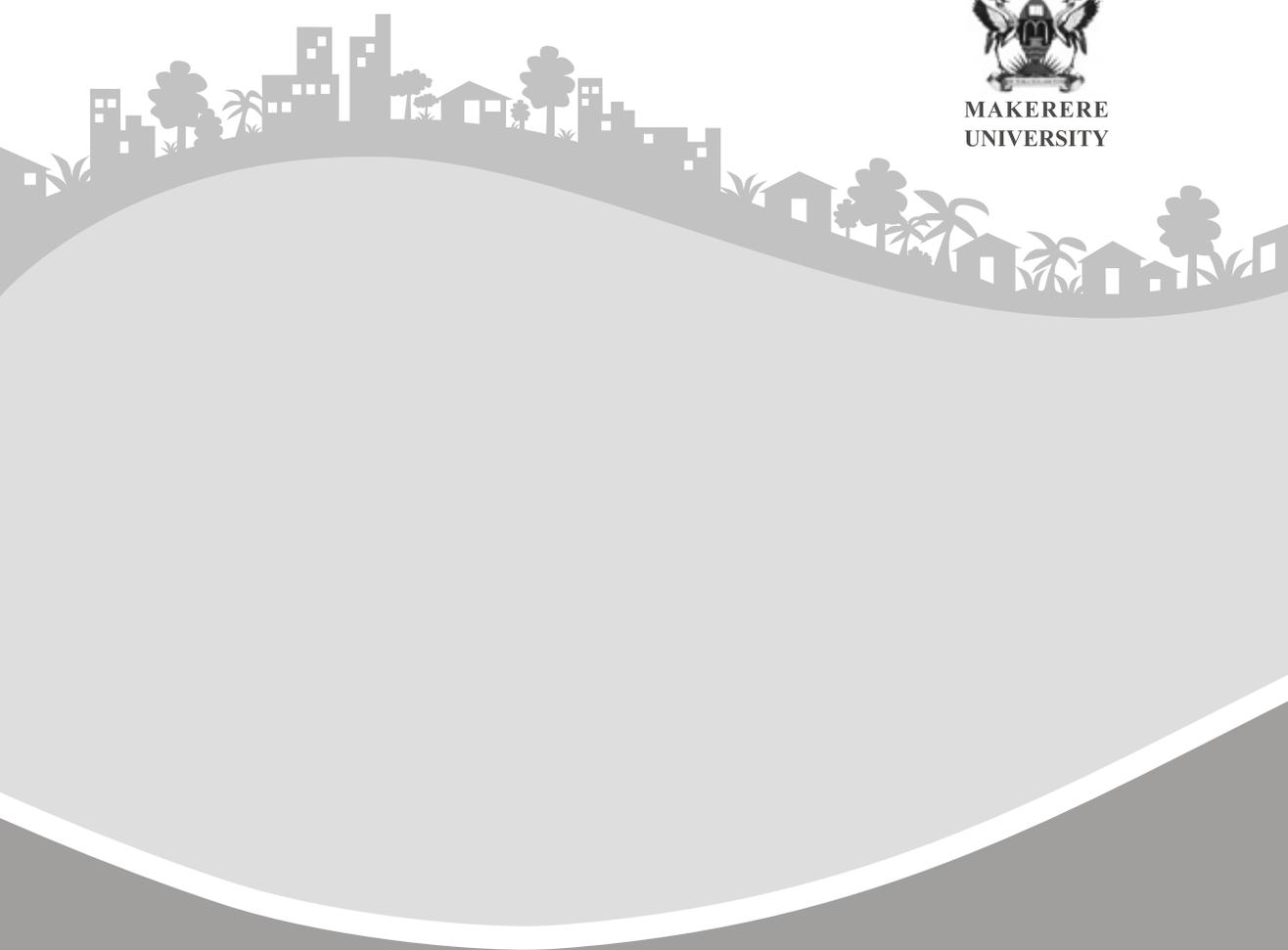
Editors: Donald **Cole** • Diana **Lee-Smith** • George **Nasinyama**



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Healthy city harvests:**Generating evidence to guide policy on urban agriculture**

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Foreword

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Centre for Urban and Community Studies,
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The subject of this book has been an important one to many of us – both researchers and policy-makers – for many years now. It has been important since so many urban residents, both in developed, and developing countries, have been raising animals and cultivating fruits and vegetables to enhance their incomes and to improve their families' food security. These activities, invisible to many, have at best been defined as "illegal" or a "concern", even though they are widely practiced. But in very recent months, just preceding the completion of the book, the issue of urban food supply has become a matter of extreme apprehension and even alarm. Why? Note the following, typical headlines over the last six months: "Forget oil, the new global crisis is food"; "Soaring food prices threaten stability"; "Fear of rice riots as surge in demand hits nations across the Far East"; and "World in grip of food crisis". Clearly, what was already a tight situation for millions of the urban poor in cities across the world – but particularly in the poorest developing countries – has become even more widespread and desperate. Urban food supplies are not only an important and central policy issue, but in some countries they are *the* central policy issue.

At this writing I do not have any special insight into what will be the outcome of the current spiral of tight food supplies and dramatically higher prices for staple commodities. Because of high energy prices and very inelastic wages and incomes for the majority of the world's poor urban dwellers, the results cannot be positive. But what this emerging situation serves to underline, ever more dramatically over time, is the great importance of finding ways and means for urban dwellers to cultivate and produce even more of the food they need for subsistence, and for their local governments to support them in this effort. I say "local governments" because – although other levels of government such as the provincial/state and national levels are undoubtedly very important – it is at the local level that regulations and bye-laws are most often passed which apply in the most direct fashion to the cultivation and use of land for agricultural purposes. All over the world, local governments have been given

much of the power to regulate land use in cities and towns, even if their regulations can be overlaid by legislation at other levels, and even if their ability to actually enforce their own regulations and bye-laws is sporadic at best and often arbitrary in its execution.

From the perspective of local governments, this is one of the first books which explores, in a truly multidisciplinary fashion, the complex range of issues which both help explain why urban agriculture takes place, and looks carefully at the important obstacles to its effective uptake in a particular local context. From different professional viewpoints we learn about health benefits of urban farming for children's nutritional status, about health risks from heavy metal and organic contaminants in food and about the proper management of urban livestock to reduce risk. We also learn about the history of public health efforts to control illness and disease in 19th century Europe and America, as a backdrop to the construction of colonial building and public health regulations that were commonplace in African cities by the 1940s. But as restrictive as these regulations were, they became even tighter and more aggressively defended in the post-colonial period, particularly with respect to the informal sector and the pursuit of agriculture in large metropolitan areas. Elsewhere I have written about the quasi-permanent "state of war" between municipal authorities and informal sector hawkers (many of whom are women selling food they have either produced or purchased in the city). Urban agriculture has often been a victim of this war, but the losers are not only the poor producers (mostly women, at least in East Africa), but also the majority of the population – since in many cities, the majority of the population are living close to pure subsistence levels.

Luckily, there is a ray of light in this otherwise dreary account. We can applaud the dedication of those who have lobbied for a more flexible and supportive approach to what should be considered (in most respects) a positive, rather than an illegitimate and unacceptable practice. And partly as a result of their dedication, we have the story in this book of how, based on past research and advocacy and on the more recent influence of the CGIAR's Urban Harvest program, the Kampala City Council had the wisdom to pass a series of Ordinances defining the conditions under which urban agriculture can, henceforth, be carried out in the municipal area. To the best of my knowledge, this is the first time a serious legislative reform has been developed to support urban agriculture. One hopes other cities, facing many of the same problems, will also see the light. The researchers who grace the pages of this book have helped us to see the invisible, and to see it in a realistic, but positive fashion.

Toronto, June 2008

Acknowledgments

Producing this book involved an enormous number of people and institutions worldwide. Apart from the research that took place in the years 2002-2005, production of the manuscript that compiles the research took the same length of time, from 2005-2008.

The original research grant on health impact assessment of urban agriculture in Kampala came from the Canadian International Development Agency (CIDA) through its Linkage Fund with the CGIAR – the Consultative Group on International Agricultural Research, a global partnership of governments, multilateral organizations and private foundations that works to promote food security, poverty eradication and the sound management of natural resources in the developing world. The grant was awarded to Urban Harvest, a System-Wide Initiative of the CGIAR on Urban and Peri-Urban Agriculture (originally know as SIUPA), in partnership with the University of Toronto’s Department of Public Health Sciences.

The institutional home of Urban Harvest is CIP – the International Potato Center – one of the fifteen international agricultural research centers supported by the CGIAR, located in Lima, Peru. CIP, the Department of Public Health Sciences at the University of Toronto and the Department of Veterinary Public Health and Preventive Medicine at Makerere University, provided assistance without which the book could not have come about. CIP provided financial resources and all three provided space and staff time.

The partnership approach fostered by the CIDA-Linkage grant and by Urban Harvest itself drew numerous others into the research. Several institutions, both academic and non-academic, took part in the project from the Canadian side. They included the Department of Public Health Sciences, the Centre for International Health (CIH), the Institute for Environmental Sciences (IES) and the Centre for Urban and Community Studies (CUCS) of the University of Toronto, in addition to Ryerson University and the University of Guelph. Additional funds were raised from the International Development Research Centre (IDRC) to support both Canadian and Ugandan graduate students working on component studies. A total of four

Agropolis awards were made to studies that appear in Chapters 5, 6, 7 and 9 of the book, while the research in Chapter 11 benefited from a grant from IDRC's East and Southern Africa Regional Office in Nairobi and a special award of World Bank funds managed by Urban Harvest.

On the Ugandan side, a steering committee structure was established to manage the Health and Urban Agriculture project. This structure, whose story is told in Chapter 12 of the book, formed a nexus for building and consolidating partnerships, energizing research-to-policy linkages, raising additional resources, and eventually building a formal organization, the Kampala Urban Food Security, Agriculture and Livestock Coordinating Committee (KUFSALCC) for addressing all aspects of urban agriculture in the city of Kampala in collaboration with Kampala City Council (KCC). The physical space provided by the Department of Veterinary Public Health and Preventive Medicine at Makerere University became the base for the research and a resource center on urban agriculture (UA). It was the location of workshops for both the health impacts assessment project and the complementary "Strengthening UA in Kampala" project led by the CGIAR-supported International Center for Tropical Agriculture (CIAT). Towards the end of that project in early 2004, the Health and UA Committee exhibited considerable leadership in drawing together the different strands of research into a coherent plan for follow-up activities on UA in Kampala in general.

Additional support for both research and policy-related work on urban agriculture and health issues in Kampala was provided by the World Bank, through its support to Urban Harvest and the Livestock Production Programme of the Department for International Development (DfID-LPP) in UK. This made possible the livestock research described in Chapters 10 and 11 of the book and the participatory process of revision of the City Ordinances governing urban agriculture in Kampala, described in Chapter 12.

The role of the Kampala City Council, its officers and elected representatives, in engaging with issues of urban agriculture research and legal change – the first example in Uganda of fulfilling the potential of the Ugandan Constitution for participatory law review – is inestimable. Only time will tell if this really has an impact on hunger and poverty in Kampala, a question the book attempts to tease out.

In addition to the pioneering work on urban agriculture in Kampala that went before this book, for which particular mention must be made of Margaret Azuba of Kampala City Council, Maria Kaweesa and Environmental Alert, Daniel Maxwell, Gertrude Atukunda and John Musisi Muwanga, the contribution of Winnie Makumbi deserves special mention. As an elected Councilor in Kampala she played a pivotal role not only in the research, by taking part in the project committee and getting out in the field to learn from her constituents, but also in moving forward the legal review as an expert politician. Her untimely death at a young age, early in 2008, was a sad loss to good urban governance in Kampala and in Africa. This book is dedicated to her memory.

Producing the research outputs and outcomes could not have been possible without the supportive collaboration of the residents of Kampala, both farmers and non-farmers, men, women and children, who gave not only consent to be researched, but also their time and enthusiasm. They live in many of the 98 parishes of Kampala City. It is hoped that, ultimately, the recommendations they asked for on how to farm better, and a supportive/better environment in the city for urban agriculture, will emerge from this collective endeavor. Apart from the names of those appearing as authors of book chapters, the collaborators, researchers and research assistants involved in generating the data are truly too numerous to mention, but some are listed here.

In relation to research reported in Chapters 5 and 6, the authors would like to thank three excellent research assistants: Mr. Lukwago Fred Brany, Ms. Turyashemererwa Florence Mary and Mr. Richard Kajura. Thanks also to Ms. Lilisha Burris who assisted in entering the questionnaire data. Support from Makerere University in Kampala was greatly appreciated. We thank Professor George Nasinyama and the Department of Veterinary Medicine, other members of the Kampala Urban Food Security, Agriculture and Livestock Coordinating Committee (KUFALCC) as well as Dr. Joyce Kikafunda and the Department of Food Science and Technology. On-going assistance and expertise from Diana Lee-Smith, Gordon Prain and Regina Kapinga of the International Potato Center (CIP) was also very much valued.

The authors of Chapter 7 wish to thank the International Development Research Centre (IDRC), Canada and Makerere University Graduate School for financial support, and the International Foundation for Science (IFS), Sweden in collaboration with the Organization for the Prohibition of Chemical Weapons (OPCW), Netherlands, for a donation of Atomic Absorption Spectrophotometer (AAS) equipment that made this study possible. Permission to re-publish material from two already published articles by the authors was granted by Elsevier Environmental Research and by the International Journal of Environmental Science and Technology¹. Both studies were carried out as part of the Doctoral work of the lead author as well as the work of the Urban Agriculture and Health Research Coordinating Committee, which she chaired from October 2002 – October 2003.

Chapter 8 is based on work done for a Master of Science thesis completed for the University of Toronto, Graduate Department of Public Health and the Institute for Environmental Studies in 2005, entitled “A screening-level risk assessment of children exposed to chemical contaminants in Kampala, Uganda”. The author gratefully acknowledges the guidance and support of her supervisors, Professors Donald Cole and Miriam Diamond. She also thanks the members of her thesis committee, Dr. Angela Li-Muller, Professor James Purdham and Professor Andrea

¹ Nabulo, G, Oryem-Origa, H & Diamond, M. 2006. 'Assessment of lead, cadmium and zinc contamination of roadside soils, surface films and vegetables in Kampala City, Uganda', *Environmental Research*, vol. 101, pp. 42-52.
Nabulo, G, Oryem-Origa, H, Nasinyama, G & Cole, D. 2008. 'Assessment of Zn, Cu, Pb and Ni contamination in wetland soils and plants in the Lake Victoria Basin', *International Journal of Environmental Science and Technology*, vol. 5, no. 1, pp. 65-74.

Sass-Kortsak, who provided valuable assistance and suggestions, Professor James Dooley who provided thoughtful feedback regarding the thesis, and Dr. Diana Lee-Smith, former African Regional Coordinator for Urban Harvest, for her help in editing the material used in this article. Deep appreciation is also extended to the members of the Diamond Lab group in Toronto, past and present, whose work was both a source and an inspiration. Jennifer Truong and Heather Jones-Otazo contributed enormously, as did the members of the Urban Harvest team in Kampala, Uganda, particularly Professor George Nasinyama, Abdulrahman Lubowa and Grace Nabulo, who tirelessly assisted throughout the work in Uganda. Finally, the financial support provided by the National Sciences and Engineering Research Council of Canada (NSERC) and the International Development Research Centre (IDRC) Agropolis award is also acknowledged.

Financial support provided by the UK Department of International Development (DfID) made possible the work reported in Chapter 9. The authors also acknowledge with gratitude the permission granted by Kampala City Council to sample the Kiteezi Waste Dump Site and the drainage channel. The authors of Chapter 10 are grateful for the help of Frank Mwiine in developing the questionnaire and Research Assistants, Moses Makoha and Immaculate Nabukenya, in administering it. In addition, they would like to acknowledge Renée Sebastian's assistance with the wealth ranking categorization and Donald Cole's contribution as a reviewer.

Producing the manuscript could not have been done without financial support from CIP and generous provision of logistical support from the Department of Public Health Sciences, now the Dalla Lana School of Public Health, University of Toronto. Even with that support, it would never have been completed without the additional support of a grant from the Ford Foundation Office for Eastern and Southern Africa, whose contribution is gratefully appreciated.

At CIP we owe a personal debt to the Global Coordinator of Urban Harvest, Dr Gordon Prain. His commitment to the project has found its way into every aspect, from fund-raising to editorial overseer, including back-stopping absolutely everything and unswerving moral support. We also thank Cathy Barker and Ani Muñoz, Urban Harvest Communications Officer and Administrative Assistant respectively, who have played an invaluable part in proof-reading, tying up many loose ends and getting the manuscript ready for layout and publication.

Finally, we as editors would like to thank Jennifer Penney, Shermit Lamba, Davinder Lamba, and Sicolastica Nasinyama whose patience and forbearing have seen us through.

Donald C Cole
Diana Lee-Smith
George Nasinyama

Toronto, Nairobi and Kampala,
August 2008

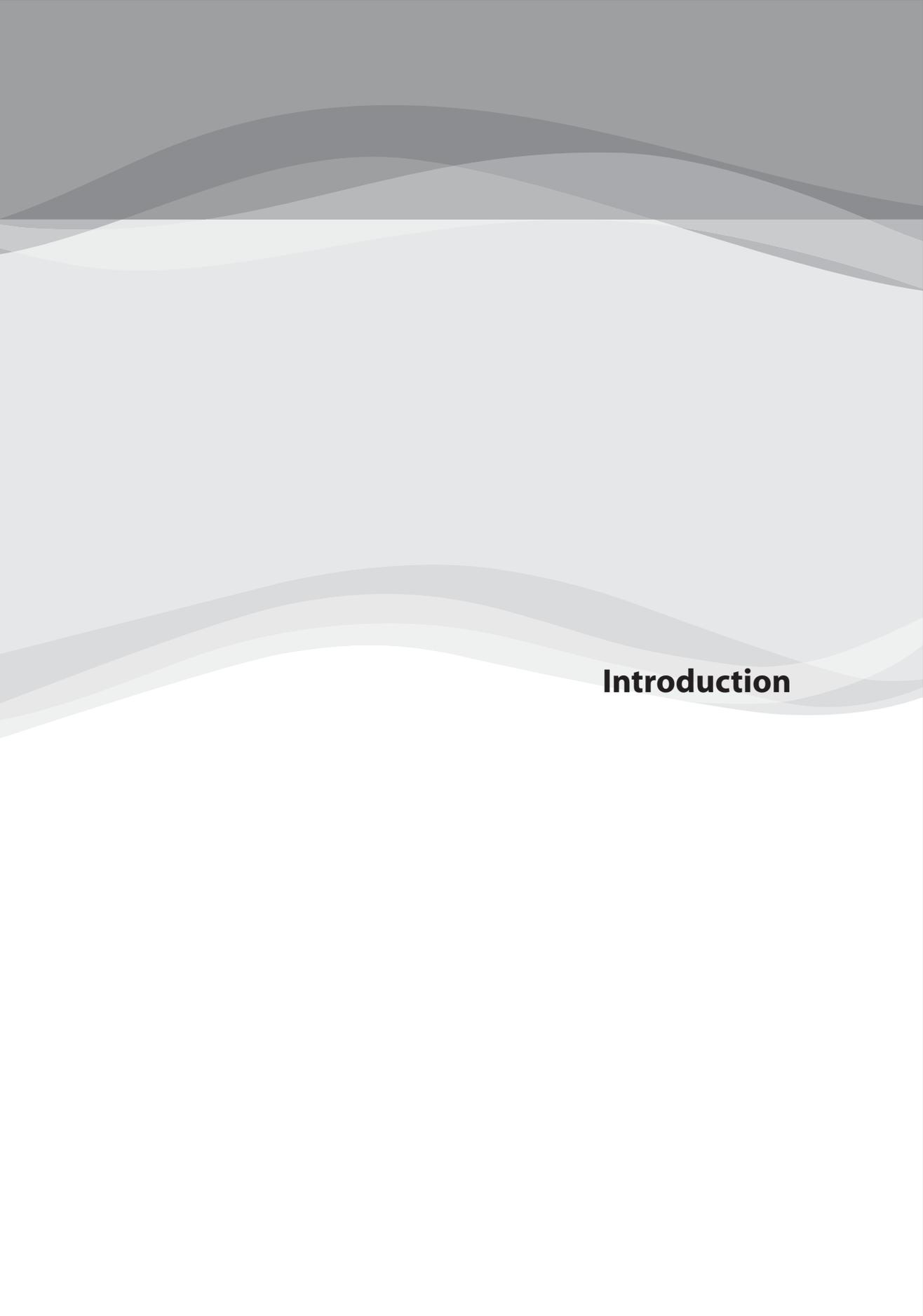
Dedication

Winnie Makumbi – in Memoriam

Winniefride JN Makumbi (1969-2008) was a tireless defender of the urban poor and a political advocate of the role of urban agriculture in supporting them. Serving two years as District Councilor, Lubaga Division, and six years as the only woman to serve as Kampala City Minister, she championed communities and helped improve opportunities for many, gaining the trust and respect of the people she represented on the Kampala City Council (KCC). Popularly known as the “Mayor of Lubaga” she was involved in promoting entrepreneurship among women and youth, and, as a representative of the KCC in the 2006 World Water Forum, seized the opportunity to emphasize the vital need to involve local communities in the search for low-cost solutions to wastewater management for poor urban areas.

Winnie understood the significant role that agriculture can make in contributing to the household food security and incomes of the urban poor and between 2001 and 2006 she helped steer the process leading to the creation of the Kampala Urban Agriculture Ordinances. She also shared her experience of this policy making process with other city administrators in Africa.

Her untimely death, at such a young age, has come as a great loss to her family, friends and colleagues and to all those who share with her the vision of healthy, productive and prosperous urban communities. This book is dedicated to her memory.



Introduction

CHAPTER 1

Can the city produce safe food?

Diana Lee-Smith • Donald C. Cole

BACKGROUND

In mid 2008, as we were editing this book, a global food crisis was again grabbing world attention with acute food shortages in thirty-six countries, more than half of them in Africa (FAO 2008). Because of unequal access to food, there is roughly the same proportion of food insecure households and malnourished children in urban slums as in rural areas (UN-Habitat 2006, pp.104-107). Urban agriculture is once more being recognized as an important response that millions of families use to obtain food. The internationally recognized Right to Food (FAO 2005) implies that urban food production and distribution should be encouraged not only to alleviate crisis situations such as that now prevailing, but also as part of a longer-term strategy for hunger and poverty alleviation. However, fostering such self-reliance and promoting the safe production and distribution of urban as well as rural food present enormous challenges for urban stakeholders and municipal policymakers (FAO 2000). This book attempts to unpack the urban agriculture component of these challenges, drawing on experiences in one city of sub-Saharan Africa.

The image of people farming vacant lots and roadsides in cities sometimes makes those with a vision of modernity and bright hopes of a successful Africa feel alarmed or even ashamed. Yet study after study has demonstrated that millions of people are producing food in cities, not only in poor countries but in wealthy ones as well (Smit *et al.* 2006; van Veenhuizen 2006). In fact people have been doing this for centuries, and even those who developed the cities and suburbs of North America apparently did it by farming their backyards (Harris 1996). Food is being recognized, finally, as something that has to be integrated into urban planning (Mendes 2007; Livingstone 2006).

This book asks questions about the contribution of urban agriculture to food security of urban households, about the safety of crops and animal foods from urban producers in different places, and about ways of developing policy to promote safe and healthy food production. It explores how to answer these based on an extended case study of one place, Kampala, the capital city of Uganda, between 2002 and 2005. Multiple disciplines, ranging from nutrition, the medical and veterinary sciences, chemistry and botany to geography, planning, anthropology and history, contributed. Current trends of thought in agriculture,

public health and urban studies informed the research and policy work carried out and the analysis shared here. The prime focus of this book is on public health, in contrast to a wider set of books on rural-urban linkages, urban agriculture and urban food markets that have appeared. Of necessity however, it sets public health in a broader public policy context. It uses a political science perspective to examine how choices are made about urban food production in cities and towns, since such choices, and the type of governance that produces them, profoundly affect whether the food that city farmers produce and distribute is safe. The book also uses a Human Rights lens to complement evidence-based assessment and throw light on what kinds of policy choices may be made and how. Kampala changed the way it regulates urban food production during, and partly as a result of, this study, making it an especially useful example.

The politicians and municipal staff who strive to manage African urban centers in the twenty-first century are justified in their worries about citizens who clutter the cityscapes with farming. The potential risks to human health depending on how food is produced, processed and distributed in urban areas are real. Those running African cities are not so different from their predecessors, who responded to the insanitary conditions of urban areas in the nineteenth century with the public health protection approaches of their time. All of us owe a debt to these early campaigners who cleaned up cities and made them safer. Still, it is time to move on. Science has taken us further than the restrictive models of cleanliness of the nineteenth century, through understanding the behavior of microorganisms and of our place as human beings in urban and agro-ecosystems. This book is an attempt by Ugandan and international researchers to reconfigure thinking about how to make the food produced in cities safe to eat, based on joint work in Kampala.

THE CASE

In 2002, Kampala City Council was in the process of reviewing its Ordinances, and wanted to include measures to regulate urban agriculture, which was documented as widespread, thanks to research done in the mid-1980s (Maxwell 1994). Because of its history of mis-rule, economic chaos and civil war, Uganda had numerous people farming the capital, taking advantage of the favorable climate and water supply around Lake Victoria. Active civil society organizations were helping people improve their farming and the City Council's Agriculture Department reached out to them. Although the support was patchy, there was political will and an energy driving the efforts of Ugandan professionals. Together, they worked across organizational boundaries in the framework provided by the new Uganda Constitution and decentralization policy to strengthen and institutionalize urban agriculture, even as economic conditions improved and the City regained its capacity to govern.

Also in 2002, the Urban Harvest program of the Consultative Group on International Agricultural Research (CGIAR) began supporting research on urban farming in Kampala. There was a sense that residents were increasingly engaging in food production, something eventually borne out with survey data showing that about 49 percent of Kampala households were producing some of their own food (David *et al.* forthcoming). Nevertheless, health concerns were paramount, so the city was keen to take advantage of the opportunity of

working with an expanded research team on what became known as the Urban Agriculture and Health project. The members of that team are essentially the same people who have put this book together, as chapter authors and editors.

Although a book of research results, this is not purely an academic work. Several chapters are the results of masters' or doctoral theses and the majority have been peer-reviewed. Other chapters offer more provisional results and the whole book is driven by the practical concern of a group of researchers and policy makers to improve the safety and health contributions of food produced in Kampala.

We wanted the book to be easily accessible and useful to those who need the information: policy makers themselves. Hence at the end of each of the substantive sections, we, as editors, have placed commentaries. These commentaries summarize what can be done to promote the health benefits and reduce potential health risks associated with urban agriculture, based on the findings. We fashion them in terms of key public health messages, policy principles and guidelines, drawing on sources beyond the studies as well as the findings themselves. As well, we point out important gaps and what we do NOT know, indicating further applied research that could better inform actions.

Apart from the scientific evidence, we try to capture the perspectives of a wide range of interest groups involved in urban agriculture and health – from the farmers themselves and the civil society organizations that support them to the researchers and the local government bodies that have to regulate and manage urban agriculture. All these groups were in fact involved in the research in various ways, and it is the story of that applied research that we try to tell here. Apart from those directly concerned in Kampala, we think that sharing our processes, findings and challenges will be useful for others.

TOWNS, FOOD AND HEALTH IN HISTORY

Towns have been places of food production since the dawn of human history, the separation of food production from human habitation occurring mainly as a result of the industrialization of agriculture. Of course it is common sense that crop fields take up more space than houses, so fields were outside city or fortress walls and old European towns had strips of fields radiating from villages, towns or streets. But the livestock were always closer to home, and there have always been kitchen gardens from which to pluck fresh fruit, vegetables or herbs (Mumford 1961; Steel 2008).

Refrigeration was only invented at the start of the last century. Before that, most livestock came into town on their own feet for slaughtering, or were kept in urban fields and gardens. This is the situation one still finds today in large numbers of developing country towns and cities, mainly because of poor road conditions and lack of refrigeration. Many of the parks and open spaces now existing in industrialized countries' large cities were previously "commons" where citizens grazed their livestock. Markets were urban places where farmers came to sell their produce. Supermarkets and suburban food terminals appeared only in the 1960s (Steel 2008).

The history of urban growth in North America was the history of suburbanization – colonial settlement being followed by trading and industrial towns. Citizens spread out from

towns on their own generous plots, thanks to the plentiful supply of land and the invention of the motorcar in the twentieth century. But it is only by looking into who the first suburbanites really were and how the towns were built that this history can be properly told. It was generally supposed that the suburbs of the early twentieth century were built by the wealthier middle class, while the poor lived in crowded urban tenements. In fact, most suburban development in the places studied consisted of un-serviced self-built housing put up by poor migrants (Harris 1996, pp. 284). Confronted with crowded and insanitary urban conditions in their home countries, not to mention frequent lack of rural land and employment, even possible starvation, these 19th century European migrants to North America built places of their own, found work nearby and usually grew their own food in the front or back yard. Case studies have shown that households were able to supply much of their vegetable and animal food needs from their own production in the summers and preserved food to eat during the cold winters (Harris 1996, pp. 93 – 114, 128, 197 – 203).

Livestock kept in close proximity to human beings constitute a specific type of health risk, as the transmission of zoonotic disease between animals and humans is possible. At the same time, livestock have often been kept close to human settlements throughout history as a source of fresh food, whether animal products such as milk and eggs or as meat. This is the case with much urban and peri-urban agriculture in poor countries, where mixed farming is common especially in Africa (Prain *et al.* forthcoming; Karanja *et al.* forthcoming). Ranching became economically viable with transportation and even more so with refrigeration. Urban dairies were common in Europe up to the mid twentieth century and poultry farms tend to be located in peri-urban areas in developing countries as a recent study in Botswana shows (Hovorka 2006).

Getting enough of the right kind of food is understood as necessary for good health in all human cultures. It is also the definition of food security, if the “right” kind is understood as safe, nutritious and preferred and “enough” is understood as sufficient for a healthy and active life¹. Managing the natural growth cycles of plants and animals has always and will always be the source of human food, as it is the basis of agriculture. Obviously, the way natural systems (ecosystems) function is the basis of food production, and farmers have always managed those systems to get enough food, even though this understanding is not always expressed in the same words.

For example, long before science explained the need for Nitrogen (N), Phosphorus (P) and Potassium (K) as soil nutrients for growing plants, thus enabling them to be packaged as fertilizers and sold to produce higher yields, farmers figured out that these substances were to be found abundantly in excreta (animal and human) which they could recycle to produce higher crop yields. Mixed farming systems using animal manure as a soil nutrient to grow crops and crop wastes to feed animals have been the basis of farming systems all over the world and are still common in developing countries, including their urban farming systems.

Historically, human wastes were also used to fertilize soils for crop production, and still are in some places. India has relied on soil regeneration from livestock wastes (especially

¹ “... food security exists when 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).

from the cow and the buffalo) as well as human wastes, for thousands of years until recently. For centuries, large cities in Europe such as Paris and London grew much of their food supplies in swamps or fields where human wastes were dumped. However, the awareness of the link between this practice and the spread of disease has limited its application to the use of sewage sludge after safe treatment in waste disposal plants.

However, water has always been the basic input for food production, in both crop and livestock farming. Farmers throughout history have used the natural hydrologic cycle, practicing rain-fed agriculture or locating settlements and farms near waterways or wetlands. Or they have adapted or channeled it, using furrows or other forms of irrigation including drip-feeds and hydroponics. Great cities of the past were located on waterways where food could be produced easily. In places with dry climates urban agriculture is taken for granted even now. And urban farmers in poor countries make extensive use of the available wastewater found at roadsides and in drainage ditches. The essence of kitchen gardens is that they use the water run-off from food preparation.

Cholera outbreaks in cities in industrializing countries in the nineteenth century were controlled only when discharging human waste into rivers used for water supplies was understood as the source of disease. Ideas about sanitation and the building of sewers then dominated urban public health thinking – as well as urban design and development (Steel 2008). Discoveries of the microbiological origins of many diseases led to additional emphasis on diagnostics, vaccines and drugs for treatment of many communicable diseases as the basis of disease control in the early twentieth century. Only in the latter part of the twentieth century did contamination from potentially toxic chemicals from industrialization start to raise public health concerns, galvanize the environmental movement and create a more sophisticated awareness of links between human and environmental health (MacDougall 1990, pp.10-15).

Although the public health movement of the nineteenth century successfully identified the disease pathway of human waste contamination of water supplies, the concept of recycling the nutrients removed was not well understood². Most of the excess nutrients in wastes produced from urban areas are therefore not recycled into soils effectively. One of the problems of “pollution” identified early in the environmental movement that began in the middle of the last century was the excess of nutrients showing up in the wrong places, typically sewage wastes in bodies of water causing algal blooms or overgrowth of invasive plant species. Run-off from fertilized fields causes similar problems. The global problem of nutrient overloads coming from urban settlements and the need for a better balance in ecosystems generally has only recently received attention (Forkes 2007).

As identified by the environmental movement’s seminal book “*Silent Spring*”, the widespread use of chemicals, especially in agriculture, is also disruptive to the functioning of natural ecosystems (Carson 1962). Changes in the focus of public health thinking, towards addressing environmental concerns, health promotion, advocacy and preventive health measures, came as problems like air pollution, increases in cancers, lead and asbestos

²Recent scholarship suggests the principle was understood by some in London but rejected as a practice of “the despised Chinese” and not suitable for a well-to-do nation that could afford to dump its “sewerage wealth” into the sea (Steel 2008, p.256).

poisoning occurred (MacDougall 1990). Thus concern about the harmful effects of chemicals came late in the day, well after the industrial revolution that began at least a hundred years earlier. Infrastructure technologies that make cities and modern economies work, the transportation, buildings and waste disposal systems, were not adequately designed to alleviate the public health impacts of harmful chemicals. Institutional action on such contamination and destruction of ecosystems only began in the latter part of the 20th century, with the founding of national environment protection agencies, the UN Environment Program, and other measures.

Amidst these changes, including those in agricultural practices, and the advocacy that emerged around them, sit local, regional and national governments who are required to respond to the increased need for food and different kinds of food that go with growing populations and their preferences (Hawkes *et al.* 2007). At the same time they are expected to develop general, food- and health-specific policies and laws that adequately respond to concerns surrounding human health and food production, not least the Right to Food and the Right to Health. Health concerns about urban agriculture are many, but they are balanced by the realization of its important contribution to the alleviation of hunger and poverty, the first Millennium Development Goal laid out in 2000 by the United Nations (<http://www.un.org/millenniumgoals>). As this book points out, how governments have chosen to respond to these often competing priorities is one of the areas most wanting in research on urban agriculture.

THINKING ABOUT URBAN AGRICULTURE AND HEALTH

When the International Development Research Centre (IDRC) published *Cities Feeding People* in 1994, it was one of the first books on the subject of urban agriculture anywhere³. The figures were startling, and surprisingly consistent. Of the four East African countries studied (Ethiopia, Kenya, Tanzania and Uganda), the capital cities had around a third or more of their populations growing crops and/or keeping livestock in the capital city, while there were no figures for the fourth, where only dairying had been investigated (Egziabher *et al.* 1994). Several other studies followed and in 1996 the United Nations published an encyclopedic volume on urban agriculture worldwide (Smit *et al.* 1996).

In the research on urban food production that proliferated after those first initiatives, health concerns emerged as a priority, especially as attention began to focus on the way urban and rural worlds intersect because of rapid urbanization in the South (cf. Birley & Lock 1999). Peri-urban agriculture, whether pursued by farmers surrounded by urban growth or by new migrants, was acknowledged as providing food for household members as well as income from the sales in the expanding urban market. In terms of land use, rapid urban growth with residential and commercial infill of agricultural spaces was accompanied by intensification of agricultural production in response to the increased demand for food.

Agriculture has been one way in which urban natural resources have been used. Solid and liquid wastes have been important inputs for urban and peri-urban farming but they

³ Several of the studies had already been published as reports and journal articles and works by others, such as Rakodi (1988) and Vennetier (1961) had also appeared as journal articles. Donald Freeman's book "A City of Farmers: Informal Agriculture in the Open Spaces of Nairobi," appeared in 1991.

bring with them potential health risks. The main burden of ill health in predominantly rural developing economies was characterized as communicable disease associated with under-nutrition. Non-communicable diseases, often associated with over-nutrition e.g. diabetes and obesity, were more frequently associated with almost totally urbanized developed world economies. Peri-urban locations, as well as squatter settlements of the poor, with their lack of urban services and large migrant populations with urban lifestyles, were seen as carrying a “double health burden” (Birley & Lock 1999). Their lack of access to water and sanitation promotes the spread of communicable disease, while their exposure to chemical contaminants, contributes to non-communicable disease, a growing concern in developing countries (Daar *et al.* 2007).

Meanwhile IDRC was investing in research to understand and document the complexities of the health risks involved in urban agriculture, through both its “Cities Feeding People” and “EcoHealth” initiatives. While a biomedical approach to health is primarily based on diagnosis and treatment of specific pathologies, ecohealth focuses on the interacting social, political, economic and ecological contexts that influence health. It promotes interventions that work towards more sustainable ecosystems, more equitable development, less poverty, and hence improved health and well-being (http://www.idrc.ca/en/ev-68488-201-1-DO_TOPIC.html). Urban agriculture needs an ecohealth approach because it directly uses natural resources and is intricately intertwined with how ecological processes work in an urban setting.

The focus on health and urban agriculture galvanized activity among an array of institutional partners. An early issue of the Resource Centre on Urban Agriculture and Food Security (RUAF)’s widely distributed magazine was devoted to health benefits and risks (RUAF 2001). Among CGIAR Centers, the International Water Management Institute (IWMI) carried out investigations of wastewater quality and the use of wastes in urban agriculture in many countries around the world. IWMI collaborated with the World Health Organization (WHO) to develop revised guidelines for waste water re-use, so as to facilitate safe urban food production while making better use of this valuable resource (Buechler *et al.* 2006, p.250).

When the CGIAR set up its system-wide initiative on urban and peri-urban agriculture, IDRC helped support its African regional program, and in 2004 all these partners came together to run a training course for Anglophone Africa, where capacity building materials on urban agriculture, including human health, were developed and municipal, farmer and researcher triads from multiple regions were trained (Dubbeling *et al.* 2005). All these initiatives drew on risk assessment approaches but emphasized consideration of both benefits and risks in relation to urban agriculture and how to balance them in making judgments (Lock & van Veenhuizen 2001; Cole *et al.* 2006; Boischio *et al.* 2006; Lee-Smith & Prain 2006).

The emerging body of thought is grounded in inter-disciplinary as well as inter-institutional collaboration, with African municipalities as well as universities playing key roles. More and more African municipal governments are involved in these applied research-for-development initiatives, Kampala being just one. For example, those involved in the Kampala research on health and urban agriculture took part in the development and running of the human health-related modules of the Anglophone Africa regional training course.

In a complementary stream of work, the Ford Foundation-sponsored Global Urban Research Initiative (GURI) identified, through a consultative process, that the key issue affecting rapid urbanization was urban governance. The term was defined as the relationship between civil society and the state, between rulers and the ruled, the government and the governed (McCarney *et al.* 1995; McCarney 2003, p. 36). In contrast to earlier management-oriented definitions advanced by the World Bank, this conceptualization of governance usefully captured the questions of who the players were, how they were (or should be) involved, who was making decisions about managing urban resources, and how. In one of its volumes, GURI briefly addresses the question of urban agriculture and urban natural resource management in relation to a “governance approach to the environment” (McCarney *et al.* 1995), an approach taken up by Hardoy, Mitlin & Satterthwaite (2001). Governance is a useful term because it encompasses activities crucial to urban natural resource management, such as why urban agricultural production and informal distribution mechanisms thrive in spatial and marketing niches despite a lack of institutional support (Bopda & Awono forthcoming).

Partly as a response to this lack of institutional frameworks, multi-institutional initiatives that have focused on urban food production engage not only urban municipal governments but a broad range of other stakeholders as well. The idea of stakeholder engagement with an applied research process took hold in Kampala, due in part to Uganda’s new Constitution and its decentralization policy, both of which emphasized participatory processes of government and legislation. As we shall see, not only municipal officers but politicians sat on the committee that guided the research, and urban farmers were not only research participants but also active proponents in a three-way dialogue with politicians and researchers.

STRUCTURE OF THE BOOK

The book has five sections. In Section A, we start with the perspectives of the different stakeholder groups engaged in the applied research on public health aspects of urban food production: community members (chapter 2), health researchers (chapter 3) and those involved in governance (chapter 4). In the next three sections, we present the different scientific studies undertaken on: Food Security, Nutrition and Urban Agriculture (Section B); Healthy Horticulture in Cities (Section C); and Managing Urban Livestock for Health (Section D). Each of these sections is followed by its own commentary setting out the implications for policy, public health messages and areas where further research is needed. Finally, in Section E, we come back to urban governance in relation to public health and urban food production, telling the story of how the applied research informed Kampala’s governance and exploring the wider implications of the Kampala experience for those working to construct healthy and sustainable cities.

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Perspectives
A
Section

Perspectives

Overview

This section establishes the principle central to the book's approach that understanding and finding solutions to the public health problems presented by urban food production must come through inclusion of the points of view of all stakeholders. These include the communities of urban producers, the researchers who investigate questions of health and urban food production and the local governments which run towns and cities in which urban agriculture takes place. This aspect is dealt with in Chapter 2, which gives the context of urban farming in Kampala and describes the start up and operation of the health project on which this book is based. It goes on to describe the perceptions of men and women members of local communities about health benefits and risks of urban farming, and presents their ideas and those of other stakeholders on how to manage the risks. The section also provides methodological background to the different component studies that follow, showing how they fit into an overall framework of scientific thinking. Chapter 3 addresses this through presenting the perspective of researchers on public health and urban food production, starting out with understandings of health in cities. The chapter introduces an approach to assessing health-relevant benefits and risks of urban agriculture, drawing on different disciplines, and provides a guide about the various types of scientific studies and measurements presented in subsequent chapters.

Finally, Section A examines the political context in which decisions about urban food production are made through discussing, in Chapter 4, the key stakeholder role of municipalities and other urban local governments because they pass the legislation and implement the policies governing urban food production and public health. The key concepts of governance – public decision-making that includes state and non-state actors – and of Human Rights are introduced to inform the broader context within which evidence-based policy is set.



Perspectives

Diana Lee-Smith

Urban food production in Kampala:
Community perceptions of health
impacts and how to manage them

Donald Cole
Delia Grace
Miriam Diamond

Researchers' approaches to evidence
on agriculture and human health

Christopher Gore

Healthy urban food production
and local government

CHAPTER 2

Urban food production in Kampala: community perceptions of health impacts and how to manage them

Diana Lee-Smith

BACKGROUND TO URBAN FARMING IN KAMPALA

Kampala is the capital of Uganda, a landlocked country on the equator in East Africa. The city lies on the shores of Lake Victoria at around 1,200 m (4,000 feet) altitude. Its tropical climate and ample rainfall make it suitable for agriculture, which accounts for 90 percent of Uganda's exports, 80 percent of employment and most of the raw materials that go to the mainly agro-based industrial sector, much of which is located in Kampala. Food crops dominate Uganda's agriculture, and these are mainly produced by around three million farm households, most of which farm small pieces of land mainly using hand-hoes (David *et al.* forthcoming). And while the capital is a busy modern city, agriculture is also a visible part of its life.

In 1992, 56 percent of land within municipal boundaries was used for agriculture, while an estimated 70 percent of all poultry products consumed in Kampala were produced in the city (Maxwell 1995). Economic collapse during the rule of Idi Amin in the 1970s, civil war in the 1980s and structural adjustment policies in the 1990s led many to take up urban food production (Plates 3 and 4). About 49 percent of Kampala households were farming within the city boundary in 2003. Based on Kampala City Council's classification system, about 27 percent of urban and about 56 percent of peri-urban households were farming inside the city boundary (David *et al.* forthcoming).

The farming and livelihood systems of households and communities have been characterized, from the urban center, through dense urban slums, intensively farmed peri-urban neighborhoods being rapidly filled in with more settlement, and out to the peri-urban boundary of the city where conditions come closer to those found in a rural setting. Both urban and peri-urban farming communities had a mix of farming and other means of economic survival. Most farmed next to where they lived and did so for the purpose of getting extra food, with income from selling their produce as a secondary activity (David *et al.* forthcoming).

Farming households were bigger than those of their neighbors who did not farm. About half the farmers only grew crops, and the other half had mixed farms with crops and livestock. There were more farmers growing crops only in the peri-urban areas. Urban farmers mainly

grew bananas and cocoyams and kept poultry, while peri-urban farmers mainly grew sweet potatoes and cassava. Most crops were grown for home consumption with a tendency for livestock to be kept more for income generation. Chickens, cattle and pig keeping were common commercial activities for peri-urban households and chickens, cattle and planting cocoyams in the urban areas (David *et al.* forthcoming). Peri-urban farmers had more and bigger farm plots than the urban farmers, and were more often house owners. They also owned more farm plots, while those in the urban slum often farmed “borrowed” public land around the wetland and drainage channels that discharge into Lake Victoria.

Extensive studies have categorized Kampala’s farming households, their typology outlined in the 1980s being confirmed and up-dated in 2003 (Maxwell 1994; David *et al.* forthcoming):

- Commercial
- Food self-sufficiency
- Food security
- Survival

The last two categories, those farming for food security or survival, form the large majority. Commercial farmers were very few and well-off, found mostly at the peri-urban periphery, but farmers in the other categories were also struggling to commercialize. Food self-sufficiency farmers were mostly well off and found in all areas except the inner urban neighborhood. According to a wealth ranking method, the large numbers farming for food security were among the middle income or well-off in the urban areas but among the poor in the peri-urban areas, apparently because urban farmers had other sources of income with farming helping them to save or supplement urban life-styles, whereas in the peri-urban areas they were scratching a living from farming. By contrast, the very large numbers farming for survival, so they would not starve, were only found in urban areas. These community members, the majority of them women-headed households, had few resources and could barely make ends meet. Such households were not found in the peri-urban areas because people could get more food from larger pieces of land and were less desperate for survival (David *et al.* forthcoming).

THE URBAN AGRICULTURE HEALTH PROJECT AND ITS RELATION TO KAMPALA COMMUNITIES

The Urban Agriculture Health Project started up in 2002, running in parallel with the research on urban farming systems. A committee made up of the necessary range of stakeholders met regularly to guide the content and direction of the research, which was then implemented by those with the research skills to carry it through. It was called the Urban Agriculture Health Coordinating Committee or HCC for short. Apart from officials of local and central government concerned with agriculture and researchers from Makerere University and the National Agriculture Research Organization, there were representatives of non-governmental organizations (NGOs) working with urban farmers in Kampala.

To reach out to farmers in the city, who at that time had not developed an institution or organizational structure representing their interests, a participatory research method was

set up, working closely with the group studying farming systems in the city. The Kampala City Council (KCC) classification of urban farming areas within its boundaries was used:

- *urban old*: areas of very high population density, limited available land, low prevalence of crop and local livestock production and medium prevalence of improved livestock.
- *urban new*: areas of high population density with limited available land, low prevalence of crop and local livestock production and high prevalence of improved livestock.
- *peri-urban in transition to urban*: areas of medium density and some land availability, medium prevalence of crop production, high prevalence of improved livestock and medium prevalence of local livestock.
- *peri-urban peripheral*: areas of low population density with good land availability, high prevalence of crop and local livestock production but fewer improved livestock.

Participatory appraisals were done in a site typical of each category, the unit of analysis being one or more villages from selected parishes (Plate 1): Bukesa in Central Division (urban old), Banda in Nakawa Division (urban new), Buziga, Makindye Division (peri-urban transition) and Komamboga, Kawempe Division (peri-urban peripheral). Half-day Participatory Urban Appraisals (PUAs) introduced communities and local authorities to the project as well as collecting preliminary data. Community health perceptions were derived from a free flowing discussion with participants including map-making to locate health risk areas in each community. More women than men participated in the PUA, reflecting their predominance as urban farmers as well as their commitment to learning and change.

The map-making and discussions on health risk perception were continued in other areas identified as having potential health risks such as farming on waste dumpsites. Meetings in schools were also included, working with the local NGOs and the Makerere University Department of Agricultural Extension on a project involving schools in urban agriculture extension (Miiró *et al.* forthcoming). School classes generated their own maps identifying urban agriculture health risks.

COMMUNITY PERCEPTIONS OF HEALTH RISKS FROM URBAN AGRICULTURE ACROSS THE URBAN TO PERI-URBAN CONTINUUM

Old urban area - Bukesa

Near the center of Kampala and originally part of the traditional lands of the Buganda Kingdom, this densely settled area has old colonial buildings and ruins from the period of war and conflict in the 1980s as well as informal businesses and slum housing. Farmers had small plots of banana plantain (*matoke*) intermixed with beans, yams, cassava and sometimes local vegetables, with goats and cattle tethered or grazing. They kept chickens and cattle and grew mushrooms for income generation and fruit, *matoke*, maize and beans for food. Being mainly a residential area – a mix of flats and slum dwellings – with no industries except small businesses, people expressed no fear of health risk from exposure to environmental pollution. But a high likelihood of exposure to pathogenic infections from unhygienic human waste disposal and livestock infections was observed to exist.

Table 2.1

Perceived environmental constraint	Perceived health impacts	Alleviating strategies
Lack of space for farming	Poor families prone to malnutrition	Farmers conduct farming activities that require little space such as zero grazing, poultry keeping and mushroom growing
Forced to grow food in compounds and wetlands	Risk of contamination of food crops grown in the wetlands from pollutants. Increased prevalence of malaria	Treat malaria
Theft of livestock means sharing space with animals	People risk getting diseases from livestock (zoonoses)	None suggested

New urban (slum) area - Banda

Poor people have settled on this wetland near the major Kiwanataka drainage channel, which discharges water from the city down to Lake Victoria. Farmers grew cocoyams for income as well as food, and kept poultry and cattle for income generation. They also grew green vegetables, beans, maize and bananas for food. There is little sanitation or clean water and several industries discharge waste into the channel, which floods during rains, spreading industrial and other pollutants into the area used for farming. Most households used water from protected springs near the wetland while pit latrines for human waste have been dug in the same area, with obvious risk of cross contamination due to the high water table. Residents stated that they suspect the water supply is contaminated due to farmers living near the wetland releasing human waste from pit latrines, while some people had no latrines at all and simply use the channel for that purpose especially during the night. The wetland is also used as a dumping site for animal waste (mainly from cattle) as well as waste from beer brewing and distillation, while other chemical contamination comes from upstream industries. Further, farmers deliberately used the same waters for fertilizing their crops.

Reflecting the importance of yams in Banda parish, farmers developed three ways of categorizing them according to local growing conditions. The first category was grown in areas near the sewage-contaminated channel, and these were said to taste bad when cooked. The second was grown in areas where run-off deposits have settled, and these yams were said to taste bad but not as bad as the first category. The third one was grown in dark, well-drained clay soils, and these were the yams that were said to taste good: they were starchy or floury when cooked. However, when farmers realized the difference in taste, they resorted to growing sweet potatoes and cassava in the areas that make yams taste poorly, because cassava and potatoes did not have the bad taste. Farmers had also started to grow vegetables in sacks to solve the problem of land space as well as taste, and they added cow dung to the sacks for soil fertility.

Table 2.2

Perceived environmental constraint	Perceived health impacts	Alleviating strategies
No sanitation, dumping of household waste	Flies, smells, diseases	Local youth group Banda Garbage Collectors (BAGACO) collects household waste for a small fee, packs and transports it using wheelbarrows
Farming in wetlands contaminated with human waste and livestock manure	Cholera outbreaks	None BAGACO also collects poultry waste and sells it as manure to local farmers
Pits dug for brick making and sand mining	Stagnant water attracts malarial mosquitoes	Treat malaria
Chemical pollution from industries, water is yellow colored	Unhealthy crops and fish	None suggested, except avoiding contaminated food
Abattoir waste in wetland	Flies, worms, diseases	
Theft of livestock means sharing space with animals	People risk getting diseases from livestock (zoonoses) and worms	None suggested

Peri-urban transition area - Buziga

Located in the South of Kampala on Lake Victoria, this area was lower in density than the inner areas of Kampala and mostly farmed by indigenous Baganda people with a few more well off recent settlers. Buziga farmers kept poultry and cattle and grew fruit for income and sweet potatoes, cassava and *matoke* for food. The area had only one industry, an enterprise handling fish exports, which seemed not to pose environmental or health risks. The main health risks in the area were attributed to disposal of human waste in wetlands and unplanned dumping of garbage that was not collected by KCC.

Peri-urban peripheral area - Komamboga

While farming was the most common occupation in this area on the northern edge of Kampala City, those who farmed were often poor, except for the few large commercial farmers keeping livestock (poultry, cattle and pigs) as well as growing fruit and cassava. The main source of water was open wells followed by protected springs. Few households had access to piped water and water for animals was fetched from wells. Komamboga did not benefit from KCC waste disposal, so there were no public dumpsites; each household managed its own waste disposal. Peelings and animal droppings were used as manure and animal feed. Polythene bags were burned and metals, glass and batteries thrown into latrines, the common form of sanitation. There were no industries in the parish, no unsafe places being used for farming and therefore few health problems related to farming were reported. Farmers who kept poultry in their houses were not aware of the health problems that might affect them

Table 2.3

Perceived environmental constraint	Perceived health impacts	Alleviating strategies
Eating food and vegetables contaminated by human waste	Diarrhea and intestinal worms	Use septic tanks (high income group) and latrines (low income group)
Some farmers obtain drinking water for their cattle from the wetlands	Possibility of livestock getting intestinal worms, microorganisms and other diseases	
Illegal dumping of garbage (e.g. sanitary towels, dead animals and polythene bags) in gardens, mainly by non-farmers. Even some livestock farmers dump poultry waste	Garbage attracts flies and gives off bad smells. It is also a source of disease. Non-decomposing materials such as polythene lead to intestinal obstruction and death when eaten by livestock	Use organic waste as manure, burn polythene bags, have volunteers collect and sell metallic waste such as used tins. Use cattle dung and poultry waste as manure
Farmers are cut by sharp objects dumped in wetlands	Possibility of contracting tetanus	None suggested except volunteers cleaning up as above
Presence of stagnant water provides breeding sites for mosquitoes	Increased incidence of malaria	Treat malaria with purchased drugs

as a result. Cattle keeping was not considered hazardous except if the animals themselves were infected with worms. Cultivation was taking place in wetlands but this was viewed as posing no health risks.

COMMUNITIES' PERCEPTIONS OF HEALTH RISKS AS A BASIC FACTOR IN FOOD SAFETY

Our purpose in carrying out the various studies and putting them together in this volume was to bring the different stakeholders' perspectives together for informed collective judgment about health risk mitigation strategies. Such judgments have to be feasible as well as appropriate, so information about the circumstances, values and knowledge of the stakeholders is needed in addition to expert information about measured levels of identified risk. Information about community members' perceptions of the health risks that they are exposed to and the measures they take to mitigate those risks is especially important in developing a risk mitigation strategy.

Table 2.4

Perceived environmental constraint	Perceived health impacts	Alleviating strategies
Rearing of pigs if pigs' droppings are managed with unprotected hands and feet	Worms from droppings of pigs and a certain type of fever contracted by humans	Protective gloves and boots if affordable
Cattle keeping	Infections by worms from infected animals	None suggested

The question of perception is basic to risk assessment, which always involves choice and judgment. Those making an assessment will weigh the benefits and risks of any action depending on their values, knowledge and circumstances. This is what community members, whether men or women, do every day as they grow food to feed their families or make a living, weighing the pros and cons of the risks and benefits insofar as they both understand, and can control them (Lee-Smith 2006).

Our data from the urban – peri-urban continuum clearly indicate that there are differences between urban and peri-urban farmers' perceptions of health risks from urban agriculture and that these depend on environmental conditions. Thus the increased densities of urban areas as compared to peri-urban areas bring greater exposure to more risks, but also a greater awareness of what those risks are. This was clearly demonstrated by the responses of farmers in Banda wetland slum who 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.

With increased awareness comes action, as suggested by the Banda Garbage Collection Organization BAGACO. But our consultations also brought out the limitations on action, especially by the very poor. The poor may be aware of health risks from urban agriculture but perceive that they are unable to avoid them because their life depends on getting food and water for themselves and their families (Lee-Smith 2006).

People also weigh the benefits of food production, as in the case of HIV/AIDS affected persons:

Households engaged in (farming) are able to afford a fairly balanced meal, especially those that grow vegetables. Those engaged in poultry are also able to eat some eggs, and those engaged in cattle keeping can have the milk without straining to get the money to buy those items (Key informant, livelihoods study).

Eating food being the most fundamental aspect of human life and culture, its handling and safety are inevitably a part of people's perceptions and behaviors anywhere in the world. Long established food practices to ensure their safety include drying, salting and pickling or the handling and treatment of cassava for example (Steel 2008; NRC 2006). Although at one time people were not aware of some common risks to food safety, namely the risks of contamination by microorganisms and the risks of chemical contamination discovered through scientific research, every culture has its food manners, rules and taboos that reflect their perceptions of safety. Some are clearly quite effective since human beings thrive. Thus it is important to know what people already think and do about food handling when carrying out a risk assessment. Although there is an extensive body of knowledge dealing with community and environmental health (e.g. Sheeska *et al.* 2008), there is surprisingly little literature on this subject in relation to the practice of urban agriculture (Lee-Smith 2006).

In reviewing trends in health impact assessment and the nature of evidence used, Martin Birley finds advocates of healthy public policy prefer assessments made by communities with or without expert advice. Communities can assess prospectively the likely impacts of policy, and especially its distributional effects, considering that health status is generally

lower for poorer communities and countries. In fact he points out that little research evidence is available about gradients of health status between rich and poor within developing countries (Birley 2002, p. 22).

Low-income households like other households – and especially women – do make regular health assessments: whether to eat the crops they have put pesticides on, or whether to buy lower cost foods they strongly suspect to have been adulterated. In the case of cocoyam production in contaminated wetlands in Kampala, women and men made their own health assessments and choices about the risks of heavy metal contamination versus food security. But poor and powerless communities in particular also benefit from knowledge inputs from others. Public health messages filling the gaps in what they know can help to make such judgments better informed. To arrive at this in Kampala meant both municipal regulators and scientists carrying out relevant research.

It must also be recognized that sometimes knowledge alone is not enough however. Community members with low incomes, living in neighborhoods with no water and sanitation, are constrained in what they can do to ameliorate their health conditions. Thus messages and regulations involving sophisticated health risk mitigation strategies that are beyond their means and power may be quite inappropriate. On the other hand, men and women in urban farming communities can have adaptive health risk mitigation strategies, tailored to their conditions. Knowledge about the community members' thoughts and conditions can be useful to other, expert stakeholders. Thus there is a two-way process in bringing together expert and community level perceptions of health risks and mitigation strategies, with learning on both sides.

WOMEN'S AND MEN'S DIFFERENT PERCEPTIONS

Women's as well as men's perceptions of health risks are important, because they are often different due to their circumstances, and risk mitigation strategies or public health messages that do not take account of their different roles and perceptions may be ineffective. Women's and men's roles as well as their perceptions have to be examined, and also whether the effectiveness of their risk mitigation strategies might be affected by their power and social status.

The women and men farming on contaminated dumpsites and wetlands in Kampala in 2002 stated overwhelmingly that they were aware of the risks involved but had no choice because it was their main source of food security and income. Asked what would happen if they were stopped from farming there, the responses of men and women were very different however. All the women said they would be affected, while 42 percent of the women but only half as many men said it would put them in a major economic crisis. The men had more flexibility in finding other places to farm (Nabulo *et al.* 2004, pp. 32-33).

Peasant women in sub-Saharan Africa are more often responsible than men for looking after the home, including providing food through subsistence farm production. Men are generally more responsible for providing cash for upkeep of the household through employment, a division of roles rooted in the colonial period when men rather than women were absorbed into the cash economy as laborers (Lee-Smith 1997). Women also have a

strong presence as food traders, especially in West Africa. Their sense of responsibility for feeding their families through farming is why women tend to predominate as rural and urban farmers when the food produced is for home consumption.

Recent data bear out these differences. Women form the majority of those working as urban farmers in East Africa in general, with 80 percent of farming households using exclusively female labor in the Kampala study from the 1980s (Maxwell 1995, p. 1672). This tendency was less pronounced in a stratified random urban sample from Kenya which found 56 percent of the labor was female, although there were more men in the smaller towns and more women (62 percent) in the capital (Lee-Smith & Memon 1994, p. 75).

Most data from West Africa have shown more men than women involved in urban agriculture, the difference being attributed to the fact that most of the food produced was for sale (Armar-Klemesu & Maxwell 2000; Obuobie *et al.* 2004). However, a recent study from Yaounde, the capital of Cameroun in West Africa, showed that 87 percent of urban farmers growing vegetables were women, with the percentages being 95 percent for those growing mainly for subsistence and 79 percent for those growing commercially (Bopda *et al.* forthcoming). In Kampala, the women growing crops on contaminated sites were doing it more to feed their families than were the men, who tended to sell more of the produce. Some even admitted they grew specifically for sale there and not for their families' consumption because they knew it was contaminated (Nabulo *et al.* 2004, p. 33).

The position on livestock keeping is different, especially in East Africa, where traditionally men, but not women, keep large livestock, especially cattle. However, recent studies in Kenya which perform a gender analysis have shown that although urban farming households acknowledge these conventions, most of the labor performed in looking after the animals is done by women (Ishani *et al.* 2002; Kang'ethe *et al.* forthcoming). Furthermore, poultry keeping is widely considered a women's task in many parts of Africa (Hovorka 2006; Kang'ethe *et al.* forthcoming). This aspect is also developed by Dimoulas and others in this volume (Chapter 10 below).

In both East and West Africa, women have been found to be more responsible for handling wastes than are men, an activity which is an important part of urban agriculture since domestic organic wastes as well as crop wastes and livestock manure are used as inputs in mixed farms. Women farming in low-income areas of Nakuru, Kenya were found to have a greater level of efficiency in manure re-use than men (Lee-Smith 2006; Karanja *et al.* forthcoming).

The negative health impact of a poor urban environment without water, sanitation and waste disposal was perceived by women much more than men in Dar-es-Salaam, Tanzania (Mascarenhas 1999; Lee-Smith 2006). Women in a low-income area of Kampala were both more informed and more aware than men of waste disposal practices and problems. However, while both women and men knew there were health hazards from human waste, they could do little to avoid the risk, due to the lack of services and their lack of power to change their situation (Kwagala 1999; Lee-Smith 2006). The gendered study of farmers on contaminated sites in Kampala found both that the women were farming in the more contaminated areas and that they less often used protective clothing while working than did the men (Nabulo *et al.* 2004, p. 33).

Men's and women's different roles in urban food production can affect both their awareness or perception of health risks and the strategies they use to mitigate them. These in turn may be affected by their knowledge and education. A gendered investigation of health benefits and risks associated with livestock keeping in Nakuru in Kenya found that the women were less educated and also less aware of how specific diseases are transmitted from livestock to people. Since women were found to be more involved than men in livestock-keeping tasks, their lack of education and awareness may increase the level of health risks (Kang'ethe *et al.* forthcoming).

Women's capacity to effect health risk mitigation strategies can also be limited by their power within the household. The gendered studies of urban livestock-keeping in Kenya found that while women were taking over many cattle keeping tasks, their control over decisions about their management were limited and the proceeds of the sales of cattle and milk were considered as belonging to men (Ishani *et al.* 2002; Kang'ethe *et al.* forthcoming). In Kampala, food production for household use is also considered a low status, economically marginal activity, and women specifically limit their activities so as not to be conspicuously successful and offend conventional gender stereotypes (Maxwell 1995, pp. 1673-4; Manyire 2001; Sebastian *et al.* Chapter 5 this volume). So far however, there are no studies investigating whether women's lack of power within the household affects health risk mitigation strategies in relation to urban agriculture.

STAKEHOLDER ASSESSMENT OF HEALTH RISKS AND BENEFITS

Two meetings in June and July 2002 brought together key stakeholders in urban agriculture and health in Kampala. The initiators of the project from University of Toronto and Urban Harvest invited convened people and institutions to identify the risks and benefits of urban agriculture in Kampala and establish a body to guide the research. Apart from officials of local and central government concerned with agriculture and researchers from Makerere University and the National Agriculture Research Organization, there were representatives of NGOs working with Kampala farmers and representatives of several of the Centers of the Consultative Group on International Agricultural Research (CGIAR). Using brainstorming to make a broad assessment of what health risks and benefits of urban agriculture should be investigated, these stakeholders developed the framework that would give direction to the research.

The main health benefits of urban agriculture in Kampala were identified as:

1. Improved nutrition including dietary diversity:
 - protein from livestock and livestock products,
 - energy from staples, mainly *matoke* (banana) but also cereal and root and tuber crops, and
 - micro-nutrients from fruit and vegetables which grow in abundance, especially traditional vegetables.
2. Nutritional benefits as mitigation of effects of contaminants and HIV-AIDS, including production of medicinal plants.
3. Use of organic waste to produce food (vegetable compost and livestock manure).

4. Psycho-social benefits of physical labor, greening the city, self-esteem, community organizing and social capital.

The main health risks associated with urban agriculture in Kampala were identified as:

1. 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 economic activities.
2. Bacteriological and toxic contamination from cultivation in areas where soil is polluted by garbage, run-off or other sources.
3. Bacteriological and toxic contamination of well water.
4. Transmission of disease from livestock to humans (zoonoses).
5. Air pollution from industry and traffic.
6. Poor handling of waste and its use for farming (mixing of organic and inorganic).

After beginning the process of guiding the research direction, the group formalized this at its second meeting by constituting the Urban Agriculture Health Coordinating Committee (HCC) with a representative array of stakeholders. The crucial task of identifying how, and through what studies, such investigations would be carried out through the life of the project given available resources, fell within the competence of the researchers who were members of the HCC and they formed an active sub-group.

The list of perceived risks and benefits was translated into an array of studies amenable to scientific investigation that would provide as much of the required information as possible. This list also had to be responsive to the team's disciplinary strengths and weaknesses and the additional resources, including financial, which could be raised through their efforts. The subjects to be investigated were:

- Aspects of food security affected by urban agriculture
- Aspects of nutrition affected by urban agriculture
- Contamination of urban crops by pathogens
- Contamination of urban crops by heavy metals
- Threats to health coming from complex organic compounds via urban agriculture
- Health risks from zoonoses transmitted to people by the most common types of livestock in Kampala, namely chickens, cattle and pigs.

The results of this array of studies form the essential core and subject matter of this book, contained in Chapters 5 through 11, in Sections B, C and D. The different studies varied in depth and complexity depending mostly on the resources, both intellectual and financial, which could be mobilized. For example, a study of the use of organic wastes as pig-feed had to be postponed until 2007 because of lack of funds.

Within each of the specialized research studies emerging from this analysis, a specific methodological approach was developed to involve communities. These are described in each chapter in the three sections of the book below, dealing with Urban Food and Nutrition Security, Healthy Urban Horticulture and Managing Urban Livestock for Health. The principle of feedback

of research results to the communities from whom data were collected was reiterated in each meeting of the Health Coordinating Committee, and the commitment to develop public health messages based on the findings of the research was also made by the committee.

The ethical position on community feedback of research results was one of the concerns that led the Committee eventually to establish itself as an independent research body, with a constitution and registered as a non-governmental body in Uganda, devoted to the production and application of urban agriculture research. This story is told more fully in Chapter 12 below.

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CHAPTER 3

Researchers' approaches to evidence on urban agriculture and human health

Donald C. Cole • Delia Grace • Miriam Diamond

Urban agriculture has been lauded as an economic survival strategy for poor families in difficult times, advocated as providing food for the poor, and vilified for contaminating urban food chains. How can civil society organizations, municipal managers and public health practitioners sort through these competing claims? Further, how can researchers provide grounded, locally relevant research that refutes or substantiates urban agriculture as promoting or damaging the health of producers, traders and consumers?

This chapter picks up the threads of Chapter 1's history of urban agriculture and health and introduction of ways to understand their relationship. It also tries to respond to the community and stakeholder perceptions laid out in Chapter 2. We describe how researchers in diverse disciplines, including physical chemistry, urban geography, development sociology, veterinary epidemiology, risk analysis, research synthesis and public health sciences, understand and conceptualize – or “frame” – the relationships between urban agriculture and human health. We review concepts of cities as systems and the implications of this for our understanding of urban agriculture and health relationships. We summarize and discuss documentation of the benefits and harms associated with urban agriculture, including the “how” of their documentation and synthesis. Finally, we provide recommendations for studying the health benefits and hazards associated with urban agriculture in cities such as Kampala.

CITIES WITH URBAN AGRICULTURE AS A SYSTEM AND CONTEXT FOR HEALTH

Cities as Systems

In-migration is the sincerest form of flattery, and the massive human migration to cities in lower and middle-income countries is powerful testimony to the draw of urban over rural livelihoods. For migrants, cities can improve quality of life, provide work opportunities, and improve access to a wider range of services, while for societies, they bring economies of scale and higher economic productivity (De Haan 2000). But these opportunities and advantages rest on efficient resource and waste flows, themselves dependent on adequate infrastructure, developed human capital, substantial financial resources and competent governance.

While some resources are drawn from outside, others are embedded in the city as its physical infrastructure or material stock (e.g. building materials) or mobile resources generated within the city boundaries (e.g. urban agriculture). The material stock is many tons per person and flows of materials have also increased in recent times, the greatest increases coming from material flows for cleaning and waste management, followed by communication and residence (Brunner & Rechberger 2001). Thinking of cities as organisms with an urban metabolism helps understand these stocks and flows (Kennedy *et al.* 2007; Kennedy 2008) and provides the insight that massive resource flows in poorly managed cities result in a dysfunctional city metabolism. Resource use exceeds capacity to assimilate and disperse wastes; toxins accumulate, vital functions deteriorate and eventually systems fail. Municipalities in developing countries have been estimated to collect only 30-60 percent of the waste in their cities, while serving just half the population (Bazoglu *et al.* 2006, p. 132).

Urban agriculture in a city systems context

Urban agriculture (UA) comprises a broad set of agricultural activities carried out in cities or in close proximity. As indicated in Chapter 1, urban agriculture has had an intimate relationship with cities historically, accepting organic wastes, including treated human sewage and providing fresh foods in return. For example, the process of urban-rural nutrient recycling was prevalent in China, where 14 of the country's 15 largest cities were largely self-sufficient in food, supplying a majority of their food requirements from agricultural suburbs, which were kept fertile using treated human waste (Girardet 1992).

Conventionally, the benefits of farming in poor countries are measured in terms of income and food security; a more inclusive assessment includes contributions to biological diversity, ecosystem services, psychological well-being and social sustainability in poor urban areas. As conceptualized by Spiaggi and colleagues (2005) when describing work in Argentina, indicators of urban agro-ecosystem function include: 1) environmental (biodiversity, soil composition and water quality); 2) social (diversity of participants, extent of participation); 3) economic (resource inputs, income and in-kind outputs); and 4) technical and productive factors (e.g. quality of vermi-compost). Each of these can also be seen as determinants of human health.

Cities and human health

Cities influence health in positive and negative ways. Above all, cities offer a wider range of livelihood options than are generally available to the rural migrants that flock to them. Further, cities have invested in infrastructure providing market access, clean drinking water, sanitation services and public safety for at least some residents. Combined, income and services contribute to what has been viewed as "the urban advantage". However, when confounding factors are removed this advantage disappears for the urban poor (Bazoglu *et al.* 2006, part 3; Vlahov *et al.* 2007), who not only have fewer livelihood opportunities and access services (in comparison to the rich) but also greater exposures to health threats.

Inequities across social groups defined by race, caste, income or assets are increasing in many lower and middle-income countries (Vlahov *et al.* 2007). Air and water pollution disproportionately affect the urban poor (Stephens 2000), the most visible manifestations of inequity being the burgeoning slums (WHO 2005). The association between slums and sickness is consistent and alarming: Nairobi slum children suffer diarrhea episodes, a leading cause of death in malnourished cities, at least monthly (APHRC 2002). Housing and other environmental and social conditions in these slums generate health impacts that span all stages of the “epidemiological transition” i.e. infectious diseases such as malaria and water or food borne diarrhea (category 1), chronic diseases such as diabetes and heart disease (category 2), and injuries (category 3) (Campbell & Campbell 2007).

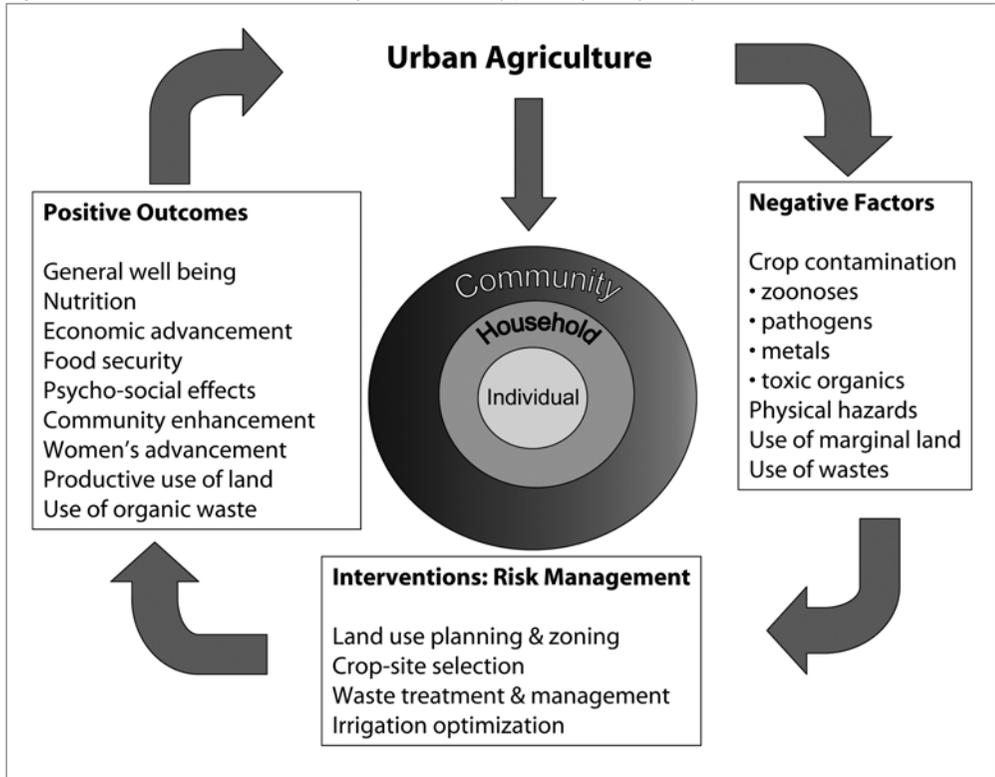
Urban, including global, influences have brought other changes to living and food systems that impact the health of urban populations. The intensity of interactions, fast pace of city life, availability of recreational drugs and scattered social networks can impact negatively on mental health. Close proximity of vehicles, widespread availability of firearms and inadequate public safety all contribute to more frequent injuries (UN Habitat 2001). Urban women often work outside of the home, making breast-feeding and child care more difficult and reducing time available for providing nutritious yet inexpensive meals. At the same time, greater access to fast foods, supermarkets and advertising in cities can result in a more calorie-rich diet, spurring obesity among urban populations (Maxwell *et al.* 2000; Garrett 2000).

THINKING ABOUT HUMAN HEALTH IMPACTS ASSOCIATED WITH URBAN AGRICULTURE

This section tries to deconstruct UA benefits and harms in relation to urban living and in relation to rural agriculture. Focusing down from cities in general to UA in particular reveals a related complex mix of potential health benefits and harms both for urban agriculturalists themselves and for their suppliers, neighbors and clients (Brown & Jameson 2000; Flynn 1999). The greater dismay over potential health risks than celebration of health benefits associated with UA (Lock & De Zeeuw 2001) can be attributed to the cognitive bias of risk averseness: given the choice of avoiding a loss and obtaining an equivalent gain most people prefer the former, which works against efforts to understand and weigh the benefits and harms of UA.

A conceptual model of UA is needed to link the numerous factors that impinge positively and negatively on human health. Figure 3.1 summarizes the factors that positively and negatively impact health at individual, household and community levels. In turn, these factors inform management actions that can be taken to strengthen the positive outcomes by ameliorating the negative aspects. We see the individual nested within the household, which customarily provides the psycho-social and economic well being of the family to the individual. The family is nested within community that also intimately affects family and hence individual well being. The community, in turn, is influenced by a range of cultural, political and economic factors.

Figure 3.1 Factors associated with urban agriculture that may positively or negatively affect human health



Decision-makers may need to distinguish between potential health benefits and hazards associated with urban agriculture *per se* versus those attributable to living in cities, as noted above. Further, they wish to distinguish those associated with conducting agriculture in cities *per se* versus those that occur with agriculture, whether urban or rural. While public health has conventionally only been concerned with human health risks from an ecosystem perspective, these are a subset of interlinked 'health' risks including:

- From the environment to animals and people: Chemical agents in the soil, air and water which harm livestock and city farmers e.g. lead
- From crops to animals and people: Biological or chemical agents in food crops and animal fodder that harm livestock and humans e.g. aflatoxins
- From animals and people to animals: Human- or animal-origin diseases that decrease health and production in livestock e.g. tuberculosis
- From animals to people: Diseases that livestock pass to humans e.g. cryptosporidiosis

An ecosystem perspective that positions human health in this context of livestock and environmental health helps in understanding causation and association. While agriculture may give rise directly to some hazards, it may also cycle, reduce or increase hazards originating from other sources. For instance, livestock may act as concentrators, multipliers or eliminators of hazards transmitted through wastewater to people:

- Concentrator - Organic chemicals are stored in liver or kidney, resulting in higher concentrations in livestock organs than in the source water e.g. cadmium (Sedki *et al.* 2003);
- Multiplier - Calves infected by a few hundred *Cryptosporidium* oocysts in water can subsequently shed many million oocysts that are infective to humans;
- Eliminator: Antibiotic residues in water consumed by cattle are broken down in the rumen, and the milk produced by the cattle is free of residues

Banning agriculture from cities re-distributes the burden of ill health associated with being around agriculture or working in agriculture (Cole 2006), such as those above, towards rural populations. Hazards associated with agriculture and food contamination are mostly not location-specific; while in some cases, urban environmental conditions do increase the likelihood of hazards causing harm (e.g. diseases associated with overcrowding and confinement such as tuberculosis), these are balanced by other cases where urban environments reduce risk (e.g. diseases associated with wild ruminants or extensive grazing will be less of a problem). Teasing out these distinctions is hard for a research project focused only on urban agriculture such as the one in this book, both because of the complexity of relationships determining health benefits or harms in ecosystems and the limited resources available.

MAJOR HEALTH BENEFITS WITH URBAN AGRICULTURE

Contributions to urban livelihoods, as indicated by Kampala farmers in Chapter 2, are the major benefits associated with urban agriculture. As regards livestock, substantial evidence has accumulated on the livelihood benefits of animals in cities including dairying (see www.sdp.org); but crop production has been and remains a major contributor to urban livelihoods (Box 3.1). Given that poverty is a primary determinant of health, reduction of poverty is associated with decreased vulnerability to ill health and greater options for coping with its consequences. Nevertheless, urban livelihoods are complex and varied (for example women and men have substantially different components to their respective income sources and resources), and agriculture may only dominate livelihood strategies in peri-urban interface areas (Maxwell *et al.* 2000 re. Accra, Ghana; Brook & Dávila 2000, Chapter 6 pp. 156-217, for Hubli-Dharwad, India and Kumasi, Ghana; Aberra 2006 for Yabello, Ethiopia).

Box 3.1

In pre-colonial Nigeria, the edges of cities consisted of intensively farmed land where the majority of the urban population worked each day (Winters 1983) while in eastern and central African cities, the quarters of these cities were separated and the spaces between them used for farming. As one observer said of Kampala, "it was less of a city than an immense garden" (Gutkind 1963). UA expands during times of hardship and food insecurity and as economies improve, farming out of necessity is replaced by farming for recreation and to obtain healthier food. The last two decades have seen participation in UA in sub-Saharan Africa increase from 10-25 percent of the population to up to 70 percent (Rogerson 1997), largely in response to economic pressures, but also fostered by development initiatives and an increasingly supportive political climate.

In parallel work, the Kampala team documented the importance of agriculture as a contributor to livelihoods in many urban households, though considerable variation occurred as to the extent of activity and the specific role of crop production and livestock raising (David *et al.* forthcoming). But constructing livelihoods in complex urban labor markets is a formidable challenge for the poor and rural migrants (De Haan 2000). Although the latter may be only temporarily located in urban areas, they may also have responsibilities for remittances back to rural household members (Tacoli 2000). Given the greater dependency on cash income and the low wages from work at insecure jobs (Frankenberger *et al.* 2000) and the responsibilities for childcare, particularly among women (Engle 2000), urban households must juggle a range of activities to obtain income, procure food and other resources and care for household members.

Hunger alleviation and improvement of nutritional status either from consumption of UA products directly or more commonly from the money generated by selling products, is usually considered the second major benefit of UA. For the 40 percent of city-dwellers living in poverty, food purchases make up 60-80 percent of the household budget (Garrett 2000). First-line coping strategies include: purchasing in cheap nearby informal markets; relying on street-vended food (40 percent of the food budget among the poorest); and engaging in urban agriculture. Urban agriculture also underpins the first two strategies: most of its products are sold in informal markets, and street food vendors source mainly from these. At the family level, food insecurity comes as a result of the complex interplay between low and variable family incomes and high per-unit food costs due to inefficient food-marketing systems in urban areas (Garrett 2000). Nearly all urban farmers auto-consume at least some products, obtaining calories, supplying nutritional deficits and smoothing fluctuations associated with seasonal changes in grain prices. Micro-nutrients and high quality protein are scarce in developing country diets and can be supplied by livestock products and fresh fruits and vegetables (Yeudall 2006). Urban agriculture can also address the 'dual burden' (increasing obesity and diet related disease in the face of persisting under-nutrition) through providing fresh fruit and vegetables.

Another important health benefit is generating income required for health care; this is a major use of cash generated from farming, especially when controlled by women (Baumgartner & Belevi 2001). Other health benefits include: the psycho-social support provided by urban gardening; biophilic gratification from keeping livestock; aesthetic pleasure from a greener environment; enjoyment of home-produced food; and opportunities for outdoor exercise. These are harder to measure, but in some settings, even among the very poor, they may predominate (Slater 2001).

POTENTIAL HARMS ASSOCIATED WITH URBAN AGRICULTURE

A useful set of categories for the potential health harms associated with urban agriculture is: physical, psycho-social, biological and chemical (Cole *et al.* 2006). Although important, physical and psycho-social hazards were not further investigated systematically in Kampala, beyond the participatory assessments described in Chapter 2. Some basic distinctions between biological and chemical hazards associated with urban agriculture are set out in Table 1 below.

Physical hazards usually involve some direct transfer of energy to the body, as in a violent attack on a farmer irrigating at night, with the resultant injury. Almost half of urban cultivators in Nairobi, Kenya have been exposed to theft, the majority of victims being women (Freeman 1991) and free-roaming livestock can damage gardens as well as being traffic hazards (Lee Smith *et al.* 1987). Plastic bags, nails, broken glass and metallic shards in waste dumps used for urban agriculture may cause injury directly to the farmer, farm children or others if ingested or handled.

Psycho-social hazards include the stresses of work overload resulting in adverse psycho-social effects especially for women (Avotri & Walters 1999). Anxiety and stress resulting from land insecurity or the unclear legal status of farming or the fear of losing livestock or crops through theft or disease are also factors.

Biological hazards include small living organisms that can infect animals and human beings. Most important are viruses, bacteria and parasites of different kinds. Three major routes of exposure to different kinds of pathogens have importance for urban agriculture: wastewater, crops (for details of both see Table 9.1 in Chapter 9), and livestock (for pathogens associated with livestock see Box 11.1 in Chapter 11), either directly or via their waste or products (see Dimoulas *et al.* Chapter 10). Other, under-researched pathways, include fodder, vectors associated with urban agriculture, urban wildlife and pests.

Chemical hazards are widespread in cities (Diamond *et al.* 2001), and many enter the food system, most inadvertently. For a range of contaminants, food consumption is the major route of exposure in the general human population and dietary intake rates of some contaminants in “average urban” populations are above tolerable limits. At the same time, many of the foods that contain elevated concentrations of contaminants also confer considerable health benefits (as above). People and animals may also be exposed to chemical hazards through water, direct contact or aerosol. Priority chemical hazards include: pesticides, fertilizers, drug residues, metals (see Chapter 7), hormones, combustion by-products (see Chapter 8), and industrial by-products and pollutants.

Table 3.1 Differences between biological and chemical health hazards in UA

Hazard	Biological	Chemical
Type	Pathogenic*	Toxic
Source	Excreta, organic matter, especially in decay	Manufacturing processes & products & combustion products
Main exposure pathways	Solid waste & wastewater	Solid waste, wastewater, air
Behavior in environmental media	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. Some sewage treatment and water purification	Currently limited – some source controls, re-use, emission controls, and landfill burial

* Some biological organisms are beneficial e.g. soil bacteria. Here we only refer to pathogenic bacteria, viruses and parasites

ASSESSING BENEFITS AND HARMS OF URBAN AGRICULTURE

A conceptual framework is a first step in organizing thinking about health benefits and harms, but going from knowledge to action requires practical methods to generate credible information. Four families of approaches with potential to profoundly increase the capacity of stakeholders to measure and manage the impacts of urban agriculture are presented here: Participatory Learning and Action (PLA), Health Impact Assessment (HIA), Evidence-based Policy, and Risk Analysis.

PLA

For documenting the benefits of UA in general (Chapter 2) and for particular aspects (e.g. smallholder-dairying in Chapter 11), participatory methods have been invaluable to the studies in this book, providing overviews and allowing in-depth descriptions. They put a 'human face' on statistics. Participatory approaches are advocated on two grounds: ethics and expediency. People have a right to participate in questions affecting their livelihoods and participatory approaches can empower urban agriculturists and their clients. Development theory suggests and practice demonstrates that interventions based on participation, local needs, capacities and social realities are not only more effective than top-down implementation, but deliver the benefits of enhanced social capital and empowerment.

The sustainable livelihoods framework, a recent addition to the Participatory Approaches family, offers a way of categorizing the benefits of UA in terms of its contribution to five 'capitals' (DFID 2006): human capital (nutrition, farming skills), natural capital (soil fertility, removal of toxins); physical capital (farm buildings, infrastructure); financial capital (farm income and fungible assets such as livestock); social capital (gifts of farm produce, status as a farmer). Urban agriculture's contribution to sustainable livelihoods has been one of the major advantages cited by many authors (Tinsley 2003), particularly in providing food security among vulnerable populations (Yaro 2004).

But the qualitative and often subjective information generated by PLA may not answer all valid questions. To generate cost and profit information for example, of great interest to decision-makers, economic analyses using established methods (e.g. enterprise and partial budgets, market analysis, supply chain studies, efficiency analysis, econometric analysis etc.) are required, something common in agriculture in general and applied extensively to the impact of AIDS in recent years (Gillespie 2006).

HIA

Health impact assessment (HIA) is "a combination of procedures, methods and tools by which a policy, program or project may be judged as to its potential effects on the health of a population and the distribution of effects within the population" (WHO Gothenburg Consensus Paper cited in Kemm *et al.* 2004). Approaches to HIA for urban and peri-urban resource development projects have included UA as discussed in Chapter 1 (Birley & Lock 1999). Most HIAs include a core set of components: identification of potential health hazards,

assessment of potential health impacts and suggested implementation of health safeguards or risk mitigation measures.

The first step of an HIA is to identify potential health hazards and benefits. This is a broad scoping exercise aimed at examining all potential health hazards including those in common with rural agriculture as well as those unique to UA. Following the risk analysis framework, potential health hazards are often classified as physical, psycho-social, biological or chemical as above.

The second step is assessing potential impacts. Three approaches generally used may be summarized as: health outcomes, economic, and sociological approaches.

Health outcomes, promoted by WHO, is the standard method for disease burden assessment. Health adjusted life years (HALY) counts equivalent years of 'healthy' life lost due to poor health or disability and potential years of life lost due to premature death, with a discount reflecting societal preferences (years lost to the very young or very old count for less). Disability adjusted health years (DALY) are commonly used, one DALY being one lost year of 'healthy' life.

Economic measures to assess the value of health impacts include cost of illness, human capital, hedonic pricing and willingness to pay. Cost of illness measures the direct and sometimes indirect cost of being sick: medical fees, lost productivity, psychological suffering, etc. Human capital methods assess the reduction in lifetime contribution to the economy. Hedonic pricing assesses the extra wages needed to make risky jobs attractive to workers (e.g. mining) or the expenses incurred in trying to avert risk (e.g. boiling water). Willingness to pay assesses how much people would be prepared to pay to avoid negative health outcomes. Estimates given by these methods rarely converge and all are open to ethical objections. For example most people prefer to ignore income when allocating health resources and to support the worse off, children, and those whose behavior has not contributed to their health problem, all of whom would be ignored by economic analyses.

Sociological measures enrich our understanding of health impacts by capturing emotional, social and psychological effects. For example, cysticercosis (caused by larval stages of the pig tapeworm) is the most common cause of adult-onset epilepsy in developing countries. Epilepsy is often attributed to demonic possession or necromantic attack – as such the impact is far greater than health or economic metrics would suggest.

The final step of the HIA is the recommendation of actions to decrease the adverse impacts on health. Simple, cost-effective, attractive strategies that work and are sustainable are critically lacking. For example, past food safety and quality initiatives, focusing on elimination of urban agriculture and informal food markets, have used approaches that can too often be characterized as top-down, technocratic, gender-insensitive and unsustainable.

Technically effective strategies for risk mitigation undoubtedly exist and have been summarized by Kang'ethe *et al.* (2007) as: education of farmers on hazards and prevention; quality labeling of products; education of consumers on hygiene; planting strategies to prevent lead contamination; animal health programs to reduce the double burden of zoonoses; pollution assessment and zoning of areas; monitoring of fresh urban solid waste treated soil and crops; composting methods and variable sorting to control chemical and

microbiological agents; programs to eliminate schistosomiasis occupational risks in freshwater fish farming; washing and peeling to reduce microbial loads of vegetable and fruit crops irrigated with polluted river water; crop restriction by prohibiting crops most likely to transmit disease. But information on selection, costs and, especially, sustainability of these and other strategies is lacking. In most cases the strategies appear to have been based on the discovery of a problem or potential problem creating anxiety among stakeholders, without any rigorous assessment of the actual risk represented to human health.

Evidence-based policies

What worries people often diverges from what makes them sick or kills them. We worry disproportionately about risks that are novel, unnatural, imposed by others, outside our personal control, highly publicized, mis-managed by authorities, benefit someone else or occur to famous people (Covello & Merkhofer 1994). We tend to under-estimate familiar, natural, voluntary and manageable risks that provide us important benefits. Biological hazards generally impose a far greater burden than chemical ones, yet people are typically more concerned by the latter. Neighbors may object to a noisy and smelly factory but continue to use household cooking fires that release more air pollutants and lead to more respiratory illness. In Sandman's much-quoted phrase: risk = hazard + outrage, and while the public pays too little attention to risk, experts often ignore 'outrage' (Sandman 1987). UA, under-researched because of its illegality, suffers from responses driven by outrage rather than by evidence and the failure to take into account the extent of both benefits and harms. Getting evidence and science into policy making (from local to global) can counter the tendency to make intuitive and wrong decisions about UA.

But moving towards evidence-based policy is challenging. The first problem is agreeing what constitutes evidence. Different disciplines approach assessment of credibility (e.g. Katrak *et al.* 2004) and research synthesis (e.g. Greenhalgh *et al.* 2004) differently, drawing on the nature of their research, historical traditions and "cultures of evidence". Nevertheless, for particular studies some common elements can be discerned: clearly defining how sampling was carried out (what, with whom, control groups, where, when including single or multiple visits); explicitly describing the nature of data collection or testing (type of test, test properties such as validity and reliability, quality controls); noting the analysis methods (focus, statistics, number of comparisons made, examination over time); and indicating how inferences were drawn (key criteria, comparisons with literature). Various hierarchies have been developed, starting with anecdote and intuition at the bottom, ascending through observational studies, case-controls and clinical trials to the 'gold standard' of a meta-analysis of randomized, controlled trials, carried out in multiple centers according to best-practice e.g. CONSORT or STROBE guidelines (CONSORT; STROBE).

In developing countries even studies of low scientific quality are scarce, but this does not obviate the need for researchers, practitioners, and policy makers to conscientiously investigate gray and published literature (Kang'ethe *et al.* 2007). Based on this, they can identify glaring gaps e.g. Kang'ethe and colleagues found few studies on the livelihood impacts of urban livestock keeping and notable inconsistencies (e.g. contradictory evidence

for an urban link with brucellosis). For topics where a substantive body of research exists, questions on quality can then be asked: Were the methods rigorous? Are the findings credible? Do they still hold? Are they generalizable and, if so, to what population? What and how disabling are the biases? The generally observational literature on UA and health is unfortunately far from ideal and the majority of reviews have not critically considered study quality. Through this book, while celebrating what has been well done under often difficult circumstances, we therefore highlight areas for further applied research in conjunction with stakeholders on important areas of health benefits and potential risks.

Even when evidence has been assembled and weighed, communicating it to the range of interested stakeholders is not straightforward. For example, laboratory tests often give attractively clear results (positive or negative) that seriously over-simplify the complex nature of disease diagnosis. In Chapter 11, the authors used two out of 25 available tests. Because isolation of brucella microbes (the 'gold standard' test) is difficult and slow, most tests detect the presence of antibodies, the animal's defense against microbes which indicate that a cow has been exposed to brucella by infection or vaccination and its immune system has mounted an attack. Different tests detect different antibodies and tests vary in their ability to detect animals that are really sick (called test sensitivity) and to give a clean bill of health to animals that are actually well (called test specificity). What is rarely appreciated is that accuracy of a result depends not only on these test properties but more importantly on how much disease occurs in the population.

Another danger is that establishing an evidence base leads to 'paralysis by analysis' – the criticism that experts know too much to ever recommend anything at all, and confine their conclusions to calls for additional research (preferably at their institute). But researchers often feel legitimately torn – they want to believe their findings really demonstrate something in order to give practitioners and policy makers "answers", yet they know these findings may be ambiguous or their research methods problematic with regard to sampling, testing and analysis. It is safer to demand more and better research, but the opportunity costs of waiting must be considered. Here, the precautionary principle is often invoked: a lack of information does not justify the absence of management measures (FAO 2003).

Risk analysis

Perhaps the greatest challenge for UA studies in developing countries is to move beyond identification of health hazards to risk quantification. Epidemiological studies usually focus on the negative: identification and characterization of disease. Methods for disease detection are generally established, easy to apply, and give relatively good answers. The answers they give do not necessarily address the questions consumers and policy-makers want answered however. Epidemiological surveys tell us about pathogens while most stakeholders want to know about impacts on human health and livelihoods. Risk assessment bridges these two perspectives. Starting with hazard identification, risk assessment then characterizes hazards, investigates how humans can come in contact with them, assesses the actual exposure to them given events along the food value chain and the practices of consumers, and finally assesses the ill effects resulting from exposure. Probabilistic modeling is used to take account

of natural variation and uncertainty. The results are expressed in ways that other stakeholders can easily access (for example, “we anticipate ten cases (plus or minus 4) of *E. coli* related food poisoning for every 10,000 milk portions consumed’ or “in this parish six people are likely to fall sick every year from brucellosis as a result of drinking un-boiled milk.”)

Risk assessment has not yet been widely applied in developing countries however. One problem is lack of information and experience on how to apply a structured risk assessment framework. Another is that the fluid and complex systems in smallholder production can overwhelm analysis, resulting in retreat to the safety of scientific tests. Risk analysis was developed in the context of homogenous, standardized, industrial production systems and its methods reflect this. The risk assessment approach adopted for Chapter 11 was able to identify (some) important hazards and generated interesting information on milk-related practices on the farm and in households (presented in the next section), but definitive assessments on the impacts of these hazards on human health require further studies. This highlights the difficulty of analyzing exposure routes or probable impact and demonstrates the urgent need for information and examples to guide risk analysis in the context of developing country local markets. This is important because generating information on hazards without corresponding information on risks can be counter-productive, leading to an unnecessarily negative view of urban farming, when in fact many of the hazards identified may not pose risk to human health.

Another important contribution of risk-based approaches is in the emerging and still terminologically confused field of Hazard Ranking¹ – that is determining out of the universe of hazards that are actually present in a given situation what is their relative importance. In the studies in this book, a wide range of hazards had been initially selected but because of resource constraints only a few could be investigated, and these varied in their seriousness and probability of occurrence. Given the great number of potential hazards, it would be helpful if studies explained their choice of hazard, but this is rarely seen in the literature. Comparative risk assessment can provide the type of information needed by decision-makers in setting priorities, and in preventing the diversion of resources to high profile but low impact problems (SARS versus malaria) but the approach has not yet been applied to developing country problems.

Without a framework for identifying the risks most harmful to human health, or most important because of policy objectives (e.g. diseases which are easily controlled, diseases with high impact on vulnerable groups, diseases with implications for trade) there is risk that studies may be driven by the availability of tests or the interests of investigators. In the absence of systematic hazard ranking, information can be extrapolated from analogies with common hazards in developed countries e.g. salmonellosis and campylobacteriosis are the most common food borne diseases associated with poultry in developed countries so might be expected to be also problematic in developing countries. Another source, and perhaps more useful, is historical data. For example Foot and Mouth Disease (FMD) was believed to be common in children before pasteurization became widespread, suggesting it might be a problem in developing countries where FMD is endemic and

¹ Varies known as Risk Attribution, Risk-Based Priority Setting, Comparative Risk Assessment (CRA) and Maintaining a “Risk Register”.

milk is commonly drunk raw. Adoption of the risk assessment framework, with its focus on process and the identification of critical points along the supply chain from cow to consumer, can give insight into potential hazards.

FROM RESEARCH TO USE AND FROM KNOWLEDGE TO ACTION

In the previous sections we discussed a conceptual framework for assessing benefits and harms of UA. In this final section we briefly discuss practical applications and perspectives relevant to the “real world of policy” (Sutcliffe & Court 2006).

Developing a road map

If you don't know where you are going, then any road will get you there. Scoping the study can be a powerful tool for engaging stakeholders in a common vision for understanding UA, mitigating its harms and maximizing its benefits. Scope encompasses vision, goals and objectives, methodologies, boundaries and constraints. An incomplete, ambiguous, unshared or unstable (creeping) scope reduces the value of the study to stakeholders. Risk assessment formalizes the articulation of scope, facilitating both communication and planning.

The focus of the study should be justified in terms of hazards included and hazards excluded; where there are multiple hazards, some evidence-based ranking or prioritization is needed. The *ad hoc* approaches generally used can be informative but can also lead to the omission of important hazards and inclusion of less important ones.

Policy and decision makers find it easier to balance different (and sometimes, though not necessarily, competing) objectives and methodological approaches which are consistent across research questions: if analysis of benefits is qualitative while analysis of hazards is quantitative integrated assessment is more difficult.

Acknowledging and managing trade-offs

Tradeoffs (balancing benefits and risks) are inevitable and complicated by ignorance of the extent of harms and benefits and inequities in their distribution. Sometimes, genuine win-win situations exist. Tastier cocoyams and clean milk production will decrease wastage and spoilage and deliver benefits to farmers and traders as well as consumers. In some markets safe food commands a price premium, providing incentives for farmers to supply it. Reduction of neurotoxic insecticide use among potato farmers was estimated by agricultural economists using a Tradeoffs Analysis tool (Antle *et al.* 1998) to produce increased farmer neuro-behavioral scores and farm productivity; farmers and consumers both had incentives to reduce pesticide use.

More commonly, improving food safety has net costs that often fall on the poorest and most vulnerable. In this scenario, decisions have to be made about an ‘appropriate’ or ‘acceptable’ level of health risk for a given market. Among those urban households experiencing recurrent hunger, “food on the table” to allay hunger may have higher priority than avoiding the longer-term risk of chronic diseases such as cancer due to Polycyclic Aromatic Hydrocarbon (PAH) exposure from air-pollutant contaminated vegetables.

This is complicated when one sub-group incurs the costs of health mitigation while the benefits accrue to a different group. In Kumasi, Ghana, use of cheap poultry manure for vegetable production is common. However, in certain seasons, 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).

CONCLUSION AND PERSPECTIVE

If you can't document and measure it well, you can't manage it well. This chapter has primarily focused on a science-based identification and assessment of the human health impacts associated with UA. However, assessment is ultimately sterile unless it leads to appropriate action and change. Assessment that fails to engage and generate ownership among relevant stakeholders of UA is likely to be futile. We strongly advocate that all efforts dedicated to identification, prioritization and mitigation of hazards specific to UA must be conducted through multi-stakeholder processes involving communities engaged in UA, municipal policy makers that must be motivated to manage cities for the benefit of all citizens, and transdisciplinary research teams. This book gives examples of how this can be done – diverse stakeholder perspectives as per Chapter 2, community & stakeholder roles in policy processes as per Chapter 4, and participatory approaches building on what farmers and community members are doing as per Chapter 12.

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CHAPTER 4

Healthy urban food production and local government

Christopher Gore

INTRODUCTION

This chapter examines the relationship between health and urban food production from the perspective of government, using a critical, political science approach. Despite increasing support for and promotion of urban agriculture (UA), little research investigates it as a political and policy problem¹. There is abundant research critiquing the absence of food policy and its need to be responsive to citizens and the rapidly changing international food market (Koc *et al.* 1999). There is also recent scholarship on UA promoting municipal governments' development of inclusive and participatory decision-making processes to ensure long-term policy success (Mougeot 2006, 2005). Similarly, recent scholarship on health and cities (Burriss *et al.* 2007) bridges the knowledge on 'social determinants of health' and 'governance' to advance arguments for how weaker or marginalized actors in urban centers can engage in the process of improving health outcomes. Despite these contributions, the policy and political dimension of UA research tends to prescribe what governments should be doing rather than examining how things are done – how food and agricultural policies are deliberated within government, the reasons why UA does or does not become a central policy issue, or how non-government actors can or do influence decision-making about food security and food policy.

These are questions about the politics of urban food production; they focus on the conflicts and debates that arise between actors when deciding what ought to be done, who should have decision-making authority, and who should be included in decision-making. The disciplines of political science and policy studies remain equally quiet on the policy significance of UA (Maxwell 1999). Ten years ago it was stated that "Although in recent years there has been a growing research interest and emerging literature on urban and peri-urban agriculture... relatively little attention has been given specifically to... the decision-making processes involved" (Binns & Lynch 1998, p. 779).²

¹ The terms 'urban food production' and 'urban agriculture' (UA) have the same meaning in this chapter, that is, the production of food, both crops and livestock, as well as aquaculture, within the urban boundary.

² The absence of attention to policymaking processes relating to UA holds for policymaking in general, despite long-running emphases on policy reform in Africa (Keeley & Scoones 2003).

The processes by which governments come to support or neglect the links between and knowledge about UA, food security and health need to be investigated because ‘politics’ and ‘policy processes’ influence the character and content of food policy in a fundamental way (Maxwell & Slater 2003, pp. 543-544). These observations highlight the need to investigate and explain the opportunities and constraints for urban food production to remain key public and health policy considerations, and to remain on, or reach a government’s formal agenda (Lee-Smith 2004). This chapter takes up the challenge of trying to understand what is needed for cities to develop healthier and more sustainable urban food policies and practices using a political science perspective. It focuses on how governments come to terms with competing knowledge about and arguments for and against urban food production. While not a panacea, applying a political science perspective can advance understanding of the constraints and opportunities for improving urban health and food security.

The chapter first identifies global and regional reasons to explore the politics and policy of urban health and agriculture, and then examines the historic and current relationship between urban agriculture and municipal politics in Africa and Uganda. It goes on to suggest that future research on the politics and policy of urban agriculture can benefit from the application of a ‘governance’ approach – an approach that emphasizes the power relations between actors in urban agriculture, the knowledge that is included and excluded from decision-making, and the forums or spaces where decision-making takes place. This approach combines the rich scholarship relating to urban governance and a framework for analyzing African policy processes that is cognizant of international through to local influences (McGee 2004). The chapter concludes by revisiting and emphasizing what the field of urban politics can add to the study and advancement of healthy urban food production.

URBAN FOOD POLICY AND POLITICS: GLOBAL AND REGIONAL INFLUENCES

On February 13, 2008, the Food and Agriculture Organization (FAO) announced that thirty-six countries were experiencing food crises. Of these, twenty-one were located in Africa. The FAO and World Bank both noted that the food crises stemmed largely from increased food prices, particularly those of cereals. These have been exacerbated by high energy and fertilizer prices, the demand for food crops for bio-fuel production and low food stocks, as well as regional insecurity and drought. But while the rise in food prices is having dramatic and devastating consequences for food security in many parts of the global South, it must be remembered that other grain producing regions of the world are reveling in the profit to be gained from the rise in cereal prices – prices not seen in years.

How do these global events relate to the theme of this book? Four inter-related global factors encourage more attention to the links between municipal politics, health and agriculture:

1. How global and local food supply and access are related
2. How global policy and politics relate to national and local politics
3. The fact that the Right to Food and the Right to Health are enshrined in international law
4. How global and regional demographic changes affect local food security and health.

The International Covenant on Economic, Social and Cultural Rights (UN 1966, Article 11) articulated the right of everyone to “freedom from hunger” as an expression of the Right to Food and spelled out some obligations of States Parties to the Convention to take measures towards the realization of the right. In 1999 the UN Committee on Economic, Social and Cultural Rights, in its General Comment No.12 responding to the World Food Summit Plan of Action, stated the requirement of physical and economic access at all times to adequate food or means for its procurement. According to this legal opinion on the Covenant, states are obliged to *respect* the right by not depriving anyone of access, to *protect* the right by ensuring no one else does so (e.g. by passing and enforcing legislation), and to *fulfill* the right by strengthening people’s access to food (UN-ESC 1999). As of April 2008, 163 countries were signatories to the International Covenant on Economic, Social and Cultural Rights.

In the context of ongoing tensions surrounding the distribution of emergency food supplies, and scenarios where urban and rural food production or access to food are impeded by governments, it can be seen that these international conventions that are supposed to guide government policies and practices on food access are often ignored. Brazil is a recent exception; its 2008 policies based on the Right to Food include urban agriculture in its support to family farms (Federal Republic of Brazil 2008).

The fourth global factor directing attention to local food policies is the current scale of global and African demographic change and the food supply and health challenges these trends provoke. The majority of humanity is now urban. The fact that most Africans are still rural masks the pace at which large and small towns and cities in Africa are growing (Cohen 2004). In 2005, 892 million Africans (about 40 percent) lived in cities and towns; with an urbanization rate of 3.3 percent per year the region is expected to become predominantly urban by 2025 (Stren 2005; Cohen 2004; UN 2002). However, Africa’s urbanization is de-linked from economic development. “African cities are growing despite poor macroeconomic performance and without significant direct foreign investment making it next to impossible for urban authorities to provide low-income housing, high-quality urban services, or sufficient employment” (Cohen 2004, p.46). As a result, ‘informality’ or “subsistence or economic activities that are not protected by law and/or formal contracts [like UA]” also continue to increase and are expected to remain a vibrant part of the African urban environment (Stren 2005, p.7).

In 2004, the Food and Agriculture Organization (FAO) and the World Food Programme (WFP), anticipated that food shortages and food needs would increase in sub-Saharan Africa (East African Standard 2004). This prediction seems to have come to fruition in 2008, based on the headlines earlier noted. These demographic trends also present significant challenges to improving or even maintaining human health in cities. Past assumptions held that being closer to health services in urban areas meant better health than in rural areas. However, as discussed in Chapter 1 in this book, the unplanned expansion of low-income urban settlements where health and environmental services are lacking can produce rates of morbidity and mortality similar to or higher than those in rural areas (National Research Council 2003, p.23).

Whenever countries are gripped by concerns about food access, security and price, whether real or perceived, citizens respond in three ways. First, they try to obtain and store additional food, which often leads to price increases and depletion of stocks. Second, they demand – often through protest – that governments take action to help address the problem, and third, they independently and collectively produce food for their own personal consumption and organize themselves to respond to the food security challenges (Maxwell 1995,1999). In this respect, and to state a rather obvious but significant point, the global production, supply and distribution of food have direct impacts on local food production and consumption patterns, as well as local politics and urban health.

In this way, global food issues affect local politics because the global food system has a direct impact on the character and content of debate over appropriate food and agricultural policies and practices domestically. At the international level, it is well understood that global agricultural institutions and negotiations have a direct impact on trade and food aid (Clapp 2004). Whether through subsidies, tariffs, international negotiation strategies, or through domestic agricultural and land-use policies, national governments can directly impact what food is produced, how, and for whom. Given that all agriculture – no matter the scale of production - begins in a fixed locale, and land-use is typically governed wholly or in part by municipal governments, both citizens and local governments play a critical role in food supply and food security.

With the impending fallout from climate change and the increasingly unreliable supply and price of oil, it is safe to assume that the promotion of localized food production and consumption systems across the world will only increase, and so too will the importance of municipal governments in supporting local and regional food security. Hence, from a global perspective, the need to pay attention to municipal policies, politics, and practices as they respond to food security challenges is clearly evident. Likewise the demands on local governments will be sharper. They are simultaneously expected to ensure food security, protect citizens' health from perceived and potential negative health outcomes from urban food production and to facilitate economic and income opportunities from agricultural production. Our third global factor, international principles and law, reinforce these expectations.

When the Ethiopian famine gripped world media attention in the mid-1980s with images of starvation, global concern awakened about access to food in Africa. But well prior to this, the Right to Food and the Right to Health had both been formally recognized by the international community. The United Nations General Assembly adopted the Universal Declaration of Human Rights (UDHR) in 1948. Article 25 states that “everyone has the right to a standard of living adequate for the health and well-being of himself and his family, including food...”. The Declaration forms the basis for subsequent international legislation. Food and health are inextricably linked in its formulation.

The Right to Health is also linked to safe drinking water and adequate sanitation, safe food and adequate nutrition. Health itself is defined as “a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity” (OHCHR).

These demographic changes reinforce the need to contemplate the political and policy dimensions of urban health and agriculture. Two specific aspects need to be examined:

1. How the relationship between health and urban agriculture factors into government policy and planning at the local and national levels; and
2. How municipal, sub-national and national governments are balancing international pressures with local needs.

This is particularly important given that food security has not been on the agenda of urban policy makers (Maxwell 1999) and that there is an obvious need to strengthen both food policy and policy-making (Maxwell & Slater 2003). In light of demographic changes and mounting pressures for improved government responsiveness it is important to recognize that the city highlighted in this book, Kampala, is at the center of these current and impending challenges.

Uganda is one of the least urbanized countries in the world. Only 12 percent of the population was reported to be living in urban areas according to the last census (UBOS 2002).³ With a (nighttime) population of 1.2 million and a density of 7.4 persons per square kilometer, Kampala is expected to grow at a rate of 4.1 percent per year and will continue to be the prime urban center in the country for years to come. Given that Uganda is estimated to have one of the highest population growth rates in the world at 3.4 percent and that by 2050 its total population may reach 80 to 100 million people (a 226 percent increase), it is clear that, unless access to basic services are improved, there will be enormous challenges confronting the country, particularly in urban areas like Kampala (Monitor 2003).

Another cause for concern is the Government of Uganda's expected takeover of Kampala. As of July 2008, a new law that would see that national government assuming control over the capital city was in preparation. Discussions on the possible merger of Kampala's land-use planning functions with other surrounding districts were also ongoing, thus moving towards a metropolitan or regional model. If recent urban agricultural policy innovations and activism are stifled by national government oversight it will be difficult to assess the national government's takeover as beneficial. However, the policy change could inspire local innovation and government attention to the relationship between urban health and food access if the national government taps into ongoing activities in Kampala and helps foster UA throughout the proposed new metropolitan area.

For Kampala, for other African cities, and for cities of the developing world generally, population growth projections suggest that the availability of reliable and reasonably priced food will remain central for future well-being and stability (Walton & Seddon 1994; Drakakis-Smith 1991). If there are global, national and local imperatives to focus more directly on the politics of urban food production and health, what is the historic relationship between urban politics and urban agriculture in Africa?

³ Importantly, this information is not comparable to previous censuses for the country. Prior to the 2002 census, urban areas included all geographic agglomerations of 1,000 people or more – what the Uganda Bureau of Statistics defines as 'ungazetted Trading Centres'. For the 2002 census, only those cities, municipalities and towns that have been 'gazetted' are acknowledged as urban areas. According to UBOS, "This difference in the definition is responsible for the seemingly low level of urbanization registered in the 2002 Census" (UBOS 2002, p.9).

UA AND MUNICIPAL GOVERNMENT IN AFRICA AND UGANDA

Pierre Vennetier's 1958 work in Pointe-Noire, Congo, was one of the first formal inquiries into urban farming in Africa (Mougeot 1994). For decades, the important role of urban agriculture (UA) in the life of cities and urban residents was ignored despite the fact that in many cities throughout sub-Saharan Africa, there was clear evidence that a large proportion of households – sometimes a majority – were engaged in UA. One of the first efforts to inventory the extent of UA in a country was the 1985 study of six towns in Kenya, which revealed that 29 percent of households grew food in the town where they lived, and 17 percent kept livestock (Lee-Smith *et al.* 1987). Other research from the 1980s and 1990s revealed the prominence of UA as a household practice in cities in Tanzania, Zambia and Uganda (Tripp 1997; Smit *et al.* 1996; Rakodi 1988; Maxwell 1995, 1999), and the extent to which the urban and peri-urban poor were engaged in farming (Maxwell & Zziwa 1992).

While significant on its own, this early research also revealed the extent to which UA supported households, particularly in times of political conflict, and helped inspire the emergence of new City Ordinances for UA in Kampala. This process is described below in Chapter 12. Two political observations arise from the regulatory changes that have emerged in Kampala as a result – one positive and one of concern.

First, a dynamic, diverse participatory process evolved. Local councilors from each city Division, Makerere University representatives, the Ministry of Agriculture and Animal Resources and Fisheries, officers of KCC, urban farmers, technical officers and environmental NGOs all took part. Local government actors took a leadership role on urban farming and, with others, developed an essentially political process that led to the establishment of the formal policy and legal frameworks needed to execute the Ordinances.

Apart from knowing that the KCC took action, it is important to understand the convergence of factors which led to this policy outcome because it informs an ongoing argument in the study of urban sustainability; namely that the processes used to produce sustainability goals may be as important, or more important, than specific measurable outcomes (Robinson 2006). This is because the establishment of deliberative engagement processes has the potential to create the political, social and institutional mechanisms and conditions needed to see future policy goals achieved through the development of a broad constituency of support and more robust and trusting relations between state and non-state actors. From a positive perspective then, the complexity of the urban agriculture issue and the multiple interests affiliated with it, demonstrate both the imperative and opportunity for local government to lead, as has occurred in Kampala.

The second, more concerning, political issue follows from the recognition that the relationship between urban food production and health are complex and difficult issues to address, and as a result produce many political and policy paradoxes. This touches on the whole purpose of this book, which aims to elucidate the complexity, but to do so in a way that acknowledges that examination of the evidence takes place as part of an ongoing political process which engages the stakeholders concerned in debate.

What is perhaps most striking about the process that evolved in Kampala was that it came to be at all, given the lack of focus on urban food security by the national government

and the tension between Kampala City and the national government. The city Ordinances evolved in spite of a complex, paradoxical national policy framework, which is currently inconsistent with the presence and role of UA in Kampala.

As we saw in Chapter 1, UA has faced many challenges historically. Specifically in Africa, municipal governments discouraged UA in colonial times along with other restrictions on local people's social, political and economic participation in urban life. However, post-colonial interpretations of inherited bylaws have been even more restrictive (Lee-Smith 2008). Thus, in contrast to the truism that UA has always been restricted by the letter of colonial by-laws, recent scholarship shows that, while confused, the colonial laws were fairly permissive, while the interests of officialdom in post-colonial regimes have led them to act much more restrictively (Foeken 2005, 2006; Lee-Smith 2008). The stance of African local governments towards the informal sector in general and UA in particular requires further political analysis that is beyond the scope of this chapter. Suffice it to say that, in addition to these municipal challenges, UA has also been challenged directly by national agricultural policymakers.

National agricultural policymakers in Uganda, as in other African countries, resisted the promotion of UA ostensibly for fear that it would undermine urban demand for rural produce, and, hence national agricultural recovery (Maxwell 1999; UN 1948; Lee-Smith 2004). Indeed, national agriculture and poverty-related policies and programs in operation at the time of the consultation process in Kampala ignored the role, value and contribution of urban farming. For example, neither the Plan for the Modernization of Agriculture (PMA) (Government of Uganda 2000), the National Food and Nutrition Policy (MAAIF & MOH 2003) or the Draft Food and Nutrition Strategy and Investment Plan (MAAIF & MOH 2004) made any reference to urban farming or urban agricultural practices. The emphasis of the PMA was on the transformation of rural agricultural production, therefore it may not be surprising that it omits reference to UA, particularly given that the "agricultural sector accounts for about 90 percent of exports" (Aliguma 2004, p. 6). However, neither national document relating to food and nutrition made any reference to urban farming.⁴ Moreover, the country's Poverty Reduction Strategy Paper (PRSP) – the guidance document for all national policy – made no reference to the role of urban agriculture in urban food or household security. Even in the Participatory Poverty Assessment (PPA) for Kampala, which informed the PRSP, there is little attention to UA as a means of livelihood in the city. The Kampala PPA, hence, seems inconsistent with and fails to mention other ongoing research on UA in the city.

Lack of national attention to urban food security, UA, and national food policy in Africa and in Uganda is not surprising to previous researchers (Maxwell 1995; Maxwell & Slater 2003). But important political questions and concerns arise about the relationship and consistency between national and local policy relating to food and agriculture when the Uganda PRSP is put in the context of other national poverty assessments in Africa. These "overwhelmingly emphasize the problem of rural poverty"; are missing important contextual

⁴ It is important to note that some research argues that UA should not receive formal policy attention because its 'exclusivity' undermines attention to rural-urban interactions in food security and household welfare, but also that it could draw development resources away from other areas more needed or make demands on scarce administrative capacity (Ellis & Sumberg 1998). Instead, it is argued that municipal authorities should simply take a permissive role and that UA "does not need policy with a capital 'P'..." (p.221, emphasis added).

information about the degree and character of urban poverty and, hence, produce national strategies that omit these factors (Mitlin 2004, pp. 12-18).⁵

Hence, the recent initiative taken by the KCC to produce city Ordinances for UA, the participation of national ministries and officials in this process, and the lack of attention to UA in national policies and strategies suggests that, perhaps paradoxically, an important political change may be emerging in Uganda, whereby UA may be playing a role in helping to reconcile the tension between Kampala and the national government and challenging the long-held attitudes of key decision-makers. While this may be overly optimistic, the success in establishing the Ordinances in Kampala allows for optimism, particularly given that the relationship between Kampala and the national government continues to be fractious, suggesting that things cannot get much worse.⁶

Studying how local governments deal, in policy and political terms, with the relationship between UA and health can provide insights not only on the future of food security and food policy in a country or city, but also about urban poverty and politics itself. But what approach does political science offer for improving our understanding of municipal and national policies related to UA? If we accept that understanding the opportunities and constraints to UA requires understanding how governments interpret and weigh the evidence for and against the practice, then an approach that examines the relationships between those actors included and excluded from decision-making is helpful. In politics and policy studies, the concept of *governance* has served as a useful framework for this type of analysis. The next section therefore explains how the notion of governance and its emphasis on the relationships between actors in a political process can serve as an important conceptual tool to advance research on healthy urban food production policy.

POLITICS, POLICY AND GOVERNANCE: A CONCEPTUAL APPROACH TO THE STUDY OF HEALTHY URBAN FOOD PRODUCTION

Distinctions within the concept of governance – employed in a wide array of scenarios from corporate governance, to global governance, to democratic governance, to urban governance, to environmental governance – are important in political science. There is agreement on the utility of the concept given its widespread use in research in Africa (see McCarney & Stren 2003; Swilling 1997; McCarney 2000; Evans *et al.* 2005). The term's central appeal is that it is

⁵ In one of the most telling examples provided by Mitlin (2004), she compares the evidence of urban poverty articulated in Accra, Ghana published in the country's PRSP, with that of other researchers conducting fieldwork on urban poverty at the same time. She writes: "The Ghana Strategy Paper reports that extreme poverty is 2 percent in Greater Accra... However... a study of poverty in Accra [conducted] at around the same time... found that: 'In terms of caloric intake, roughly 40 percent of households in Accra could be classified insecure... An estimated 23.6 percent of Accra's population is food insecure, consuming less than 80 percent of their caloric requirements but spending more than 50 percent of their budget on food... 22 percent of children in food insecure households are stunted...' Simply put, it is difficult to believe that these two findings related to the same city" (2004, p.17-18).

⁶ This tension was very well demonstrated during the tenure of Kampala's former mayor, John Ssebaana Kizito. Kizito was elected in 2002, beating the candidate openly endorsed by President Yoweri Museveni, Joseph Wasswa Ziritwawula. During the campaign, and throughout Kizito's tenure, KCC and the national government, and specifically Kizito and Museveni, were in open conflict over the management of the city and the decision-making authority of KCC. The Ugandan media commonly points to the fact that the Movement lost to the opposition in Kampala during the 1996, 2001 and 2006 presidential and parliamentary elections, and that any conflict is imbued with political struggle (see for example the *New Vision*, June 23, 2004, "Movement fights for Kampala"). This is also why the national government's decision to take over the management of Kampala is deemed by many to be a political move. Nonetheless, the national government points to the national constitution, which gives the government the authority to assume responsibility for Kampala.

more inclusive than the term 'government': 'governance' integrates and recognizes the activities of a range of state and non-state groups in the *process* of governing and decision-making, as well as their interrelationships in the management and delivery of services (Kjaer 2004; Hyden 1992; McCarney *et al.* 1995; Friedmann 1998; Stren & Polèse 2000). It "brings to bear the political dimension and 'places the interdependence of state and society at the centre of debate'; it "permits the incorporation of a wide variety of actors and groups in both the formal and informal sectors, as well as local, national, and international groups and agencies" (Montgomery *et al.* 2003, p. 358).

There are many definitions of governance (Hyden & Court 2002; Cheema 2005; DFID 2001; Kaufmann *et al.* 2004). However its simple definition as "the *relationship* between civil society and the state, between rulers and the ruled, the government and the governed" (McCarney *et al.* 1995, p.95), which drew from the *Report of the Governance in Africa Program* and the network of researchers involved in the Global Urban Research Initiative (GURI),⁷ is valuable for the purpose of encouraging researchers to consider more directly the political and policy dimensions of UA.⁸ This is because conceptualizing 'governance' in this way draws attention to those interests that often fall outside formal government structures and decision-making including civic associations, illegal operators, and informal-sector organizations which have made "an indelible impact on the development and morphology of urban centers" (McCarney 2003, p.37).

Focusing on the relationships between government and non-government actors in urban settings helps researchers understand "how the processes of governance are articulated in a particular site... and the fact that any locality in a city is enmeshed in a complex set of relationships linking the local with the national and the global in a way that is felt and present in the everyday life of urban dwellers" (Shami 2003, p. 80). How then does one translate this understanding of 'governance', and the horizontal and vertical linkages between state and non-state actors it emphasizes, into an analytically valuable tool for the study of urban food policy?

A GOVERNANCE APPROACH TO HEALTHY URBAN FOOD POLICY

A conception of 'governance' focused on relationships between actors is not new to policy analysts, some having reflected on the subject for years through the study of 'policy networks' (Smouts 1998, p.83). A governance approach to policy analysis suggests that how things are decided and implemented are almost as important as what is done (Kearns & Paddison 2000, p.849). For Africa, such observations have led researchers to examine how local interests are incorporated into the policy process, and to find out if citizens actually have the opportunity to influence government initiatives.

Attention to participation stems from considerable evidence that including citizens in the development of policy improves local conditions. International agencies are also more attentive to policy processes as a result of growing trends towards 'evidence-based policy',

⁷GURI was an eight year project (1991-1998) whose formal purpose was "to highlight the contribution of researchers from developing countries in improving our understanding of the dilemmas and challenges of urbanization" (Stren 2003, p.13). GURI went through three phases, the second phase being a focus on the emerging concept of 'local governance'.

⁸The recent National Research Council's book *Cities Transformed* (2003) and particularly Chapter 9 "The Challenge of Urban Governance" is one of the most authoritative reviews of the use of governance in urban studies and should be consulted, particularly for how the term evolved in different geographic settings.

'local ownership' of policy and viewing poor people as active participants or agents of their own development (McGee 2004, p. 4).⁹ But problems surrounding tokenistic or symbolic participatory processes (Cornwall & Brock 2005; Cooke & Kothari 2001; Chipoma 2003) mean that analysis of policymaking must also ask whether citizens are able to share their experience, knowledge or desires, and whether opportunities for them to do so are provided in formal decision-making processes. Together, these observations point to three important factors that can be used to describe and analyze policymaking in Africa (McGee 2004):

- 1) the **actors** included and excluded from decision-making;
- 2) the **knowledge** included and excluded from decision-making; and,
- 3) the **structure or spaces** of decision-making, considering for example, such issues as the forums for public debate and opportunities to contribute to these forums.

These factors follow from the observation that policy is a dynamic process influenced by actors from the international through to the local level, the knowledge they carry and the spaces they interact within (McGee 2004, p. 8).¹⁰ For the study of urban food policies and politics in Africa, what value does this conceptual and analytical framework add?

The approach assumes that who participates in decision-making, whose knowledge and what knowledge is included and excluded and the character of the opportunities for dialogue and debate, are all important for determining policy outcomes.

Actors are those in government or outside it who have some potential role or influence in policy and decision-making, including elected officials and technical staff, civil-society organizations, donor representatives, the general public and private businesses.

Knowledge includes technical knowledge used for statistical analysis, as well as popular knowledge derived from people's own experiences.¹¹

Policy space alludes to moments where interactions between actors occur and where the possibility for new policy direction can emerge. It can be a physical site (meeting) or sustained periods of time (formal consultation processes, conferences) that are institutionalized. There may be spaces that are closed or open to any number of actors, official spaces where only some are invited to participate, or autonomous spaces that function outside formal state processes (McGee 2004, pp. 9-26).

Using these factors to analyze the political process surrounding UA in Africa can provide valuable knowledge about how problems and solutions to urban food security and urban health are framed, and how certain actors, knowledge and spaces are deemed more or less important in producing outcomes. For example, while some might argue that Kampala's new city Ordinances were a result of its consultative process, this explanation would provide little comparative analytical value for researchers, or more importantly, few lessons for other advocates or governments wanting to replicate Kampala's policy development success.

⁹ 'Evidence-based policy' focuses on how knowledge gets translated into policy and whose knowledge gets used in policy.

¹⁰ These categories are inspired and directly drawn from recent frameworks applied to policy analysis in Africa and Uganda (Brock *et al.* 2004; Keeley & Scoones 2003; Leach & Mearns 1996; Gore 2007).

¹¹ McGee identifies two types of knowledge – *produced* and *constructed*. *Produced* knowledge includes knowledge that is produced by certain actors to inform policy, such as household survey data. *Constructed* knowledge can be explicit or implicit and focuses on knowledge generally omitted from policy processes. It includes firsthand knowledge of poverty through direct experience (explicit), as well as discourses and narratives that are often hidden or embedded in policy (implicit).

However, examining the character of relations in the policymaking process with the above three factors as a guide, as we do below in Chapter 12 and also by Hooton *et al.* (2007), we are able to more clearly identify what helped or hindered the creation of legislation for UA. More specifically, we are able to answer difficult questions that other advocates and governments will be interested in, such as which actors played a dominant role in the process; what knowledge and evidence about health and urban agriculture proved convincing and how; and what was the character of the spaces for dialogue and deliberation.

CONCLUSION: THE POLITICS OF URBAN FOOD PRODUCTION AND HEALTH

From a global perspective, the rising price of basic foodstuffs, ensuing protests about food access and price, and the general global concern about future food security reinforce the importance of local government policies and practices surrounding food and agriculture. Layered on top of these very urgent and real global food challenges are international laws that formally and directly oblige both national and local governments to improve access to food and eliminate hunger. Together, these global factors suggest that there is an urgent need for governments to reconcile the relationship between urban agriculture and health.

Ways of understanding the role of agriculture and food in daily life are increasing in research and advocacy. For example a concept of ‘civic agriculture’ – countering the industrializing trend of agriculture through local food production in the United States – is tied to community social and economic development (Lyson 2004, p.1). Given the significant political dimensions to urban agriculture that we have explored in this chapter, it is not surprising that politics, power and participation are also central elements in civic agriculture, which “... flourishes in a democratic environment... Indeed, citizen participation in agriculture and food-related organizations and associations is a cornerstone of civic agriculture. Through active engagement in the food system, civic agriculture has the potential to transform individuals from passive consumers into active food citizens” (Lyson 2004, pp. 76-77).

Concepts like civic agriculture are part of wider discussions about place-based politics and community participation in municipal affairs. However, when considering the politics of urban food production in African cities, what stands out about a concept like ‘civic agriculture’ is that it arose in North America to counter a trend that has not yet emerged in most of sub-Saharan Africa. That is, while countries like Uganda move to further modernize and industrialize agricultural production, the concern to promote local food production has not yet surfaced. Nevertheless, it is suggested that while scholars in the North are not yet accustomed to learning from their Southern colleagues, there is an important opportunity here for the urban agricultural movement in cities like Kampala – with its somewhat different focus on the issues of household food security and food safety – to serve as an example of the political and policy processes needed to promote civic agriculture.

Seen through the lens of urban governance and the relationships between actors – their participation, knowledge, and space for decision-making and interaction – the Kampala case enhances understanding of how urban food production can be made healthier. Kampala’s experience does not provide a ready-made model but rather a framework for how to understand the politics of urban food production in a way that is responsive to the reality of

urban settings and respectful of the minutiae of everyday life. In this way, it may open up possibilities of understanding the complex terrains of practice and power that constitute African politics generally (Shami 2003, p. 80),¹² and the relationships between urban food production, health and politics specifically.

Examining government and non-government interactions in this way improves understanding of the processes promoting and denying urban agricultural practices in a particular urban setting. It also helps when trying to understand how policy (local, national and international) is informed by the practices of citizens, while simultaneously incorporating the knowledge and presence of international and domestic NGOs, and international organizations. The underlying political assumption is that the character of relationships between the actors in a particular urban setting, the character of governance, reveals why some issues become constructed as policy problems and others as solutions, and who is shaping these definitions and responses.

A political approach to the study of UA focuses on how the presence and absence of different knowledge, ideas and actors and the forums in which interactions take place, influence the definition of problems and solutions. To encourage this approach is to encourage researchers focused on urban agriculture to move inside the process of decision-making and inquire how those controlling or driving decisions respond to their external environment. While difficult, this approach can reveal answers to critical questions about the promotion or denial of urban agriculture in African cities: Who participated and how are non-government interests able to contribute? Who has been driving or directing the process? Who defined the problem(s) and did this definition determine deliberations? How is local, household knowledge and everyday experience incorporated and was it influential in decision-making? What evidence is being privileged and why? What formal and informal forums exist for communication and exchange of ideas and what rules governed deliberation?

As the chapters in this book reveal, and the results from Kampala's legal review suggest, attention to the political and procedural dimensions of UA policy development are critical for laying the groundwork for locally-informed and government-sanctioned sustainable urban food strategies. This is supported by other evidence from East Africa suggesting that processes where farmers, researchers and government officials interact can produce substantive changes in the minds of government decision-makers (Mazingira 2006; Foeken 2006, pp. 163-164). These victories are remarkable achievements given past and ongoing attitudes and concerns about farming in African cities. In conjunction with the recognition that UA promotes food and nutrition security in cities as examined in the next section of this book, political advocacy now appears to be producing results. But as the global momentum to promote healthy urban food production practices increases, a word of caution is in order.

¹² Shami writes: "Research should not aim at providing ready-made models of urban governance that can be replicated, but rather provide a model of how to work on local issues in local ways. What can be replicated is the approach and the philosophy behind the research, but not the procedures and activities. Ethnographies of governance in different settings that respect the minutiae of everyday urban life while not underestimating the role of structure, space, and hegemony open up new possibilities for understanding the complex terrains of practice and power that constitute the cityscapes of the twenty-first century" (2003, p.80).

Social and political context matters when trying to achieve sustainable outcomes. In legalizing agricultural production in cities and promoting the use of vacant land for food production, a complex, multilevel political process is needed to ensure lasting outcomes. The ideas, knowledge and experience of multiple interests have to be shared and urban agriculture will reveal its deeply political, conflict-laden nature, touching as it does on land ownership and access, poverty, health, housing and general urban development. But to ignore deliberative processes where evidence and knowledge can be debated, or to shun the building of broad constituencies of support in the name of fast-tracked policy or regulatory goals will almost certainly result in deeper political cleavages or mistrust between government and citizens. Ignoring the political dimensions of healthy urban food production would undermine long-term, sustainable, healthy food policies and practices in one of the most critical social and political settings of Africa's future – the city.

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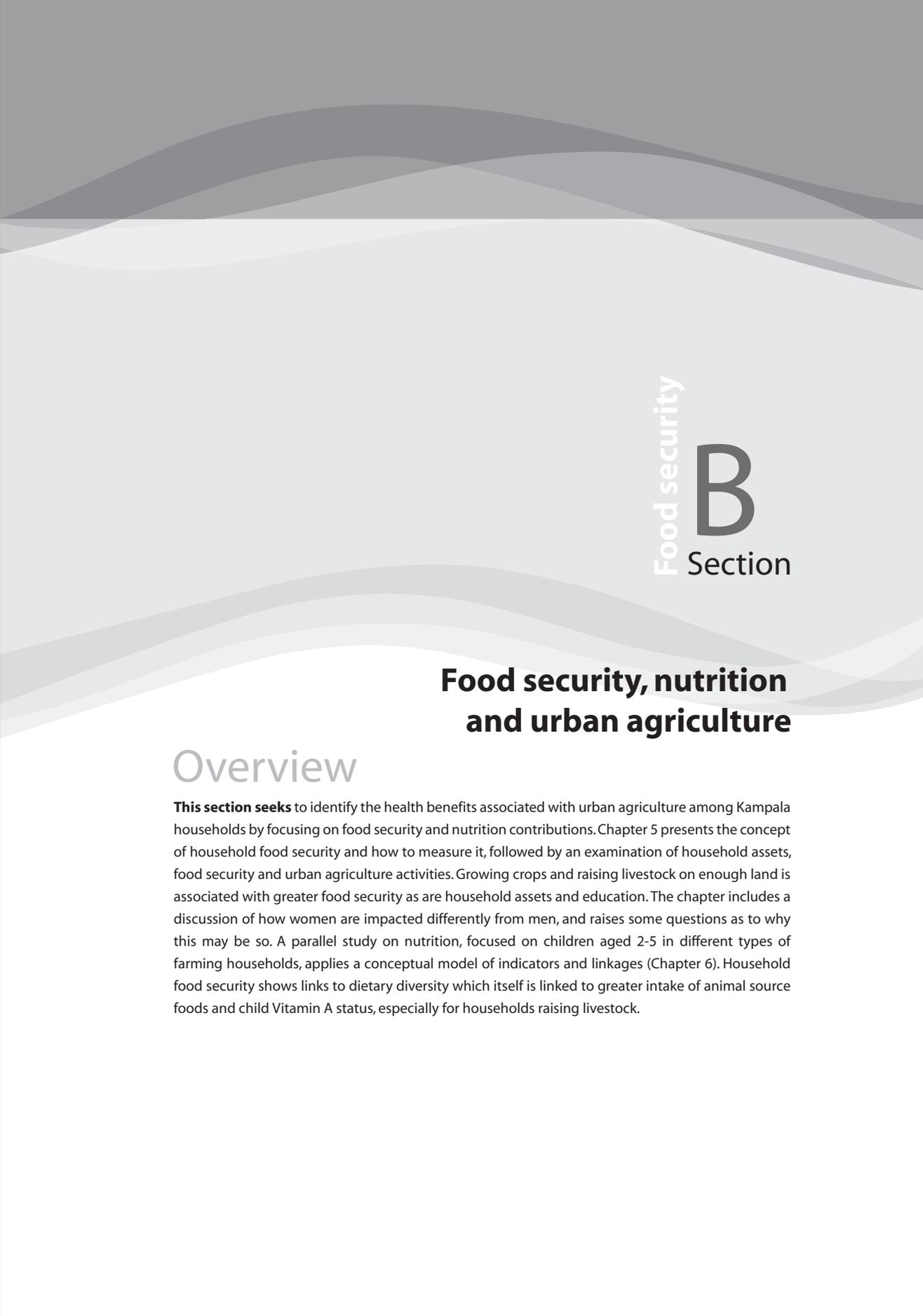
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Food security
B
Section

Food security, nutrition and urban agriculture

Overview

This section seeks to identify the health benefits associated with urban agriculture among Kampala households by focusing on food security and nutrition contributions. Chapter 5 presents the concept of household food security and how to measure it, followed by an examination of household assets, food security and urban agriculture activities. Growing crops and raising livestock on enough land is associated with greater food security as are household assets and education. The chapter includes a discussion of how women are impacted differently from men, and raises some questions as to why this may be so. A parallel study on nutrition, focused on children aged 2-5 in different types of farming households, applies a conceptual model of indicators and linkages (Chapter 6). Household food security shows links to dietary diversity which itself is linked to greater intake of animal source foods and child Vitamin A status, especially for households raising livestock.



Food security, nutrition and urban agriculture

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The association between household
food security and urban farming in
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Nutritional security of children
of urban farmers

CHAPTER 5

The association between household food security and urban farming in Kampala

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• Donald C. Cole • Selahadin Ibrahim

INTRODUCTION

Urban agriculture is promoted as an important livelihood strategy with the potential to contribute to food security of urban dwellers by increasing access and availability to food in urban settings (Koc *et al.* 1999). Current evidence, all cross-sectional, of greater food security among urban farm households is mixed, some smaller focus group based studies and large surveys demonstrating positive relationships (Mboganie-Mwangi & Foeken 1996; Maxwell 1995) and others finding either little relationship or one that varies by years (Foeken 2006) or more complex relationships across vastly different household livelihoods (Maxwell *et al.* 2000). Food security is of interest to policy makers for a number of reasons, including the fact that it is a necessary (although not necessarily sufficient) precursor for nutrition security, which will be explained in the following chapter by Yeudall and others.

Food security has been defined as a state when '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). It is valuable to understand which factors may affect food security, including those related to urban agriculture. Availability, access and utilization are recognized as major determinants of food security, with a hierarchical relationship whereby each is a necessary, although not necessarily sufficient precursor for the next (Webb 2006). This chapter aims to elucidate relationships between engaging in urban agriculture and food security, so that factors in households affecting both food security and nutrition security can be understood and better managed in the interests of future generations of well-fed, healthy children (Plates 5 and 6).

Currently, there are over 200 published definitions of food security (Smith *et al.* 1992), reflecting its complexity and multi-factorial nature. The main concepts emerging from the literature are that there must be:

1. Enough food for an active and healthy life;
2. Sufficient access to food in a culturally acceptable manner; and
3. A sense of security in permanently acquiring food (Maxwell & Smith 1992).

The U.S. Household Food Security Survey Module, developed and validated for use in U.S. populations (Frongillo 1999; Bickel & Nod 2000; Keenan *et al.* 2001), includes questions on food quantity and quality, psychological and social effects of food insecurity and hunger (Wolfe & Frongillo 2001). Food security scales developed in other countries using similar methods (Lorenzana & Mercado 2002; Maxwell 1996; Maxwell *et al.* 1999; Frongillo *et al.* 2003) have to be culturally appropriate and based on strategies used by those who actually experience food insecurity. From his work in Kampala, Maxwell (1996) suggested a method based on the frequency and severity of food consumption-related coping mechanisms used by households faced with food insufficiency. He assumed that the primary caregiver — the one responsible for obtaining and preparing food for the rest of the household — used specific strategies to adapt to food shortages. These were identified through focus group discussions and included: dietary change, food-seeking, household structure and rationing strategies (Maxwell *et al.* 1999).

Although Maxwell found little difference in household food security between farming and non-farming households in 1993 in Kampala (Maxwell 1995), his analysis did not distinguish among the various characteristics of urban farming that might be associated with household food security. Our study therefore aimed to better understand factors related to household food security by examining its associations with socio-economic characteristics and urban farming activities. Specifically, the two main objectives were to explore the associations between:

1. Household socio-economic characteristics and household food security; and
2. Urban farming practices and household food security (see Appendix 1).

This chapter presents the approach used and the findings of the study. It is concluded that the main elements of urban agriculture that affect household food security are wealth, land size, livestock keeping, gender and education. These are examined in relation to other sources that inform the reader about the conditions of urban farming in Kampala to draw conclusions about the next steps in addressing improved household food security through farming in the city.

METHODS

Study Setting and Design

The study used a cross-sectional design, with data collected near the end of the post-harvest season (August – October 2003) in Kampala, Uganda. Areas selected for study were intended to be representative of all areas within Kampala's municipal boundaries. At the time of writing, Kampala is divided into five divisions comprising approximately 20 parishes each, with each parish further divided into zones. Parish selection was conducted with the cooperation of collaborating researchers and Kampala City Council (KCC) officials. Three parishes where respondent fatigue was reported and ten with little or no urban agriculture were excluded and the remaining ones were grouped in three categories (urban proper, peri-urban, transition) according to geographic characteristics affecting urban agricultural practices. Parishes having both urban and peri-urban characteristics were classified as 'transition'.

Parishes were randomly selected within each category, so that the number of parishes in each category was proportionate to the overall distribution of these categories in Kampala. This resulted in the selection of 13 parishes representing the five divisions (Plate 1).

An analysis of socio-economic and farming system changes along Kampala's urban to peri-urban continuum, also carried out in 2003 – 2004, used KCC's four categories of urban and peri-urban areas (David *et al.* forthcoming). Our methods are compatible as we do not examine differences along the continuum but rather select across it in order to obtain a representative sample.

Study Population

Two zones in each selected parish were randomly selected and community members from each zone invited to a recruitment meeting. Households eligible for the study had at least one child aged 2-5 years as inclusion of post weaning children was necessary for the parallel analyses regarding child nutrition. A sample of both farming and non-farming households was selected within each zone. Farming households were over-sampled because of our focus on examining urban farming activities. Respondents in participating households were the primary caregivers of the children. Written consent was obtained from all respondents through a signed consent form translated into their language of preference (English or Luganda). The study was approved by the University of Toronto Research Ethics Board and the Uganda National Council of Science and Technology.

Measures

The questionnaire was developed using questions from Maxwell's research in 1993 (Maxwell 1995) and from the most recent Uganda Demographic and Health Survey (Uganda Bureau of Statistics & ORC Macro 2001). It was pre-tested in Kampala by trained interviewers fluent in the main local languages, and adapted to ensure that the questions were culturally appropriate and had face validity when translated into Luganda. Data were collected from the household's primary caregiver on: household food security, assets, demographics and farming practices. New variables were constructed by analyzing this data set.

Household Food Security (HFS) Indicator

The HFS indicator was developed from four questions regarding coping mechanisms commonly used by households in Kampala during times of food insecurity, as determined by focus group discussions in a previous study (Maxwell 1996) and subsequent methodological work (Maxwell *et al.* 1999). Each coping mechanism was ranked in order of severity, as some coping mechanisms are stronger indicators of food insecurity than others, and assigned a corresponding lesser or greater weight. The coping mechanism items and their respective weights are summarized in Table 1. The weighted values for each question were added to give a cumulative HFS score, ranging from 0, least food insecure, to 19, most food secure. HFS was used as a continuous dependent variable in regression analyses.

Table 5.1 Household food security score (range 0-19): coping strategy items, item weights, and item response proportions

Individual Items	Response	Weighted Value	Response proportions n (%)
In the past month, how often did you:			
Eat food that was not preferred	Never	2	35 (11)
	A few times	1	197 (67)
	Frequently	0	64 (22)
	Missing	0	0 (0)
Limit portion sizes	Never	3	104 (35)
	A few times	1.5	158 (53)
	Frequently	0	33 (11)
	Missing	N/A	1 (1)
Skip one or more meals in a day	Never	6	161 (54)
	A few times	3	98 (33)
	Frequently	0	37 (13)
	Missing	0	0 (0)
Borrow money or food	Never	8	114 (39)
	A few times	4	157 (53)
	Frequently	0	25 (8)
	Missing	0	0 (0)

Asset-Based Wealth Indicator

Household wealth was measured by creating an asset-based wealth indicator using questions from the Uganda Demographic and Health Survey (Filmer & Pritchett 1999, 2001). Data regarding household income were not collected since this information is often unknown by the primary caregivers and may therefore be an unreliable measure of wealth. Information for an alternative wealth indicator based on household consumption, defined as the total value of goods or services consumed, would also have been difficult to obtain in this setting.

Recent research on the impact of social inequalities on health suggests that similar results are obtained whether socio-economic status is measured by household consumption or by a household asset-based wealth index (Wagstaff & Watanabe 2003). A household asset score was therefore created from nine items: concrete floor, radio, piped drinking water, new iron sheets as roof, electricity, bicycle, refrigerator, domestic worker employed, and vehicle. A value of 1 was given to each asset present in the household giving a maximum score of 9 and the cumulative score used as a continuous variable for regression analysis.

Demographic Variables

Education levels of the head of household and the primary caregiver (PC) were described as primary education or less and secondary education or higher and treated as a binary variable. The PC was also asked if s/he had ever received formal nutrition education and to describe the education source. The number of cash earners was formulated as a binary variable of one versus more than one. The dependency ratio was calculated by dividing the number of people in the household by the number of cash earners and was kept as a continuous variable in subsequent analyses. Age was also kept as a continuous variable.

Farming Variables

Households were asked to report all crops grown and their main reason for growing each on a ranking scale from 1 to 5, the highest rank being for sale purposes only and the lowest being for household consumption only. A continuous variable of the number of crops being grown was created. A total crop purpose variable was created by calculating a simple mean of the crop-specific crop purpose scores. For example, in a household growing five crops, the purpose score for each crop was added and the resulting sum was divided by five. Crops were also grouped into one of five categories commonly used by the World Food Programme (Bunch & Murphy 1997): starchy staples, beans/nuts, vegetables, fruits, and other. Five binary variables were created to evaluate whether the household grew at least one of the crops in the respective category.

A variable called the Tropical Livestock Unit (TLU) was created to quantify and compare the variety of livestock farmed in a standardized manner. Generally, 1 TLU=250 kg of live animal weight (Jahnke 1982) and in keeping with standard conversions used by the Food and Agriculture Organization, animal-specific TLUs were calculated by multiplying the number of each type of animal by the following factors: cattle, 0.70; pigs, 0.20; sheep and goats, 0.1; chickens, turkeys, ducks and rabbits, 0.01. The animal-specific TLUs were then added to create an overall TLU for each household. Those with no animals were assigned a TLU value of 0. The TLU was used as a continuous variable in the analysis. Similar to the crop purpose variable, a livestock purpose variable was created. However, since a purpose was listed for each type of animal, the overall livestock purpose was weighted by the animal-specific TLU.

The size of land used for farming was formulated as a binary variable of less than or equal to a quarter acre versus greater than a quarter acre, as it was found during pre-testing that this cut-off could be reliably estimated and communicated by household members. Those not using any land for farming were grouped into the =1/4 acre (0.1 hectare) category. Finally, the respondent was asked if the household used urban agriculture as a source of income.

Analysis

Data were double entered into Epi Info (version 3.2.2, Centers for Disease Control and Prevention, Atlanta). If there was a lack of concordance, the questionnaire data was checked and necessary corrections made to create a new data set. Analyses were conducted using SAS (version 8, SAS Institute, Cary, NC). Descriptive statistics were performed to describe the study population and examine the distribution of independent and dependent variables. Multivariable linear regression analyses were conducted on three population subsets:

1. All participants (n=296)
2. Participants growing crops (n=215),
3. Participants rearing livestock (n=139)

A separate set of regression models was run for each subset. Model 1 was run separately for farmers and non-farmers as well as for all participants.

The HFS score was tested for normality by examining its distribution, where a skewness value of greater than 3.0 or kurtosis value of greater than 8.0 would indicate a non-normal

distribution (Kline 1998). The assumption of normality was met and univariable analyses conducted between the independent variables and the HFS score.

Variables with a p value of 0.20 or less in the univariable analyses with the HFS score (the *a priori* significance level set for inclusion) were considered in the full multiple regression models. All possible two-way interactions were initially added and significant interactions ($p < 0.05$) retained. Households with missing data were excluded.

A manual, stepwise, backwards regression was then used to create the final (reduced) models. Variables were individually excluded if they had a corresponding p value of > 0.20 in the full model and if their removal did not change the coefficients of any of the significant main effect variables by more than 10 percent. All continuous variables were tested for linearity in the final models by plotting the HFS score against each independent variable (Altman 1991). In addition, the variance inflation factors of each model were examined to test for multi-co-linearity, where a factor value of greater than or equal to 10 was an indication of variables involved in multi-co-linearities (Freund & Littell 2001). Finally, model fit was evaluated by examining plots of the residuals to ensure constant residual variance around a mean of zero, indicative of the residuals being normally distributed (Altman 1991).

DESCRIPTIVE RESULTS

Questionnaire survey data were obtained for 296 households. The sample included 61 non-farming households, 96 households growing crops only, and 139 households raising livestock. As expected, most of those raising livestock were also growing crops (119/139) so that the total number of households growing crops was 215 (96 + 119). Complete data on all variables of interest in the regression models were obtained for 91 percent (268/296) of households for the model 1 (all participants), 97 percent (209/215) of households for model 2 (those growing crops), and 92 percent (128/139) of households for model 3 (those raising animals). The mean HFS score was 12.2 (SD 4.5, range 1-19) and did not differ significantly among the three population subsets. The mean score among households growing crops or raising animals was 12.3 (SD 4.6, range 12.5-19) and among non-farming households was 11.8 (SD 4.4 range 11-16). Although somewhat higher among farming versus non-farming households, the difference was not significant (univariate regression $\hat{\alpha} = 0.68$; 95 percent Confidence Interval -0.54, 1.89; $p = 0.28$).

Table 5.2 summarizes the characteristics of the primary caregiver (respondent) and the head of household as defined by the respondents. Nearly all of the PCs (93 percent) were women and 23 percent of households were female-headed. According to the Uganda Demographic and Health Survey 2001, performed by Macro International Inc. (Calverton, MD), this is similar to the overall urban population in Uganda where 28 percent of households are female-headed.

In contrast, 66 percent of the heads of households and 55 percent of the PCs in our population reported having a secondary education or higher whereas this level of education is only reported by 41 percent of the overall urban population in Uganda. In addition, 39 percent (112/289) of those responding to questions regarding nutrition education reported

receiving some form of nutrition education in the past, which was most commonly given by NGOs or during peri-natal counseling.

On average, there were 6.9 people per household (SD 3.2 people, range 2-24 people) and 45 percent (134/296) of households had more than one cash earner. The mean dependency ratio was 5.1 (SD 2.7, range 2-24). Frequencies of households having the assets comprising the asset score were as follows: concrete floor, 85 percent (253/295); radio, 81 percent (241/296); piped drinking water, 73 percent (217/296); new iron sheets as roof, 54 percent (159/294); electricity, 49 percent (144/295); bicycle, 19 percent (55/294); refrigerator, 16 percent (47/296); domestic worker employed, 11 percent (32/293); vehicle, 8 percent (23/294). The mean asset score was 3.9 (SD 1.7, range 0-8).

Table 5.2 Demographic profile of the households (n=296)

Characteristic		Head of Household n (%)	Primary Caregiver n (%)
Sex	Male	226 (76)	19 (6)
	Female	69 (23)	275 (93)
	Not recorded	1 (1)	2 (1)
Age group	<25	7 (2)	55 (18)
	25-34	115 (39)	133 (45)
	35-44	89 (30)	60 (20)
	45-54	51 (17)	29 (10)
	=55	32 (11)	19 (6)
	Not recorded	2 (1)	2 (1)
Education	None	13 (4)	21 (7)
	Primary	80 (27)	109 (37)
	Secondary	151 (51)	130 (44)
	Higher	45 (15)	33 (11)
	Not recorded	7 (2)	3 (1)

Tables 5.3 and 5.4 show the households' farming characteristics. Nearly half the farming population received some income from farming in the past year, indicating that urban farming is one component of livelihood strategies households implement to achieve maximal benefits from available resources (Chambers 1988; Corbett 1988; Maxwell & Smith 1992; Davies 1993). The majority (76 percent) farmed on plots adjacent to their homes and 40 percent farmed on a total land area of a quarter acre or less. Among those growing crops, the mean number of crops grown was 6.4 (SD 3.1, range 1-14). Nearly all (98 percent) households growing crops grew some kind of starchy staple, while only half (54 percent) grew vegetables. Crops were primarily grown for consumption, as demonstrated by the crop purpose score, while livestock were more often kept for income purposes, as demonstrated by the livestock purpose score. All these data are consistent with contemporary surveys of urban farming households in Kampala (David *et al.* forthcoming).

Table 5.3 Farming characteristics of the households

Characteristic		n (%)
Farming status ^[a]	No crops or animals	61 (21)
	Growing crops	96 (32)
	Raising animals ^[b]	139 (47)
City class ^[a]	Urban	52 (18)
	Transition	79 (27)
	Peri-Urban	165 (56)
Number of years farming ^[c]	< 5	88 (37)
	5-10	87 (37)
	> 10	53 (23)
	Missing	7 (3)
Income from urban agriculture (UA) ^[c]	Yes	128 (54)
	No	107 (46)
Size of farming land, acre ^[c]	= 1/4	95 (40)
	>1/4	140 (60)
Location of farming plots ^[c]	Adjacent to the house	178 (76)
	Away from the house	57 (24)

^[a] Includes all households growing crops (n=215).

^[b] Frequencies based on households reporting at least one crop in the category.

^[c] Includes all households raising animals (n=139).

ANALYTICAL RESULTS AND DISCUSSION

In this study, household wealth, as measured by an asset-based wealth indicator, was positively associated with HFS (Model 1, $\hat{\alpha}=0.60$, 95 percent CI: -0.05, 1.24; Model 2, $\hat{\alpha}=0.57$, 95 percent CI: 0.22, 0.93; Model 3, $\hat{\alpha}=0.43$, 95 percent CI: -0.03, 0.90). To demonstrate, this association was significant in model 2 (households growing crops) where each unit in the asset score is associated with a 0.57 unit increase in the HFS score. This finding is consistent with the literature in which wealth and food security are consistently and inextricably linked. However, after controlling for potential confounders in the multivariable regression models, there were aspects of urban agriculture that mediated the relationship between wealth and household food security. The full and reduced multivariable models are shown in Appendix I, but the main research findings are discussed below.

Raising Pigs as an Income Generating Activity

As in prior work in Kampala (Maxwell 1995), there were no significant differences in HFS between farming and non-farming households. However, among households raising animals (model 3), raising pigs was associated with greater HFS ($\hat{\alpha}=1.64$, 95 percent CI: -0.09, 3.38). It appears that this is a significant income generating activity as 85 percent (22/26) of those households raising pigs were doing so for sale purposes only.

Table 5.4 Crop and livestock specific characteristics of the households

Characteristic		n (%)
Common Crops ^[a]	Bananas	164 (76)
	Cassava	143 (67)
	Sweet potatoes	123 (57)
	Jackfruit	107 (50)
	Beans	101(47)
Crop groupings ^{[a] [b]}	Starchy staples	210 (98)
	Fruits	150 (70)
	Vegetables	115 (54)
	Beans/nuts	104 (48)
Crop Number (quartiles) ^[a]	1-4	66 (31)
	5-6	51 (24)
	7-8	47 (22)
	9-14	51 (24)
Crop Purpose Score ^[a]	1	139 (66)
	1.01-2	54 (26)
	>2	18 (9)
Characteristic		n (%)
Livestock type ^[c]	Poultry	96 (69)
	Cattle	36 (26)
	Pigs	29 (21)
	Other	6 (4)
Tropical Livestock Unit (quartiles) ^[c]	0.01-0.10	36 (26)
	0.11-0.70	35 (25)
	0.71-2.10	34 (25)
	2.11-10.6	34 (25)
Livestock Purpose Score ^[c]	1	39 (28)
	1.01-2	11 (8)
	2.01-3	6 (4)
	3.01-4.00	26 (19)
	4.01-4.99	26 (19)
	5	31 (22)

^[a] Includes all households growing crops (n=215).

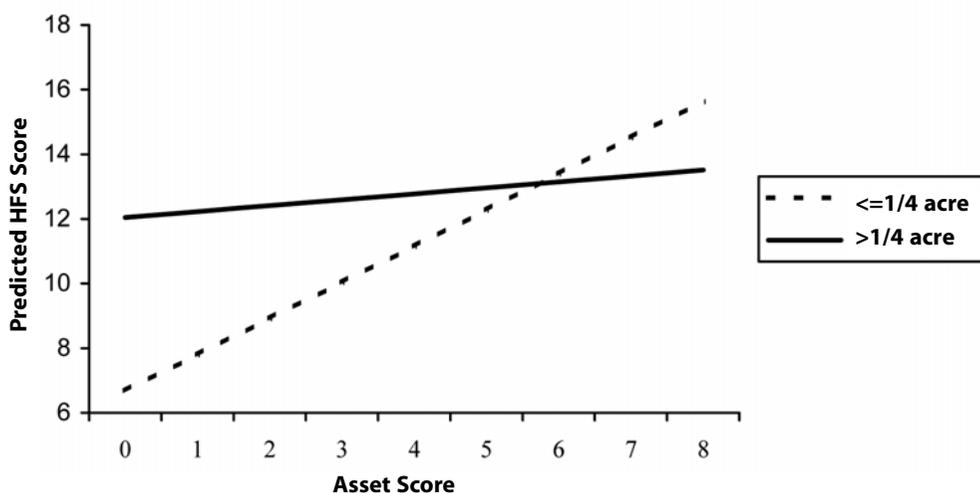
^[b] Frequencies based on households reporting at least one crop in the category.

^[c] Includes all households raising animals (n=139).

Land Size, Wealth and Household Food Security

Households that farmed more than a quarter acre tended to have greater HFS than those with less land (Model 1: $\hat{\alpha} = 1.80$, 95 percent CI 0.24, 3.36). However, those with more than a quarter acre were less dependent on wealth for obtaining household food security. Conversely, household wealth was highly associated with HFS among those with a quarter acre or less (Figure 5.1).

Fig. 5.1 The interaction between size of land and asset score in Model 1



One possible explanation for this finding is that those cultivating more land produced more food for home consumption or for sale, both of which could contribute to better HFS. Another factor may be the location in the city, as 70 percent of those with >1/4 acre of land lived in peri-urban areas. Therefore, similar to livelihoods in rural areas, it is likely that these households are more self-sufficient and therefore less dependent on wealth for HFS than those living in central urban areas.

The importance of this finding lies in the fact that the size of land being farmed, perhaps an indicator of the intensity of the farming, mitigates the association between urban poverty and household food security. As suggested in previous literature (Maxwell 1995), policies facilitating greater access to land for the poor may have a positive effect on HFS. However, land is an expensive asset and is often perceived by Ugandans as a major form of security and socio-economic status (MFPED 2000). Therefore, the feasibility of promoting greater access to land in the city of Kampala should be examined further. In addition, intra-household dynamics and gender roles must be taken into consideration to ensure that greater access to land translates into maximal benefits in terms of HFS.

Intra-Household Roles and Food Security

An emerging theme from the literature is that urban agriculture is essentially a strategy by women, rather than the entire household, to secure food. In addition, Maxwell noted that women who farmed preferred to keep their activities modest in appearance so as to avoid possible intra-household conflicts surrounding control of resources (Maxwell 1994, 1995). In this study, the respondents (primary caregivers) were predominantly women and were responsible for obtaining and preparing food for the household.

Various intra-household characteristics were associated with HFS. Specifically, although sex of the household head was not independently associated with HFS, it modified other relationships. Among households raising animals, female-headed households (households

without a male head) had greater food security than male-headed households when the size of land was a quarter acre or less. However, male-headed households had greater HFS when the size of land was larger (see Appendix 1).

Conventions on the gender division of labor in sub-Saharan Africa, including Uganda, associate women with responsibility for the home, including production of subsistence food. This applies to urban as well as rural farming when it is for home consumption (Lee-Smith 1997, 2006; Maxwell 1995, p. 1673). Maxwell found women provided 80 percent of the labor going into urban agriculture in Kampala (Maxwell 1995, p. 1672). On the other hand, men rather than women are nominally associated with raising large livestock, especially cattle, in East Africa (Ishani *et al.* 2002; Lee-Smith, Chapter 2 this volume). Typically, women and men did not share information on household budgets fully, and Maxwell pointed out that women would conceal savings on food through farming so as not to reduce their husbands' contributions (Maxwell 1995, pp. 1673-4).

Thus one explanation for our data may be that women in male-headed households can make better use of the larger plots of land, given they can also get financial input from their husbands, as well as possibly some assistance with labor, whereas women on their own lack this extra resource. Specifically, women in male-headed households can successfully raise livestock that ostensibly belong to their husbands. Probably the female-headed households with small pieces of land can make better use of it for a small mixed farm including modest numbers of livestock than if they are deciding on how to do this with a spouse who has a different agenda. Such households with larger pieces of land would be constrained not only by having fewer resources but also by not wishing to draw attention to themselves as independent wealthy women, which would stigmatize them socially (Maxwell 1995; Manyire 2001).

A previous study examining the role of gender on urban agriculture in Kampala found women grew crops requiring minimal resources, including time and labor (Nabulo *et al.* 2004) mainly because women are also responsible for household tasks, including cooking and caring for the family. While increasing women's resources for urban agriculture may be helpful, it is essential that intra-household roles be better understood so as to facilitate women's contribution to HFS. And instead of accepting that women have lower social status and are not supposed to succeed economically, any strategy of increasing women's access to more land for urban agriculture, for example, would need accompanying gender policies that include creating awareness of women's rights and equality.

A second interaction reflecting intra-household roles was demonstrated in model 2 (those growing crops). When the PC had primary or no education, female-headed households were more food secure than male-headed households. However, when the PC had secondary or higher education, male-headed households were more food secure. Like the other puzzling finding, this again suggests that female-headed households are better able to secure food for the household when there are fewer resources to work with (i.e. less land and less education). We can speculate that these women have greater control than in male-headed households and are able to stretch resources better. This is consistent with the literature demonstrating that access that household members have to food is strongly associated with the control they have over household resources or income, particularly for women and

their children (Kabeer 1991). But why are the more educated women heading households less able to ensure household food security? One tentative explanation might be that women of higher social status (suggested by education) are less willing or able to flout norms of gender behavior by being successful farmers than their less educated counterparts. The findings need investigation through detailed qualitative research.

Education and Household Food Security

Greater HFS was seen among households where the PC had secondary education or higher and also where the PC had received nutrition education in the past. However, among those raising animals, nutrition education was only associated with HFS when the PC also had secondary education or higher (See Appendix 1). This could reflect differing types of nutrition education received by more educated versus less educated primary caregivers. However, since education is seen as socially desirable, it is possible that the answers to questions regarding nutrition education may have reflected perceived desirable answers rather than the actual education.

Although the pathway by which education affects household food security cannot be fully established from this study, it is clear that there is an important association between household food security and the primary caregiver's education.

Limitations of the Study

The cross-sectional nature of the data provides uncertainty regarding the temporality of the associations between HFS and household socio-economic or farming characteristics. Furthermore, although the parishes and zones were randomly selected throughout Kampala, a convenience sample of households was taken from each zone. Compared to the overall urban population in Kampala (Uganda Bureau of Statistics & ORC Macro 2001), our sample was more highly educated, included only households with at least one child aged 2-5 years, and had a higher proportion of farming households (79 percent versus 35 percent in Maxwell and colleagues work). Therefore, although the study areas are representative of Kampala, the individual households may not be. Urban farming households' size being larger than the urban norm has been noted in other studies (Foeken 2006; Bopda *et al.* forthcoming; David *et al.* forthcoming).

Wealth was measured by an asset-based index using nine different assets. Although it is clear that some assets are better indicators of wealth than others (i.e. vehicle vs. radio) there was no validated weighting system available, nor were focus group discussions conducted to create a new weighting system. Therefore, to limit bias in creating the score, each asset was given a score of 1 if it was present in the household. The lack of weighting used in creating the asset-based wealth index is, however, a major limitation of the study that should be taken into consideration. Future research should focus on developing locally adapted and weighted asset-based wealth indexes. One method of doing this could be to incorporate data regarding assets from the Uganda Demographic and Health Surveys and develop asset-specific weights based on the prevalence of each asset in Ugandan households.

There are several challenges in measuring HFS. The approach often used to measure food security in developing countries is to understand the local food related activities through in-depth interviews and subsequently develop indicators to identify food secure and food insecure households (Wolfe & Frongillo 2001). In this study, HFS was measured using food-related coping strategies, based upon prior qualitative work delineating common strategies reported during focus group discussions in Kampala in 1993. We did not conduct our own focus group discussions and it is possible that over ten years the strategies used by households have changed. Further, the high proportion reporting “never” to several items indicate that our HFS indicator may not have been as sensitive as desirable to less severe forms of food security. Finally, the pathways by which intra-household dynamics affected HFS remain opaque in the work here and would benefit from qualitative research in Kampala.

Assessing and Monitoring Household Food Security

Given the multi-factorial nature of food security, there has been considerable debate about its optimal method of measurement. In fact, it has been suggested that food security is too complex to be adequately measured by a single indicator (Maxwell *et al.* 1999). With no gold standard for measuring HFS, various measurements have been used as proxies, such as household food consumption patterns and nutritional status (Maxwell & Frankenberger 1992; Haddad *et al.* 1994; Bouis 1993). Consumption-based approaches, including the evaluation of food consumption through 24-hour dietary recalls or measuring the depletion of household food stocks, are limited because they are vulnerable to measurement error and require additional resources (Bouis 1993). In addition, although they address ‘sufficiency’ these measures overlook access and vulnerability.

Recognizing this, researchers have developed instruments that take the multiple components of food security into consideration. Food security needs to be defined and measured based on the events that take place and coping strategies used among those who actually experience insufficiency, as where Maxwell and colleagues identified country specific items through focus group discussions (Maxwell *et al.* 1999). Other country specific scales have been developed as a result (Maxwell 1996; Maxwell *et al.* 1999; Lorenzana & Mercado 2002; Frongillo *et al.* 2003).

There are advantages to this approach. First, it evaluates the sufficiency component of food security while also examining actual strategies that household members use to meet their food needs. As a result, food security strategies are seen as an integral part of an overall livelihood strategy. This is especially important since it has been argued that food security and livelihood security are inevitably intertwined (Chambers 1988; Corbett 1988; Maxwell & Smith 1992; Davies 1993). Second, it is a practical alternative to consumption or livelihood measures as it is easy to apply and adapt to different locations.

Despite the limitations in measuring HFS, this method is useful in assessing concepts that may not be captured by quantitative measures. The disadvantage of creating new HFS scales is that there are no baseline data for comparing results. Therefore, similar to scales developed and validated in USA, it would be useful for a scale to be developed for Uganda

so that HFS could be monitored and assessed in a systematic way. Further, monitoring over time is important, as the limited longitudinal data shows seasonal and annual variations in HFS among farming and non-farming households (Maxwell 1995; Foeken 2006, p. 190). This dynamism can only be captured by more frequent, comparable longitudinal data which can sort out seasonal and secular trends – all the more important with the food crisis now facing lower income countries.

CONCLUSIONS AND RECOMMENDATIONS

This chapter has shown that the main ways urban agriculture affects food security are wealth, land, livestock, gender and education. The following conclusions and recommendations can be drawn from the results of this research:

- There is an association between wealth and household food security. This finding is consistent with the literature in which wealth and food security are consistently and inextricably linked. However, urban agricultural activities can mediate the association between urban poverty and household food insecurity. Therefore, urban agricultural activities should be promoted as a strategy to strengthen household food security.
- Raising pigs is associated with greater household food security through generating income for the household. The impact of raising pigs and other urban livestock on income and household food security should be further assessed.
- The size of land being farmed, perhaps an indicator of farming intensity, mitigates the association between wealth and HFS. While greater access to land may alleviate the effects of urban poverty on HFS the feasibility and methods of doing this should be studied further. Intra-household dynamics and gender roles must be taken into consideration to ensure that greater access to land translates into maximal benefits in terms of HFS.
- HFS was dependent upon intra-household roles as evidenced by differences between male and female-headed households. There is a need to examine the intra-household roles associated with urban agriculture so that interventions are appropriate for female-headed households and women in male-headed households, particularly because women are shown to be key players in HFS.
- Higher education of the primary caregiver was strongly associated with HFS. Interventions aimed at increasing female education could therefore be expected to impact food security and should be supported.
- There are several challenges in measuring HFS. The approach often used to measure food security in developing countries is to understand the local food-related activities through in-depth interviews and subsequently develop indicators to identify food secure and food insecure households. An HFS scale should be developed and applied in Uganda to permit systematic monitoring and assessment.

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Appendix Multivariable Linear Regression Models

Table 5A.1 Model 1 - Factors influencing the household food security score among **all participating households** (Multivariable regression, n=268)

	Models					
	Univariable		Full Multivariable*		Reduced Multivariable**	
	B	95% CI	B	95% CI	B	95% CI
Intercept	---	---	7.29	4.56, 10.03	7.30	4.70, 9.91
Socio-economic variables	B	95% CI	B	95% CI	B	95% CI
Male head of household	1.77	0.55, 2.99	0.98	-0.21, 2.17	0.96	-0.20, 2.12
Secondary school or higher (HOH)	2.02	0.91, 3.12	-3.05	-0.57, -0.33	-2.93	-5.62, -0.24
Secondary school or higher (PC)	2.38	1.35, 3.42	1.44	0.31, 2.58	1.42	0.30, 2.55
Nutrition education received (PC)	1.96	0.88, 3.03	0.92	-0.09, 1.03	0.98	-0.02, 1.98
More than 1 cash earner	1.32	0.26, 2.39	0.00	-1.21, 1.21	---	---
Dependency ratio	-0.19	-0.38, 0.01	-0.13	-0.34, 0.08	-0.13	-0.31, 0.04
Asset Score	0.93	0.63, 1.24	0.54	-0.12, 1.20	0.60	-0.05, 1.24
Farming variables						
Tropical Livestock Unit	0.40	0.08, 0.75	-0.01	-0.37, 0.36	---	---
Raising pigs	2.09	0.30, 3.88	1.03	-0.64, 2.70	1.19	-0.43, 2.81
More than ¼ acre of land	1.67	0.62, 2.72	5.09	2.55, 7.64	5.36	2.90, 7.83
Urban agriculture as income	1.40	0.34, 2.47	0.58	-0.58, 1.74	---	---
Interaction terms						
Size of land * Asset score	---	---	-0.91	-1.50, -0.32	-0.94	-1.51, -0.36
HOH education * Asset score	---	---	0.83	0.13, 1.53	0.79	0.09, 1.48

*R²=0.2723

**R²=0.2691

Table 5A.2 Model 2 - Factors influencing the household food security score among **households growing crops** (Multivariable regression, n=209)

	Models					
	Univariable		Full Multivariable*		Reduced Multivariable**	
	B	95% CI	B	95% CI	B	95% CI
Intercept	---	---	8.92	6.48, 11.36	9.06	6.81, 11.31
Socio-economic variables	B	95% CI	B	95% CI	B	95% CI
Male head of household	1.57	0.19, 2.96	-1.21	-3.22, 0.81	-1.13	-3.12, 0.85
Secondary school or higher (HOH)	1.68	0.42, 2.94	-0.39	-1.90, 1.19	-0.34	-1.79, 1.11
Secondary school or higher (PC)	2.29	1.10, 3.49	-0.35	-2.81, 2.10	-0.37	-2.78, 2.03
Nutrition education received (PC)	2.19	0.98, 3.39	1.22	0.05, 2.39	1.22	0.06, 2.38
More than 1 cash earner	1.66	0.46, 2.87	0.32	-1.11, 1.76	---	---
Dependency ratio	-0.21	-0.42, 0.01	-0.10	-0.34, 0.14	-0.13	-0.33, 0.06
Asset Score	0.86	0.52, 1.21	0.55	0.18, 0.92	0.57	0.22, 0.93
Farming variables						
Crop Number	0.10	-0.08, 0.28	0.00	-0.24, 0.23	---	---
Grows vegetables	0.80	-0.42, 2.03	0.13	-1.31, 1.58	---	---
Number of year farming	-0.08	-0.15, 0.00	-0.08	-0.16, 0.00	-0.08	-0.15, 0.00
More than ¼ acre of land	2.03	0.80, 3.25	1.97	0.67, 3.27	1.98	0.83, 3.12
Urban agriculture as income	1.72	0.50, 2.93	0.98	-0.18, 2.15	1.04	-0.10, 2.17
Interaction terms						
PC education * Sex of HOH	---	---	2.96	0.36, 5.57	2.97	0.44, 5.50

*R²=0.2746

**R²=0.2737

Table 5A.3 Model 3 - Factors influencing the household food security score among households raising animals
(Multivariable regression, n=128)

	Models					
	Univariable		Full Multivariable*		Reduced Multivariable**	
Intercept	---	---	B	95% CI	B	95% CI
			10.8	6.93, 14.62	11.0	7.44, 14.60
Socio-economic variables	B	95% CI	B	95% CI	B	95% CI
Male head of household	1.73	0.00, 3.46	-1.60	-4.27, 1.07	-1.69	-4.30, 0.93
Secondary school or higher (HOH)	1.67	0.08, 3.26	-0.31	-2.21, 1.60	-0.40	-2.27, 1.47
Age of PC	-0.05	-0.12, 0.02	-0.04	-0.10, 0.03	-0.03	-0.10, 0.03
Secondary school or higher (PC)	2.02	0.53, 3.50	0.37	-1.79, 2.54	0.39	-1.72, 2.50
Nutrition education received (PC)	1.66	0.15, 3.16	-1.10	-3.24, 1.03	-1.15	-3.25, 0.95
More than 1 cash earner	1.02	-0.50, 2.53	0.07	-1.44, 1.58	---	---
Asset Score	0.78	0.35, 1.22	0.40	-0.09, 0.88	0.43	-0.03, 0.90
Farming variables						
Tropical livestock unit	0.48	0.09, 0.86	0.11	-0.29, 0.50	---	---
Raising pigs	2.18	0.33, 4.03	1.61	-0.15, 3.37	1.64	-0.09, 3.38
More than ¼ acre of land	1.80	0.24, 3.36	-1.37	-4.19, 1.45	-1.46	-4.23, 1.31
Urban agriculture as income	1.76	0.14, 3.38	0.30	-1.34, 1.93	---	---
Interaction terms						
PC Education * Nutrition education	---	---	3.44	0.59, 6.30	3.63	0.86, 6.40
Sex of HOH * Size of land	---	---	4.16	0.81, 7.51	4.39	1.13, 7.64

*R²=0.2935

**R²=0.2898

CHAPTER 6

Nutritional security of children of urban farmers

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BACKGROUND

Food security (described in the previous chapter by Sebastian and colleagues) is a necessary pre-condition to nutrition security (Babu & Pinstруп-Andersen 1994; Haddad *et al.* 1994). Nutrition security, achieved when a household has secure access to food, ideally leads to adequate nutritional status contributing to a healthy life for household members (Weingärtner 2004). The nutritional status of individuals and populations is assessed using a variety of dietary, anthropometric, laboratory and clinical methods (Gibson 2005). For example, child weight for age z score (WAZ) reflects both chronic and acute under-nutrition, and reduction in the national prevalence of low WAZ has been selected as a Millennium Development Goal indicator (SCN 2004). The role of factors beyond food security, including access to a sanitary environment, adequate health services and knowledgeable care, many of which are of interest to policy makers and urban agriculture (UA) practitioners alike, must also be taken into account when examining nutritional security (UNICEF 1990). Although UA may pose a complex set of health risks, associated with agriculture in general (Hawkes & Ruel 2006) as well as UA specific (Cole *et al.* 2006), UA remains an important livelihood strategy that can contribute to household food and nutrition security by increasing access and availability to food in urban settings (Koc *et al.* 1999).

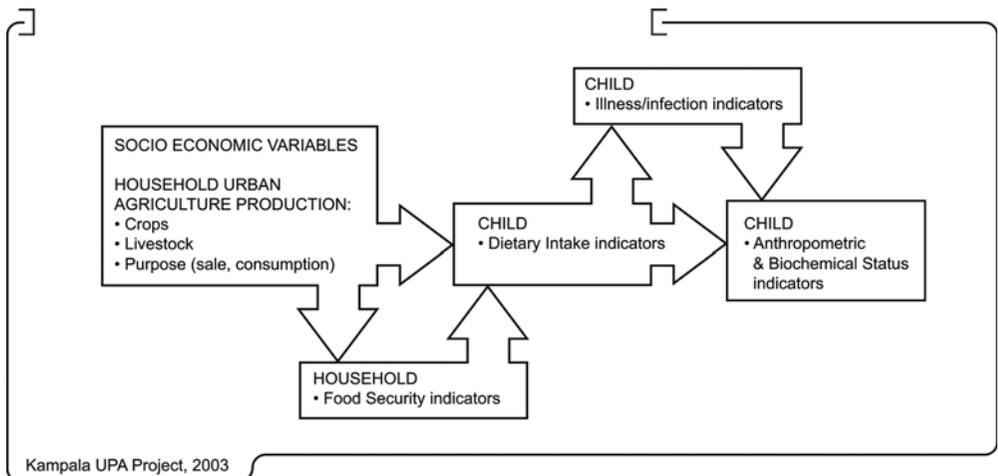
Vitamin A and iron deficiency are among the most serious health problems currently affecting the Ugandan population, particularly children (Bachou 2002). It has been estimated that one out of four infant and child deaths can be prevented, and the severity of illnesses can be reduced, by improving vitamin A status (Johnson-Welch 1999; Beaton 1993). Similarly, improving iron status can prevent neurological damage in children and significantly increase work capacity in adolescence and adulthood (Johnson-Welch 1999; WHO 2002). Food-based interventions in other countries have been shown to decrease vitamin A and iron deficiencies (Johnson-Welch 1999; Low *et al.* 2007). For example, promotion of increased household production and consumption of orange-fleshed sweetpotatoes (OFSP) led to higher intakes of vitamin A in Kenya (Hagenimana *et al.* 1999), and higher intakes and serum retinol in Mozambique (Low *et al.* 2007). Similarly, in Ethiopia, children living in households that owned at least one cow and consumed milk more than four times a week were less likely to manifest

symptoms of vitamin A deficiency (Ayalew *et al.* 1999). Despite these examples, rigorous published studies regarding the impact of involvement in agricultural activities on nutrition are limited, as noted by Berti and colleagues (2004) in relation to agricultural interventions in general, and more recently Kang'ethe and colleagues (2007) in relation to urban agriculture in particular.

In Uganda overall, households who relied more heavily on their own production of food were more likely to have children who were stunted in econometric analyses of population survey data (Bahiigwa & Younger 2005). In contrast, in Kampala, children in farming households had better nutritional status, as measured by height for age z score (HAZ) than non-farming households (Maxwell *et al.* 1998). Work among Nairobi poor found lower proportions of severely malnourished (weight for age) and wasted (weight for height) children in small samples of urban farmers in comparison to non-farmers (Mboganie-Mwangi & Foeken 1996). Although similar work in the plentiful season in Nakuru was confounded by differences in socioeconomic status (urban farm households generally wealthier) and climatic variation (drought in the year of survey), different results were found for younger pre-school children (6-23 months, worse or lower anthropometric indices in farm households) and older ones (24-59 months, better or higher anthropometric indices) (Foeken 2006, pp. 86-89).

Despite the widespread interest in promoting sustainable, robust food systems to support increasing urban populations, there remains limited evidence in the published literature regarding not only the mechanism by which UA can 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. In this chapter we describe how we aimed to respond to this call by examining the links among household characteristics, urban agriculture activities and food security and pre-school child dietary intake, anthropometric and biochemical indicators. Figure 6.1 summarizes our hypothesized linkages.

Figure 6.1 Framework of linkages between household urban agriculture and child nutrition



Specifically, in relation to nutrition security we hypothesized that dietary quality (percentage of energy from animal source foods [%ASF] and dietary diversity) would have an impact on infection (as measured by C reactive protein – CRP), which would in turn have an impact on biochemical (hemoglobin and retinol) and anthropometric indices (weight for age z score – WAZ and body mass index z score – ZBMI) of nutritional status. Other direct pathways were also explored, such as those between assets and WAZ.

METHODS

Population

The same households involved in the assessment of household food security (see Sebastian and colleagues Chapter 5) participated, namely farming and non-farming households with children selected within each zone (Plates 7, 8 and 9). We over-sampled farming households to achieve power in detecting associations between our focal independent factors of interest, urban agriculture activities, and our dependent food and nutritional security indicators.

In each eligible household, one child aged 2 to 5 years was chosen as the index child. We focused on nutritional assessment of this age group for several reasons. First they are among the more vulnerable members of Ugandan households (Bahigwa & Younger 2005). Second, as the mean duration of breastfeeding reported in the 2001 Uganda Demographic and Health Survey (UDHS) was 21.6 months the contribution of breast milk, which is difficult to measure in field conditions, to their dietary intake, was likely to be minimal (UBOS & ORC Macro 2001). Finally, they would be more likely to be eating crops or animal source foods that might be produced by a farming household than would younger children. Children's caregivers provided proxy consent for the measures taken on each child, in keeping with ethical approvals noted in Chapter 5.

Measures

To assess the entire path towards nutritional outcomes we drew on a number of the measures noted in Chapter 5. Among the different options for nutritional assessment (Yeudall *et al.* 2006), we selected a parsimonious set of dietary, anthropometric and biochemical indicators for the index child. One child between the ages of 2 and 5 years was selected per household to participate in the study of nutritional status indicators. Dietary intake data was collected using the modified interactive 24-hour recall procedure previously validated in African populations (Gibson & Ferguson 1999). Source of food consumed (purchased, home production or other including gift, food for work) was recorded for each food eaten and percentage total energy from home production calculated for each index child. The diet diversity score was calculated by counting the number of unique food items reported for each child in a single 24 hour recall using the method of Hatloy and colleagues (Hatloy *et al.* 1998). Water and sugar added to other foods or beverages were not included in the diet diversity score. Percent contribution of animal source foods (%ASF) was calculated by dividing energy intake from animal sources by total energy intake, as described by Allen and colleagues (1991). The contribution of other major food groups as a percentage of energy intake was also calculated using food groups suggested by the World Food 2.0 program.

Where a mixed food could be classified in more than one food group (for example bean sauce with tomatoes and onions), the predominant ingredient was used to classify the food into a food group. If it was not possible to determine a predominant (for example *samosa*), the food was classified as a mixture. All dietary intake data was entered into the World Food Dietary Assessment System 2.0 for calculation of nutrient totals.

Standing height, weight, and mid-upper-arm circumference (MUAC) were measured in triplicate by trained research assistants using calibrated equipment and standardized techniques (Lohman *et al.* 1988). The children were measured wearing light clothing without shoes. Each research assistant performed only one measurement to eliminate inter-examiner error. Height was measured to the nearest millimeter with a portable stadiometer. Weight was measured to the nearest 0.1 kg with a portable battery-operated scale. MUAC was measured on the right side with a fiberglass insertion tape (Ross Laboratory). Z-scores for height-for-age (HAZ), weight-for-age (WAZ), weight-for-height (WHZ), and body mass index (ZBMI) were calculated with the SAS program provided by the Centers for Disease Control and Prevention (CDC) based on the CDC 2000 reference growth data (CDC 2005). Z-scores for MUAC were calculated using the US reference data based on the National Health and Nutrition Examination Survey (NHANES) I and II data for African-Americans and compiled by Frisancho (1990). The least mean squares (LMS) method was used to correct for skewed body composition indices expressed as z-scores where appropriate (Davies *et al.* 1993).

Finger prick blood samples were collected in the field into cuvettes for determination of hemoglobin (Hb) by portable hemoglobinometer (Hemocue AB, Sweden); results were recorded to the nearest 1 g/L. A commercial standard supplied by the manufacturer was read at the beginning of each day's collection for quality control purposes. Dried finger prick blood spot samples were collected on a filter paper card and sent to Craft Technologies (Wilson NC) for analysis of serum retinol and C-reactive protein (CRP) (Craft *et al.* 2000). The methods used in these tests followed the manufacturer's directions and included quality control measures.

Statistical Analysis

Descriptive and initial comparison analyses were conducted in SAS version 9.1 and Mplus version 4.1. All continuous variables were examined for normality. The statistical significance of correlations was assessed by Pearson's correlation coefficient for continuous variables and differences in proportions between groups were assessed by Pearson's chi square test for categorical data. Differences between groups for normally distributed variables with homogeneity of variance were assessed by General Linear Models, controlling for age and sex. Statistical significance was set as a p value of < 0.05. This step both aided understanding of the key contrasts and assisted with variable reduction. We reduced to two different indicators of dietary intake (diet diversity and %ASF), representing different aspects of dietary quality, and two anthropometric indicators, one for growth (WAZ) and one for body composition (ZBMI).

Path models have been used in nutrition research to understand complex sets of relationships (Perez-Escamilla *et al.* 1999). Exploratory path analysis was used to examine the relationships between variables, as per the hypothesized model (Figure 6.1). Modifications were made according to the populations for analysis: the entire sample (including non-farming households), those growing crops and those raising animals. Covariates such as asset score and age were retained. The relationship between C-reactive protein and retinol was not examined, since the final retinol values were corrected for C-reactive protein prior to inclusion in the analysis. The models were run using Mplus version 4.1 and markedly non-significant paths dropped ($p > 0.2$). List-wise deletion was applied. Then the models were re-run with the remaining variables and Modification Indices provided by Mplus were used to add paths and correlated errors. The modification indices provided by the Mplus show the improvement in the chi-square value that could be obtained if that path was added to the model. Effects were added and errors correlated with the model if they statistically contributed to the model and if they also were consistent with our theoretical understanding of relationships. To account for non-normality of variables (e.g. %ASF and the resulting biases) we used robust estimates of standard errors using estimation methods implemented in Mplus. For the final models (for each type of farming household and overall), several goodness-of-fit indices were used to arrive at the most appropriate sets of paths with demonstrated adequate fit (details of the model-fitting can be found in Yeudall *et al.* 2007).

RESULTS

Household characteristics

Among the 296 households participating in the food security analyses (see Chapter 5), crop-farming households had lower asset scores than other households, in keeping with the lower capitalization required for growing crops (Table 6.1). Few differences were observed in caregiver education but clearly greater access to land was observed among farming households, similar to findings from Mozambique (Egal *et al.* 2003).

Table 6.1 Selected socio-demographic and farming characteristics by household farming type

		Non Farming (n=61)	Livestock Farming (n=139) ²	Crop Farming (n=215) ²	All (n=296)
Asset score ¹	(n= 296)	4.1 (3.6, 4.5)	4.1 (3.8, 4.5)	3.5 (3.2, 3.9)	3.9 (3.7, 4.1)
Education < primary	(n= 296)	52.7%	53.7%	56.3%	54.5%
Land size <1/4 hectare	(n= 296)	100.0%	37.7%	41.4%	50.1%
% kcal home production ^{1,3}	(n= 281)	3.7 (1.4, 6.0)	14.3 (11.1, 17.6)	12.6 (9.0, 16.2)	11.8 (9.8, 13.9)

¹ Arithmetic mean (95% Confidence Interval or CI)

² n=20 raised livestock only, n=119 livestock farmers also raised crops, n=96 grew crops only

³ Difference between non-farming and farming groups significant $p < 0.001$

Food security and dietary variables of nutritional security

The percentage of total energy consumed by the index child from home production was substantially greater among children from farming households (14.3 percent among livestock keepers and 12.6 percent among crop farmers) than from non-farming households (3.7 percent) (see Table 6.1). These differences are hard to compare with Southern African data that calculated percentages of expenditure equivalents rather than kilocalories (Egal *et al.* 2003). The mean household food security (HFS) score was 12.1 (SD 4.5) and is reported in Table 6.2 along with dietary diversity and quality variables. The mean dietary diversity score was 11.7 and the mean %ASF was 11.0 percent (see Table 6.2). There was a significant effect of sex on diet diversity score (mean difference= 1, $p=0.01$), with girls consuming on average one more food per day compared to boys, but no such relationship was found with %ASF.

Table 6.2 Selected food and nutritional security variables of index children by farming type

		Non Farming (n=61)	Livestock Farming (n=139) ²	Crop Farming (n=215) ²	All (n=296)
Household Food Security	(n= 296)	11.3 (10.1, 12.5)	11.7 (11.2, 12.2)	11.9 (11.0, 12.9)	12.1 (11.6, 12.7)
Dietary diversity ³	(n= 281)	11.3 (10.2, 12.4)	11.7 (11.2, 12.2)	11.4 (10.7, 12.1)	11.7 (11.2, 12.1)
% kcal Animal Source Food	(n= 281)	11.5 (7.8, 15.1)	11.9 (9.6, 14.1)	9.8 (7.7, 11.9)	11.0 (10.0, 12.4)
CRP mg/dL	(n= 255)	2.37 (1.09, 3.65)	2.14 (1.33, 2.95)	1.99 (1.24, 2.73)	2.13 (1.62, 2.63)
HAZ	(n= 256)	-0.41 (-0.90, -0.08)	-0.37 (-0.72, -0.03)	-0.52 (-0.91, -0.14)	-0.44 (-0.66, -0.21)
WAZ	(n= 256)	-0.30 (-0.64, -0.04)	-0.17 (-0.40, -0.06)	-0.43 (-0.72, -0.15)	-0.29 (-0.45, -0.13)
ZBMI	(n= 256)	0.12 (-0.10, 0.34)	0.29 (0.12, 0.45)	0.19 (-0.05, 0.44)	0.22 (0.10, 0.34)
ZMUAC	(n= 256)	-0.37 (-0.58, -0.15)	-0.24 (-0.40, -0.07)	-0.33 (-0.52, -0.14)	-0.30 (-0.40, -0.19)
Hemoglobin g/dL	(n= 251)	11.7 (11.2, 12.2)	11.6 (11.3, 12.7)	11.9 (11.5, 12.2)	11.7 (11.5, 11.9)
Retinol μ mol/g	(n= 263)	0.966 (0.868, 1.064)	1.001 (0.959, 1.043)	0.968 (0.897, 1.039)	0.995 (0.955, 1.036)

¹ Arithmetic mean (95% Confidence Interval or CI)

² n=20 raised livestock only, n=119 livestock farmers also raised crops, n=96 raised crops only

HAZ = height-for-age z-score; WAZ = weight-for-age z-score; ZBMI = body mass index z-score; ZMUAC = mid upper arm circumference z-score

³ Difference between livestock and other/non farmers significant $p<0.05$

Examples of 24-hour dietary recalls within the highest and lowest quartiles of dietary diversity and percentage contribution of animal source foods are presented in Table 6.3.

Table 6.3 Examples of 24-hour recalls within highest and lowest quartiles of dietary diversity score (DDS) and percentage contribution of animal source foods (%ASF)

	Highest quartile diet diversity	Lowest quartile diet diversity
Highest quartile %ASF	DDS=25, %ASF=46.7% Samosa and tea with milk and sugar Bean sauce with chapatti, green pepper, Irish potato and tea with milk and sugar Banana and sugarcane Banana and jackfruit and sugarcane Groundnut sauce, green leaf relish, fish relish, rice and <i>matoke</i> , yam and passion fruit juice Samosa and passion fruit juice Fried soya, roasted groundnut, fish relish and tea with milk and sugar	DDS =5, %ASF=55.4% Whole cow's milk with sugar and bun Rice with avocado Whole cow's milk with sugar Samosa
Lowest quartile %ASF	DDS=14, %ASF=0% Maize porridge with tea and sugar Cabbage relish (with tomato and oil) and chapatti with tea and sugar Passion fruit and green maize Bean sauce, green leaf relish, eggplant, rice and sweetpotato Orange and sugarcane Green leaf relish, eggplant, rice and tea with sugar	DDS =4, %ASF=0% Tea with sugar, bun Sweetpotato with groundnut sauce Sugarcane Sweetpotato with eggplant relish

As expected, starchy staples contributed the highest median proportion of energy (41.9 percent, 32.3-55.2 percent), followed by nuts, seeds and beans (11.7 percent, 0.6-22.1 percent), sugar and sweets (10 percent, 6.4-15.7 percent), fruit (3.8 percent, 0-8.8 percent) and vegetables (3.6 percent, 0-10.8 percent). Fats and oils, beverages and mixed dishes each contributed less than 1 percent of total energy intake. There were no statistically significant differences observed among farming groups. The proportion of the sample who consumed at least one food from a food group ranged from a high of 99.3 percent and 97.1 percent for starchy staples and sugar respectively to a low of 12.2 percent for fats and oils and 33.1 percent for mixed dishes. Fruits and vegetables were consumed by 68.3 percent and 70.1 percent of the sample respectively, and nuts, seeds and beans by 75.2 percent of children surveyed. The three foods consumed the most frequently for each of the food groups is summarized in Table 6.4.

Table 6.4 Three most frequently consumed foods for each food group

Starchy staples	Nuts, seeds and beans	Animal source foods
Maize based foods	Beans & bean sauce	Cow's milk
Plantain/ <i>matoke</i>	Groundnuts & groundnut sauce	Fish
Rice	Sesame seed/ <i>simsim</i>	Beef
Sugars and sweets	Fruits	Vegetables
Sugar	Passion fruit	Green leaves
Sugarcane	Banana	Sweetpotato
Candy	Jackfruit	Irish potato
Fats and oils*	Beverages	Mixed dishes*
Margarine	Tea	Samosa
Ghee	Carbonated drinks	Doughnut
	Coffee	

*Only two foods consumed in this food group

Anthropometric and biochemical variables of nutrition security

Although some variation could be observed in the child anthropometric and biological measures across types of households e.g. ZBMI and ZMUAC being higher in livestock raising households, none of the differences were statistically significant (see Table 2). In models, there was a residual age effect for ZBMI, despite all raw anthropometric measures being transformed to z-scores to eliminate the effect of age and sex, so age was retained in subsequent models. There was a significant correlation between age and hemoglobin level ($r = 0.231, p < .001$), older children tending to have higher hemoglobin levels. There was no significant relationship between retinol level and age or sex.

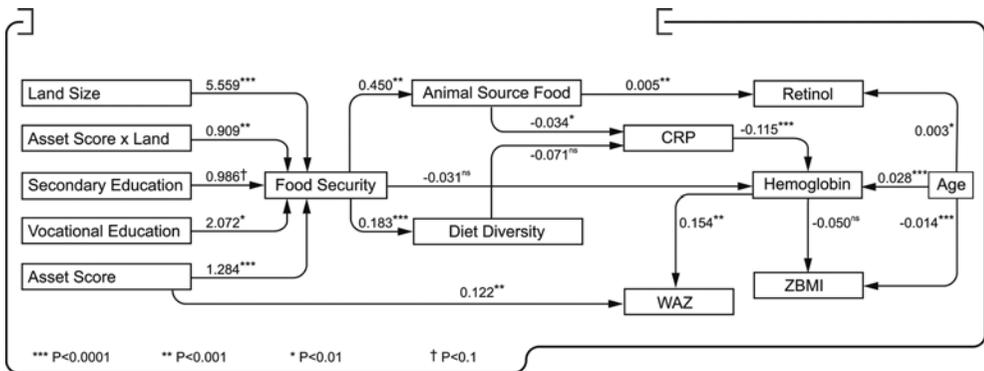
Relationships among farming, food and nutrition security characteristics

The HFS score was significantly positively correlated with tropical livestock units ($r = 0.142, p = .017$), dietary diversity ($r = 0.230, p < .001$), %ASF ($r = 0.185, p = .002$), and WAZ ($r = 0.149, p = .017$). The correlation with HAZ approached significance ($r = 0.109, p = .076$). There were no significant relationships between HFS and the age, sex or biochemical measurements of the index child (data not reported). After age and sex were controlled for, children from families that did not raise livestock (whether or not they also grew crops) had a significantly lower average dietary diversity score than children from families that raised livestock. Although there were no significant differences in anthropometric variables in relation to farming, there was a non-significant trend for the improved growth and body composition variable among livestock farmers.

Exploratory path analysis

Of the 296 participants, 215 had sufficiently complete data to be included in the exploratory path analysis. For these households, the relationships among asset score, land size and their interaction, along with education of the primary caregiver, remained significant in relation to HFS, consistent with findings in the larger sample described in Chapter 5 (see Figure 6.2).

Figure 6.2 Path Model and Un-standardized Path Coefficient for Full Sample (n=215)



CRP= C-reactive protein; WAZ= weight-for-age z-score; ZBMI= body mass index z-score

HFS was positively associated with child dietary intake variables, in keeping with our conceptions of the linkages. Further, dietary quality, as measured by %ASF, had a significant negative relationship with infection, as measured by C-reactive protein i.e. those with better dietary quality had lower CRP indicating less infection. Infection had a significant negative relationship with hemoglobin level, which in turn had a significant positive relationship with WAZ, consistent with better overall nutritional status, and a non-significant negative relationship with ZBMI. Finally, %ASF had a significant positive relationship with retinol. Age retained its significant relationship with retinol, hemoglobin and ZBMI, and asset score retained its significant relationship with WAZ. Substituting ZMUAC for ZBMI as a measure of body composition did not significantly alter the model, and therefore ZBMI was retained as the measure of body composition because it is more commonly used.

The same relationships remained when crop-farming households were examined ($n = 161$), with the exception of the interaction of land size and asset score with HFS, %ASF with infection, and age with retinol. Among livestock-raising households ($n = 109$), land size, asset score, and age of the index child retained their significant relationship with HFS, %ASF was positively associated with retinol, and age was associated positively with hemoglobin and negatively with ZBMI. Substituting ZMUAC for ZBMI as a measure of body composition did not significantly alter the model, so ZBMI was retained as the measure of body composition because it is more commonly used.

DISCUSSION

Our findings are consistent with the hypothesized linkages between urban agriculture and food and nutrition security. Of particular note is the pathway illustrating the significant positive relationship between HFS and subsequent child consumption of animal-source foods, which in turn was positively associated with child retinol levels. Consumption of animal-source foods was significantly negatively associated with C-reactive protein, which in turn was significantly negatively associated with hemoglobin, and hemoglobin was significantly positively associated with WAZ. The relationship between CRP and retinol was not examined because the final retinol values were corrected for CRP. These findings highlight the importance of efforts to increase animal-source foods in children's diets to improve nutritional status (Allen 2003). The findings in relation to retinol, hemoglobin and WAZ are of particular interest to policy makers who need to make decisions on resource allocations for programs to improve not only child nutritional status but also gross domestic product (GDP). If additional longitudinal studies observe a similar association, then existing algorithms in the PROFILES program (www.aedprofiles.org/) and the World Health (2002) report can help determine potential GDP gains and/or disability adjusted life year gains. Likewise investment in programs to increase consumption of animal source foods, including urban agriculture, would be seen as a means of implementing the policy goal (Ross *et al.* 2003).

With the exception of area of land and number of tropical livestock units in relation to HFS and dietary quality, there were no significant differences in measures of food or nutrition security in relation to general categories of urban agricultural activities. There were, however, non-significant trends toward improved food and nutrition security indicators in children of

farming families. One of the advantages of path modeling is that it can disaggregate the distinct associations among multiple variables. In our models, we did not see distinct effects of raising livestock or of wealth. Rather, we observed that assets contributed directly to HFS and WAZ, but indirectly to nutritional security indicators such as consumption of animal-source food (ASF) and dietary diversity. Such a pathway is consistent with models of complex relationships between livestock production by households and better nutritional status of household members, as postulated by animal and health researchers (Randolph *et al.* 2007). In addition to assets, however, the amount of land available for agriculture and the education level of the primary caregiver also contributed directly to HFS and then indirectly to the other nutrition indicators. In Figure 6.2 this means nutrition indicators located to the right of food security, namely the biochemical and anthropometric indicators.

The two measures of dietary quality used in this study, namely diet diversity and percentage contribution of ASF, demonstrated different relationships with other nutrition security measures, reflecting in part the complexity of dietary quality as a construct and the subsequent challenge in identifying a single measure to characterize it. The contribution of ASF to diet quality in resource-poor countries is widely agreed upon amongst nutritionists, largely because ASF are known to more readily provide highly bio-available micronutrients such as iron, vitamin A and zinc than plant based foods. They also have been demonstrated to be associated with nutrition security measures (Murphy & Allen 2003). Similarly the value of a diverse diet in relation to dietary quality is not in dispute, with the vast majority of population-based dietary recommendations including directional statements regarding the value of increasing diversity in food choices based on evidence of associations with reduced health risks and nutrition security measures such as HAZ (Ruel 2003; Arimond & Ruel 2004). There remains, however, a lack of consensus regarding the optimal way to measure dietary diversity, making comparisons among studies difficult (for an in depth discussion of the issues see Ruel 2003). Table 6.3 demonstrates the challenge in measuring dietary quality by providing examples of 24-hour recalls that score in the upper quartile for diet diversity and the lower quartile for %ASF and vice versa. In this study we chose to use a food as opposed to food-group based measure of diet diversity, in large part because our use of standardized recipes in our food composition table makes assigning food groups to mixed dishes a challenge and because questions remain regarding valid methods of weighting the contribution of various food groups to an overall diet diversity score. Several groups including the International Food Policy Research Institute (www.ifpri.org) and the Food and Nutrition Technical Assistance Program (www.fantaproject.org) are investing considerable resources in the development and evaluation of diet diversity scales that can be used in field settings to capture dietary quality (Swindale & Bilinsky 2006).

In examining the contribution of different food groups, of note is the relatively high contribution of sugars and sweets to total energy intake. Some authors have suggested sugar consumption can be viewed as a proxy for improved socioeconomic status, in that consumption of sugar reflects ability to access or purchase food (Swindale & Bilinsky 2006). Indeed there was a statistically significant positive correlation between contribution of sugars and sweets to overall energy intake and the socioeconomic indicator we used, namely asset

score ($r=0.118$, $p=0.05$). A joint WHO/FAO report on Diet, Nutrition and the Prevention of Chronic Diseases recommended no more than 10 percent of energy be obtained from 'added' or 'free' sugars (excluding sugars bound in whole foods such as fruits, but including sugars added to processed and prepared foods) (WHO/FAO 2003). The median level observed in the diets of these children approaches the upper limit recommended in the report and warrants further investigation, particularly if an improvement in socioeconomic conditions as a result of urban farming interventions might lead to a higher contribution of added sugar to energy intake and a subsequent increase in risk factors for chronic diseases associated with over-nutrition.

Our results are consistent with the findings of a recent review of the effectiveness of agricultural interventions in relation to nutritional outcomes, which concluded that although most interventions increased food production, they did not necessarily improve the nutrition or health of participating households (Berti *et al.* 2004). Although the review did not focus on urban agriculture specifically, the authors' observation that successful interventions investing more broadly in different types of human capital had a greater likelihood of success (although greater investment was not a guarantee of success) supports our conclusions that more research is required to understand the complex relationships and livelihood trade-offs in urban agriculture. For example, although home-produced foods provided a significantly higher percentage of calories in the diets of children of farming families, this difference was not necessarily associated with improved nutrition security status. It is possible that income from the sale of food could be used to improve conditions necessary for optimal nutrition security e.g. through better access to health care and/or purchase of high quality food, so further study examining the fate of agricultural production is warranted.

Additional studies utilizing a livelihoods framework, including a more detailed characterization of urban agricultural activities, could strengthen our understanding of the pathways by which urban agriculture can influence food and nutrition security (Joffe 2007). Clearly, challenges associated with insecurity in general and land tenure in particular, as identified by Bryld (2003) and others (Hawkes & Ruel 2006; Cole *et al.* 2006) must be taken into account. A recent review examining whether the promotion of animal production can improve nutritional status concluded that it was unclear whether improvements in nutrition security measures were indirectly influenced by increased income or directly impacted by increased animal production (Leroy & Frongillo 2007). The authors recommended that methodologically stronger studies are needed to be able to answer the question. A study utilizing a longitudinal design would overcome some of the limitations associated with our cross-sectional study, and additional power provided by a larger sample could add further insights. Further, randomized studies, such as that showing the success of combined agricultural and nutritional interventions around OFSP in improving nutritional security measures in general and vitamin A status in particular (Low *et al.* 2007) should be considered in multi-city studies with greater resources.

In conclusion, our findings are supportive of efforts to enhance access to land for urban farming and engagement in activities aimed at improving the quality of the dietary intake of urban residents, in particular with respect to increasing consumption of animal-source

foods. The potential for urban agriculture to contribute to the alleviation of several major health challenges, including vitamin A deficiency and anemia, warrants further investigation. A better understanding of the complex relationships among agricultural interventions and food and nutrition security outcomes is crucial in the planning, implementation and evaluation of agricultural interventions to contribute to effective program-planning activities and policy development.

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Food security, nutrition and urban agriculture

Editors' Commentary

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EDITORS' COMMENTARY

WHAT DO WE KNOW?

It is clearly established that the main factor associated with better household food security (HFS) is wealth. Urban agriculture (UA) can contribute to wealth through income and reductions in spending required on food in the household. In our work, the following aspects of UA mitigated household food insecurity:

- larger size of land being farmed,
- raising pigs as part of UA, and
- education of the primary caregiver, particularly secondary education.

With regards to nutrition, we were able to show links among household food security, child consumption of animal source foods and child retinol levels. These findings highlight the importance of efforts to increase the inclusion of animal-source foods as well as vitamin A-rich foods, such as orange-flesh sweetpotato, in the diets of children to improve nutritional status.

These factors based on statistical analysis correspond to livelihood strategies adopted by urban farmers, especially those able to raise livestock (see section D as well). These farmers clearly state that UA is beneficial in terms of both the nutritional and wealth generating contributions to their livelihoods.

Since the primary caregivers were all women, we are certain that education of women and girls who engage in UA will also benefit household food security. There were other effects of gender on HFS and nutrition but their meaning was less clear. The intra-household roles associated with urban agriculture need to be much better understood. More, especially qualitative, in-depth research is needed to understand the statistical patterns.

Kampala has made significant strides in developing UA typologies. The City Council has a classification of urban and peri-urban agriculture land use types within its boundaries.

WHAT CAN BE DONE?

General Principles

Local as well as central governments are obliged to respect the Right to Food, meaning they cannot stop people from providing themselves with food essential to their survival. They also have to prevent others from stopping them. Clear policy direction has to be set to meet this goal while ensuring food safety, consistent with government obligations on the Right to Health.

Municipalities should, like Kampala, have an Agriculture or Food Department, to develop and lead this area of policy. They should be aware of the potential food and nutrition security benefits of UA and assist urban farmers in producing nutrient-rich products for home consumption and city markets.

Secure and sustainable urban livelihoods are one policy goal and nutrition needs another. The role of municipalities is to link the needs of consumers and small-scale urban producers through facilitating a broad-based interdisciplinary collaboration among relevant stakeholders. Following the direction set by the drafting of KCC Ordinances on UA, a participatory analysis of local constraints and opportunities can be developed for policy and program design and implementation.

Policy Priorities

(see Gore, Chapter 4, above)

1. Review the Brazilian Right to Food model which includes UA in support to family farms;
2. Adoption of the framework suggested by researchers David, Maxwell and others of targeted assistance to Kampala's four types of UA farm households: "survival", "sufficiency", "food security" and "commercial", listed in order of their prevalence in the city's population. Other cities could use a similar typology, with interventions from emergency safety nets to marketing support;
3. Target households in the "survival" and "sufficiency" categories – especially those headed by women – for support including land access for UA;
4. Institute appropriate urban planning and tenure measures to support UA; and
5. Building on existing programs, promote a multi-channel communication strategy, involving health centers, schools, markets and street food vending points. Messages, advice and training on land access and farming methods are needed, as well as those from nutritionists, food technologists, health workers and home-economists (see key messages below).

Areas for Key Messages

- Food production, purchasing, processing, storage, preparation and distribution to make the best use of scarce resources, in cash or kind, for appropriate nutrition;
- Selection of nutrient-rich foods to supplement the common diet, such as fast-growing crops and small livestock that are culturally acceptable and easy to market;

- Opportunities for processing of fresh products; and
- Nutrition education, general hygiene, child feeding and food safety.

WHAT COULD WE UNDERSTAND BETTER?

1. For improving health outcomes, further characterization of UA activities using the classifications of UA described above and utilizing a livelihoods framework, could strengthen our understanding of the pathways by which UA influences food and nutrition security (subsistence versus income generation, crop and livestock combinations).
2. Generating results on the positive contributions of UA activities to food and nutritional security of communities, households and individuals, particularly in a time of prevalent HIV/AIDS, remains a major challenge. An accurate accounting of the benefits would allow program planners and policy makers to better mitigate risks and promote benefits. A number of research tools exist, and selection should be based on resource availability, research objectives and acceptability of data collection procedures to community members.
3. Measurement of HFS is a challenge. Local food-related activities (of which UA is a very important one) have to be understood in depth and indicators for identifying food secure and food insecure households better shared. Linkage with Food and Agriculture Organization and funding for periodic monitoring in relation to UA in a systematic way would assist policy makers.
4. More precise estimates of food and nutrient intakes of urban farmers, their families and their customers would provide valuable information for further understanding UA in relation to nutrition and food security.
5. Ways of increasing access to land for UA, in order to alleviate the effects of urban poverty on household food security, should be further investigated with a strong gender focus.
6. The extent to which UA is a viable strategy to improve food security among the urban poor who are not cultivating should be investigated and municipalities advised accordingly.
7. Well-resourced, larger scale UA intervention evaluations with food and nutrition security outcomes should be conducted, particularly among vulnerable populations.
8. Our findings in relation to retinol, hemoglobin and WAZ suggest the need for follow-up longitudinal studies. If the findings are confirmed, the algorithms in the PROFILES program (www.aedprofiles.org/) and the World Health (2002) report would enable determination of potential GDP gains and/or disability adjusted life year gains. This in turn would suggest greater investment in programs to increase consumption of animal source foods, including urban agriculture, as a means of implementing the policy goals of improved nutrition and related economic development.

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Healthy horticulture in cities

Overview

This section contains three chapters, presenting methods and data on hazards to human health from metal, organic chemical and microbiological contamination of food grown in Kampala. Chapter 7 describes an assessment of metal contamination through wetland cultivation and through cultivation beside roads in Kampala based on two published scientific papers. Particular sources of metals are identified; the differential uptake of metals by different plants and specific risk mitigation approaches are suggested. Chapter 8 describes polyaromatic hydrocarbons (PAHs) found in soil, air and surface films at urban farming sites in Kampala and how to assess the potential risk they pose for pre-school children's health. It describes the construction and assumptions of a screening-level risk assessment model developed at the University of Toronto and applied in Kampala. Findings are encouraging, indicating no likelihood of immediate harm but they do emphasize the need for further specification of multiple chemical exposures and examination of their combined effects. The health hazards associated with growing crops using sewage are substantial and create public concern in Kampala, as elsewhere. Chapter 9 provides data on pathogen contamination in different sites and documents differential uptake in different crops. Although vegetables that are cooked are not a concern, those eaten fresh are highlighted as ones in which pathogen reduction approaches should be employed and alternatives found.



Healthy horticulture in cities

**Grace Nabulo,
Hannington Oryem-Origa,
George W. Nasinyama,
Donald C. Cole and
Miriam Diamond**

Assessment of heavy metal
contamination of food crops in
wetlands and from vehicle emissions

Shelby Yamamoto

Estimating children's exposure to
organic chemical contaminants

**Susan Serani, George W.
Nasinyama, Grace Nabulo,
Abdelrahman Lubowa
and Moses Makoha**

Biological hazards associated with
vegetables grown on untreated
sewage-watered soils in Kampala

CHAPTER 7

Assessment of heavy metal contamination of food crops in wetlands and from vehicle emissions

Grace Nabulo • Hannington Oryem-Origa • George W. Nasinyama • Donald C. Cole • Miriam Diamond

INTRODUCTION

Rapid urbanization and growing unemployment lead people in Kampala to grow crops in hazardous places unsuitable for development. These places include road verges, banks of drainage channels, wetlands and contaminated sites such as scrap yards and dumpsites for solid and liquid wastes. The poorest groups involved in urban agriculture are most likely to utilize high-risk sites whose toxic history is unknown (Maxwell 1994; Sawio 1998).

The hazards of wastewater and solid waste use in urban and peri-urban agriculture have been categorized into four groups: biological agents including bacteria (Chapter 9), physical (such as injuries), psycho-social (such as discrimination) and chemical hazards (Cole *et al.* 2003). Although the priority public health hazards associated with wastewater use in low-income developing countries may be primarily biological (Shuval *et al.* 1986), the study of trace metal contamination in wetlands and from traffic is nevertheless urgent. This chapter seeks to assess the impact of industry and vehicle emissions on trace metal contamination of wetlands and roadside areas used for urban agriculture respectively.

Chemical hazards include agents such as heavy metals, nutrients such as nitrogenous compounds, phosphorus compounds, minerals, insecticides, fertilizers, fungicides, herbicides and organic chemicals (see Chapter 8). In addition to biological agents, industrial effluents include chemical pollutants such as heavy metals (Hamilton *et al.* 2007). The contamination of soils by chemicals, the potential uptake by crops and the possible chronic and long-term toxic effects in humans are discussed by Chang *et al.* (1995) and by Birley & Lock (1999). Heavy metals may enter the human body through inhalation or ingestion. Routes identified in the literature include inhalation, consumption of contaminated drinking water, direct ingestion of soil and consumption of food plants grown in metal-contaminated soil (Cambra *et al.* 1999; Dudka & Miller 1999). In terms of urban agriculture, aerial deposition on crops is of concern as well as uptake from soils.

Studies have shown that urban soils receive large inputs of toxic metals from different anthropogenic sources and especially from automobile emissions (Ho & Tai 1988; Garcia & Millan 1998). Another source is municipal waste which may contain a variety of metallic substances including batteries, consumer electronics, ceramics, electric light bulbs, house

dust and paint chips, used motor oils, plastics and some inks and glass. Studies have indicated that crops grown on metal contaminated soils have higher concentrations of metals than those grown on uncontaminated soil (Dowdy & Larson 1975; Nabulo 2006). Certain trace elements are essential in plant nutrition, but plants growing in a polluted environment can accumulate trace elements at high concentrations causing a serious risk to consumers (Alloway 1990; Kabata-Pendias & Pendias 1984).

Vegetables absorb metals from contaminated soils as well as from deposits on parts of the vegetables exposed to polluted air. Plant uptake of metals depends on the metal as well as soil conditions, such as acidity and organic matter content. Studies have found that the lead (Pb) burden in the urban environment is strongly related to vehicular traffic density (Daines *et al.* 1970). Wheeler and Rolfe (1979) found that Pb levels in vegetation increased linearly with traffic density. Rodriguez-Flores & Rodriguez-Castellon (1982) found that cadmium (Cd) and Pb levels in soil and vegetation decrease with increasing distance from the roadside.

Lead (Pb) is a heavy metal of particular concern because relatively low concentrations in the blood can affect children's mental development, while Pb poisoning causes permanent neurological, developmental and behavioral disorders, particularly in children (Laidlaw *et al.* 2005; Needleman *et al.* 1990). People living in urban areas where surface soils are contaminated with Pb may be exposed through indoor and outdoor inhalation of dust and ingestion of Pb deposited on surfaces in homes and outdoors (Laidlaw *et al.* 2005). Most automobiles in Uganda use leaded gasoline, with unleaded gasoline only becoming available in early 2006.

Cadmium (Cd) is more mobile in aquatic environments than most other metals and is bio-accumulative and persistent (USPHS 1997). It is used in nickel-cadmium batteries, in metal plating, in pigments for glass and as a stabilizer for polyvinyl chloride (PVC) (USPHS 1997; WHO 1993). Cd is readily available for uptake by grains and vegetables, and as such, there is a clear association between Cd concentration in soil and plants grown on that soil (Elinder & Jarup 1996; WHO 1993). Throwing of batteries into waste pits (Chapter 2) is one potential source of soil contamination.

Zinc (Zn) is a component of tires, which is released as they wear (Doss *et al.* 1995). Although it is an essential element for higher plants, Zn is phytotoxic at elevated concentrations, and can therefore reduce crop yields and soil fertility. Soil concentrations of 70 – 400 mg/kg total Zn are considered critical, with toxicity likely above this level (Alloway *et al.* 1990).

Because of our dual focus on wetlands and traffic pollution as the main sources of contamination in Kampala, we investigated these three metals as well as copper (Cu) and nickel (Ni) in the wetlands.

MATERIALS AND METHODS

Site selection and sampling

To assess the presence of metals in wetlands used for urban agriculture, eleven wetlands in the Lake Victoria Basin around Kampala were investigated. These are shown on the maps (Plates 1 and 2) and are further described in Chapter 9 below. Samples of soil, water and

plants were analyzed for total Zn, Cu, Pb and Ni content, the metals of main concern from industrial effluent. To assess the relationship between traffic density and the risk of heavy metal uptake in urban agriculture, metal content in roadside soils, water, vegetables and air was measured at eleven sites within the city. Surface soils, atmospherically deposited surface films on windows and leaves of selected plants were sampled at known distances from the road and analyzed for Pb, Cd and Zn, the metals of main concern from vehicular traffic. A wild vegetable, *amaranthus dubius* Mart. Ex. Thell., was intensively studied.

Wetlands study sites were selected in Kampala District based on the presence of industrial waste discharge, municipal, sewage or toxic waste disposal and wastewater irrigation. Effluents from various industries were sampled at point sources before their discharge into the wetlands. To ensure maximum representation of each site, plots located 20 m apart along a line transect cut across each wetland were randomly selected. Within each plot, six quadrants measuring 25 m² were used to obtain replicate samples of soil, plants and water. Soil samples were collected from a depth of 20 cm using a soil auger to form a composite sample. Replicate water samples were collected in sample bottles from pits dug 30 cm deep at the same locations. Different plant species were collected and where several plants of the same species existed in one quadrant, three plants were randomly selected and combined to form a composite sample for each quadrant.

Eleven traffic study sites situated along busy roads originating from the city center were selected based on a preliminary survey in August 2003 (Plate 10). Households farming near the road were approached for informed consent of the farmers. On the road near each house, traffic passing both ways was counted between 6.00 a.m. and 9.00 p.m. each day for three days, and a daily mean calculated. Traffic was categorized as light (commercial taxis, private cars and pick-ups) and heavy vehicles (lorries, trailers, buses, tippers, garbage skips, tankers and tractors).

Surface soils (0-10 cm) were sampled from 10 different locations at each of five perpendicular distances from the roadway (1, 5, 10, 20 and 30 meters) and mixed together to form composite samples. Efforts were made to avoid other sources of contamination such as industrial waste, dumpsite garbage, wastewater effluents or compost that might mask the effects of motor vehicle emissions. Food crops grown in roadside gardens were sampled from three locations within a 500 m² area at each site to provide triplicate samples of the same crop. At each location, more than one specimen of each plant was taken and mixed together to form a composite sample.

Laboratory analysis

For both studies, soil and plant samples were separately placed in polythene bags and stored in cool boxes for transport to the Department of Botany research laboratory at Makerere University. Water samples were transported to the laboratory and filtered through a 0.2 µm filter then acidified to a pH < 2 using concentrated HNO₃. Soil samples were air-dried and clods and crumbs removed. The dried soil was passed through a 2 mm sieve to remove coarse particles; the soil was then sub-sampled and ground to a fine powder in a mortar in preparation for chemical analysis. A sample of 1.250g of air-dried ground soil was digested

in *aqua regia*: a mixture of 75 percent HNO_3 and 25 percent HCl (Fisher Scientific, UK). The resulting solution was analyzed for total Cu, Pb, Ni and Zn using Flame Atomic Absorption Spectrophotometer (AAS) (Perkin-Elmer Model 2380).

Soil pH was determined in a soil-water suspension of 10 g in 25 ml of deionized water using a pH meter (Aqualytica Model pH 17). Soil organic matter (SOM) content was measured by titration using Walkley-Black potassium dichromate wet oxidation (Nelson & Sommers 1982). The soil organic matter content was expressed as percent carbon (w/w). All physico-chemical parameters of the wetlands including pH, electrical conductivity (EC) and temperature were measured in situ using portable Wissenschaftlich-Technische Werkstätten (WTW) microprocessor probes and meters.

Total nitrogen content was determined using persulphate method, converting organic and inorganic nitrogen to nitrate through alkaline oxidation of all nitrogenous compounds at 100-110 °C. The total nitrogen was determined by analyzing the nitrate in the digested sample and measuring nitrate by cadmium reduction method. Ammonium-nitrogen ($\text{NH}_4\text{-N}$) was analyzed following direct Nesslerization method (APHA 1992). Total reactive phosphate (TRP) was analyzed following the ascorbic acid method (APHA 1992). All colorimetric determinations were made using a HACH DR-4000 spectrophotometer.

Individual plants were divided into root, leaves, fruit, tuber and peel. Each leaf sample was further divided in two. One portion was washed under tap water to remove dust particles, then in distilled water and finally rinsed carefully in deionized water, excess water being removed using kimwipes. The other portion was not washed. Samples were weighed to determine fresh weight and then dried in an oven at 80° C for 72 hours to determine dry weight. The dry samples were ground in a mill and about 1.250 g of the resulting powder added to a 250 ml conical flask and digested in concentrated HNO_3 (Fisher Scientific UK). The plant digests were filtered and made up to the mark in a 25 ml volumetric flask using deionized water. The resultant supernatant was analyzed for total Zn, Cu, Pb and Ni using Flame Atomic Absorption Spectrophotometer (Perkin-Elmer Model 2380).

Laboratory blanks were analyzed for the same elements to control for metal contamination during the digestion process. Reagent blanks were prepared in the same manner as the samples and the blanks used to correct instrument readings. The extraction and analytical efficiency of the AAS was validated using a standard reference material, tomato leaf (SRM 1573a, National Institute of Standards and Technology, NIST). The percentage recoveries from analysis of the standard reference material by procedures used in this study were 92 percent Zn, 97 percent Cu, 92 percent Ni and 90 percent Pb.

For the traffic study, atmospherically deposited metals were also passively sampled from surface films on window glass, which has been previously used as a convenient and cost-effective method of passively sampling ambient air concentrations (Butt *et al.* 2004). The film contains organic compounds that are at equilibrium with the gas-phase in air and organic and inorganic compounds associated with deposited air particles (Liu *et al.* 2003). Glass windows of three houses facing the road and between 5-15 m from the road were sampled at each of the eleven sites using methods presented by Diamond *et al.* (2000). The windows were first washed clean using SUPA liquid detergent (Mukwano Industries, Uganda) and tap

water and then rinsed with distilled and finally deionized water. The windows were then left for three months (100 days) without washing to accumulate pollutants and ensure that all windows had a uniform exposure period. Sampling was done by cleaning the effective window area of 1 - 2 m² using kimwipes soaked in isopropyl alcohol as a solvent, leaving a 5 cm buffer strip from window edge to avoid contamination from construction materials.

Kimwipes were added to a 250 ml conical flask and 50 ml of deionized water added, followed by 50 ml of a mixture of concentrated HNO₃ and HCl in the ratio of 1:3. The mixture was digested following the above procedure used in the digestion of soil. The final mixture was filtered and made up to 50 ml in a volumetric flask. The filtrate was then analyzed for Pb, Cd and Zn contents using a Flame Atomic Absorption Spectrophotometer (FAAS). The metal deposition in the window film was determined in µg/m²/day using a method described by Liu *et al.* (2003). This concentration was used as a direct proportion of the contaminant concentration in air.

For quality control, background levels of trace elements in soil, air and kimwipes were tested by analyzing blanks for the same elements. Three kimwipes of equal mass were used to sample particulate films from each window. Laboratory and field blanks were used to validate the signal to noise ratio. Field blanks were obtained at each of the eleven study sites by sampling the film with a kimwipe immediately after cleaning the windows. Air blanks were obtained by waving a clean kimwipe in the air for 1 minute with help of a pair of forceps. Reported metal concentrations were values in samples minus the average values in blanks. The average sample to blank ratio (S:B), calculated as the ratio of uncorrected sample value to the average value in blanks, ranged from 2-19 for Pb at peri-urban Komamboga and the urban Kagugube site.

RESULTS

Industrial effluents

Analytical results of the water samples from the selected industries and dumpsites showed high concentrations of heavy metals especially in the industrial effluents (Table 7.1).

Table 7.1 Metal concentrations in effluent released from various industries and dumping sites into the wetlands, showing international guidelines

Source	Cd (µg/L)	Pb (µg/L)	Zn (µg/L)	Cu (µg/L)
Uganda Batteries Ltd	10	5600	390	800
Peacock Paints Ltd	10	200	170	140
Kiteezi current dumping site	50	800	820	150
Wakaliga former dumping site	10	100	50	50
¹ EC COUNCIL DIRECTIVE, 1980	1	50	-	-
² US PHS, 1997; ATSDR, 1997	10	15	-	-
³ WHO, 1993	5	10	-	-

¹ = Maximum permissible concentration in water intended for human consumption;

² = Maximum permissible concentration for drinking water;

³ = Recommended limit in drinking water

Wetland soils

The total heavy metal contents in wetland soils ranged from 30.7 to 387.5 mg/kg Zn, 10.33 to 51.20 mg/kg Cu and 5.50 to 21.87 mg/kg Ni. There were significant correlations among all the metals ($p < 0.05$, $DF = 33$, t -test), implying that the heavy metals shared the same source of contamination. Katanga was the site most contaminated by Zn and Cu, followed by Bukasa and Namuwongo. Butabika and Busega wetlands were least contaminated by heavy metals (Table 7.2). Significant differences were observed in heavy metal concentrations in all the sites ($p < 0.05$, $DF = 10$, ANOVA).

Table 7.2 Heavy metal concentrations (mean, SE) for soils from selected wetlands with international guidelines in agricultural soils

SITE	Pb (mg/kg)	Ni (mg/kg)	Cu (mg/kg)	Zn (mg/kg)
Katanga	171.5 ± 36.2	21.87 ± 3.36	1.20 ± 6.69	387.5 ± 86.5
Bukasa	105.5 ± 2.7	22.33 ± 2.23	51.13 ± 1.72	318.4 ± 5.9
Namuwongo	98.2 ± 4.3	19.07 ± 1.38	42.13 ± 0.64	260.3 ± 0.6
Bwaise	67.3 ± 2.1	19.63 ± 1.47	34.50 ± 1.22	237.7 ± 7.2
Murchison Bay	54.1 ± 9.1	15.23 ± 1.64	28.70 ± 4.90	230.1 ± 40.3
Kinawataka	49.2 ± 4.6	25.93 ± 2.67	42.47 ± 2.28	225.6 ± 18.7
Kyebando	30.1 ± 7.0	6.83 ± 2.58	12.03 ± 2.86	67.9 ± 26.4
Munyonyo	27.2 ± 3.4	12.17 ± 2.09	19.77 ± 3.80	53.3 ± 11.5
Banda	27.2 ± 2.0	12.87 ± 0.35	14.00 ± 2.35	58.8 ± 6.2
Busega	18.0 ± 1.6	5.50 ± 1.30	10.33 ± 0.99	40.4 ± 2.8
Butabika	15.3 ± 1.7	6.97 ± 1.49	12.77 ± 1.35	30.7 ± 3.2
Ewers (1991) ¹	100	100	-	100
ICRCL (1997) ²	50	20	10	25
Ewers (1991) ³	50	50	50	200

1 = Recommended guideline value for maximum limit of heavy metal levels in irrigation soil

2 = Mean of heavy metal limits in soil used for agriculture and recreation recommended by Interdepartmental Committee for Redevelopment of Contaminated Land (ICRCL).

3 = Guideline values for tolerable total metal concentrations in agricultural soil recommended by the Swiss Ordinance.

Significant differences were observed in the soil characteristics of wetlands, which ranged from 4.9 ± 0.1 to 7.7 ± 0.2 percent at Munyonyo and Namuwongo, respectively. Organic matter content ranged from 3.0 ± 2.3 percent to 45.8 ± 2.0 percent at Namuwongo and Busega, respectively.

Wetland water

Metal concentrations in wetland waters ranged from 20-900 µg/L for Zn, 5-80 µg/L for Cu, and 20-100 µg/L for Ni with the lowest concentrations at Munyonyo where no waste disposal was observed (Table 7.3). The highest level of Zn was observed in wetland water from Kyebando. Concentrations of Cu and Ni below 5 µg/L and 50 µg/L respectively were not detected by the flame atomic absorption spectrophotometer used in this analysis.

Table 7.3 Mean metal concentrations in wetland water samples

Site	Pb ($\mu\text{g/L}$)	Cu ($\mu\text{g/L}$)	Ni ($\mu\text{g/L}$)	Zn ($\mu\text{g/L}$)
Katanga	250	80	ND	560
Kyebando	150	5	50	900
Banda	50	10	50	250
Busega	50	5	100	280
Bwaise	50	25	100	220
Murchison Bay	50	ND	ND	50
Namuwongo	50	20	ND	160
Bukasa	50	ND	ND	20
Butabika	10	20	ND	110
Munyonyo	ND	5	ND	20
Kinawataka	ND	40	ND	160
USEPA (2001) ¹	65	17	1400	2000

¹Recommended maximum levels of metals in irrigation water. Metal concentrations below detection limit (ND).

Murchison Bay had the highest pH, attributable to the discharge of industrial and chemical waste at Kinawataka wetland, whereas Murchison Bay received waste mainly from untreated sewage from Luzira Prisons (Table 7.4). Electrical conductivity (EC) ranged from 145 Sm^{-1} to 878.0 Sm^{-1} at Butabika and Bwaise, respectively. Total reactive phosphate ranged from 0.48 mg/L to 11.33 mg/L at Kyebando and Murchison Bay, respectively. Conversely, the TRP/TN ratio ranged from 0.65 to 18.02 at Munyonyo and Kyebando, respectively. Kyebando was characterized by low phosphate (P) but ranked highest in total nitrogen (N), followed by Busega, Bukasa, Munyonyo and Kinawataka. Kyebando is a seasonal wetland whose properties have been changed over time by human activity and waste dumping. The mean EC of water in the wetlands was significantly different at 0.05 significance level with the highest EC recorded at Katanga, consistent with this wetland having the highest metal concentrations in soil. However, Bukasa and Namuwongo did not show a significant difference in EC because the two sites receive wastewater from the same channel. Conversely, there was no significant difference in EC between the wastewater sampled from the channel and that from the wetlands ($p > 0.05$, $DF = 10$, t-test) indicating likely contamination of the wetlands with channel wastewater.

Wetland plants

Comparison of the metal levels in different plants from the same site revealed differential uptake by different plants. Cu levels in the leaves of wetland plants ranged from 6.5 to 18.9 mg/kg in ferns and *Commelina benghalensis*; and Ni concentrations ranged from 5.1 to 23.6 mg/kg in *Cyperus papyrus* and *Eichhornia crassipes* (water hyacinth), respectively.

In food crops, the highest levels of metal accumulation at all sites followed the order: Root > rhizome > leaves (Figure 7.1). Hence, the below ground parts of *C. papyrus* effectively accumulated trace metal pollutants from soil, with smaller amounts transported to the leaves. Significant differences were observed in Cu and Zn contents in leaf, rhizome and root of *C. papyrus* from Banda ($p < 0.05$, $DF = 5$, ANOVA). Differences in Cu levels were observed between

Table 7.4 Physico-chemical characteristics (mean, SE) of wetland water

SITE	pH	EC(Sm ⁻¹)	Temp.°C	TRP (mg/L)	TN (mg/L)	TN/TRP
Banda	6.91 ± 0.03	380.7 ± 2.1	22.4 ± 0.3	2.19 ± 0.47	7.53 ± 0.17	3.44
Kinawataka	5.85 ± 0.04	187.3 ± 1.2	28.3 ± 0.1	0.76 ± 0.58	8.25 ± 0.16	10.86
Butabika	6.63 ± 0.02	145.6 ± 1.4	30.4 ± 0.2	2.03 ± 1.17	6.87 ± 0.07	3.38
Murchison	8.86 ± 0.34	585.0 ± 2.6	28.2 ± 0.1	11.33 ± 8.98	7.34 ± 0.02	0.65
Bay						
Bukasa	7.17 ± 0.02	561.7 ± 0.9	30.5 ± 0.2	0.61 ± 0.19	7.56 ± 0.05	12.39
Namuwongo	7.15 ± 0.02	566.7 ± 0.9	30.7 ± 0.1	2.21 ± 2.05	7.28 ± 0.39	3.29
Munyonyo	7.34 ± 0.03	258.7 ± 1.5	28.7 ± 0.1	0.66 ± 0.38	7.28 ± 0.13	11.03
Katanga	6.97 ± 0.04	354.0 ± 2.1	25.4 ± 0.2	2.95 ± 0.34	6.35 ± 0.00	2.15
Kyebando	6.93 ± 0.03	665.3 ± 2.9	24.8 ± 0.2	0.48 ± 0.25	8.67 ± 0.06	18.02
Bwaise	6.78 ± 0.04	878.0 ± 1.2	24.8 ± 0.1	1.07 ± 0.47	7.96 ± 0.15	7.44
Busega	6.67 ± 0.01	405.7 ± 0.9	27.7 ± 0.0	0.51 ± 0.17	6.87 ± 0.00	13.47

EC = Electrical conductivity

TRP = Total reactive phosphate

TN = Total nitrogen

the leaf and root and between rhizome and root while a significant difference in Zn partitioning was observed between leaf and root of *C. papyrus* ($p < 0.05$, LSD). Similarly, significant differences were observed in Zn accumulation in leaf, rhizome and root of fern from Banda and Munyonyo sites ($p < 0.05$, DF = 5, ANOVA). Overall significant differences in Zn levels in the leaf and root and between rhizome and root ($p < 0.05$, LSD) were observed at both sites. Water hyacinth from Bukasa and Munyonyo showed significant differences in all the elements Cu, Ni and Zn between leaf, rhizome and root ($p < 0.05$, DF = 5, ANOVA).

Accumulation of Cu, Ni and Zn in the common wetland root crop *colocassia esculenta* (cocoyam) was in the order: Root > leaf > peel > tuber (Figure 7.2), following the general trend observed for metal accumulation in wetland plants; Root > rhizome > leaf when the peel and tuber are not separated. Metal concentrations in cocoyam also differed across sites with the highest levels of Cu from Namuwongo (contaminated by industrial effluent), Zn from an industrial area in Bugolobi and Ni from a waste-dump in Lugogo (Figure 7.3). Significant differences were also found in Zn content in pumpkin leaves with concentrations in a descending order ranging from Namuwongo > Bugolobi > Wakaliga (a former KCC dumpsite).

Figure 7.1 Metal accumulation and partitioning in *Cyperus papyrus*, by site

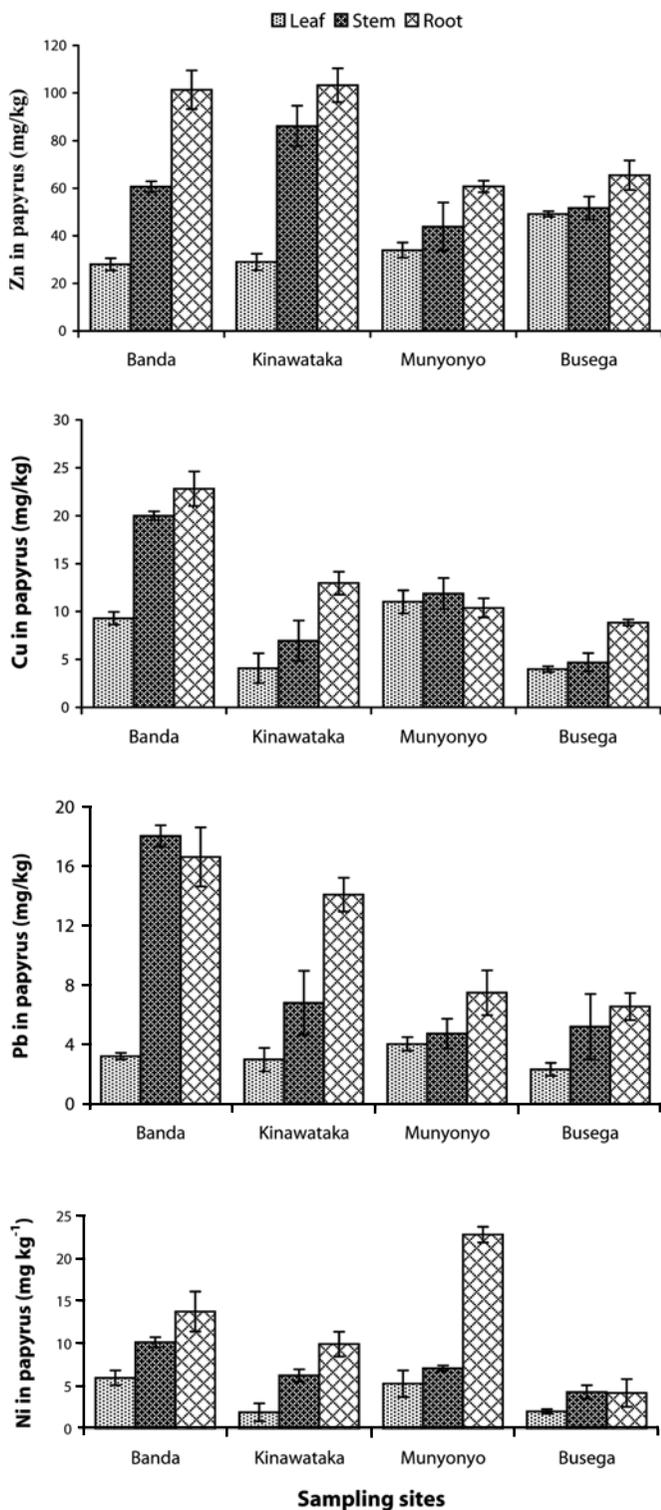


Figure 7.2 Metal accumulation and partitioning in *Colocassia esculenta* (cocoyam), by site

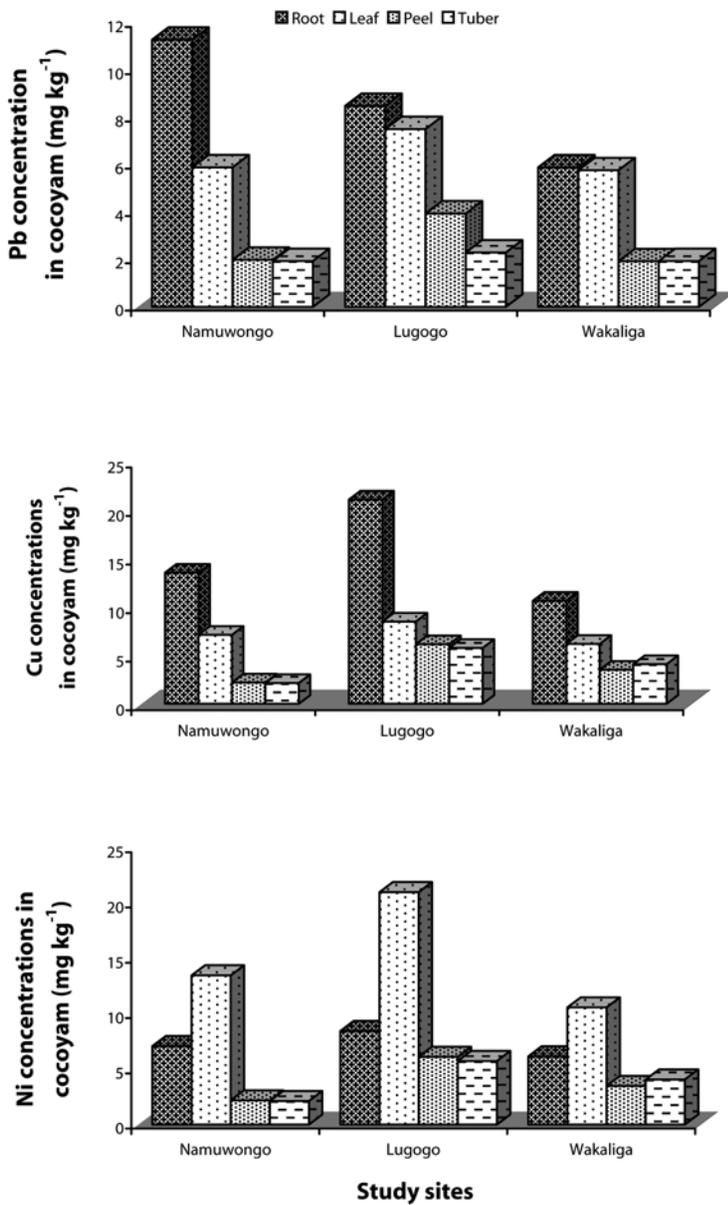
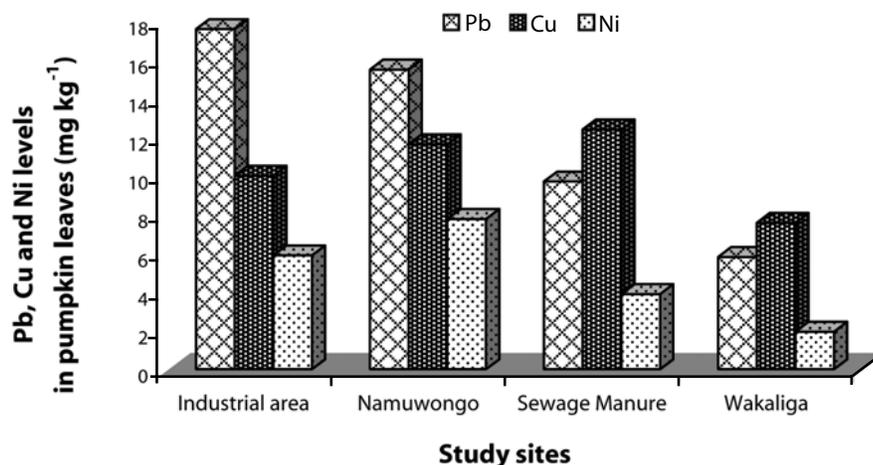


Figure 7.3 Metal accumulation in *Cucurbita maxima* (pumpkin) leaves, by site



Traffic

Light vehicles predominated on Kampala roads. No significant differences in traffic density were observed across days ($p > 0.05$, ANOVA). Traffic densities ranged from $1,600 \pm 90$ (mean, SE) vehicles per day at Kagugube to $24,000 \pm 800$ at Najjanankumbi. Although no significant differences were observed in traffic density between three pairs of sites: Greenhill and Kyebando; Kawempe and Busega; and Namugoona and Komamboga ($p > 0.05$, LSD), traffic density did differ among all sites ($p < 0.05$, ANOVA).

Roadside soils

Roadside soils were predominantly sandy (48-80 percent) with Banda having the highest proportion of sand. Clay content varied from 11-38 percent with Busega having the highest. Soil organic matter content varied from 1.13-2.94 percent except for Greenhill with 4.28 percent, attributable to extensive use of compost and mulch on the school garden. Soil pH ranged from 5.59 at Busega to 8.05 at Kawempe. All but one of the study sites (Busega) had soil pH within the acceptable range of 6.5-8.5 proposed for adoption as the standard by the Uganda National Bureau of Standards. Organic matter and soil clay content were significantly correlated with soil pH.

Total Pb concentrations in roadside soils ranged from 64.6 mg/kg DW at Banda to 30.0 mg/kg DW at Namugoona with significant differences across different sites ($p < 0.05$, $DF = 10$, ANOVA). Banda, Najjanankumbi and Bukoto (ranked second, first and third in traffic density respectively) had high Pb concentrations in soil, while those from the peri-urban sites of Greenhill, Kyebando, Namugoona and Komamboga were lower (Table 7.5). Pb contents in soil for the first three were above the recommended mean for agricultural soil (ICRCL 1987) but lower than maximum tolerable levels proposed (90-300 mg/kg DW) (Kabata-Pendias & Pendias 1984).

Table 7.5 Metal concentrations (Mean, SE and range) in roadside soils (number of replicates).

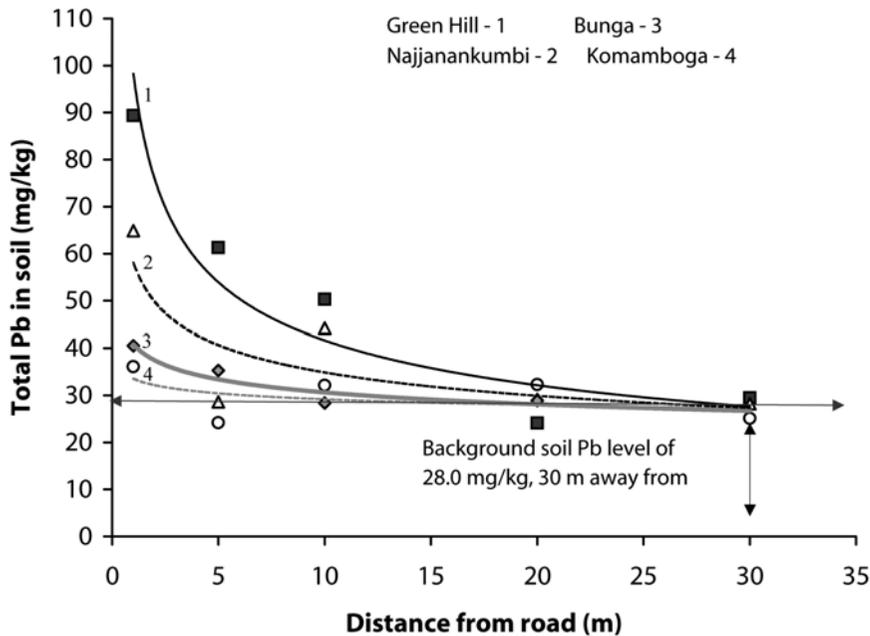
SITE	Pb (mg/kg)	Zn (mg/kg)	Cd (mg/kg)
Banda	64.6 ± 11.7 (5) (28.6-89.6)	265.6 ± 63.2 (5) (147.9-511.6)	0.80 ± 0.13 (5) (0.40-1.20)
Bukoto	62.8 ± 6.9 (3) (29.7-91.8)	117.2 ± 27.4 (5) (65.5-220.0)	1.14 ± 0.20 (5) (0.80-1.61)
Najjanankumbi	50.9 ± 11.7 (5) (24.1-89.4)	120.2 ± 25.8 (5) (64.8-195.0)	1.12 ± 0.21 (4) (0.80-1.68)
Busega	45.8 ± 8.5 (5) (24.3-65.6)	78.4 ± 18.4 (5) (38.3-140.8)	1.04 ± 0.10 (5) (0.81-1.21)
Kawempe	48.0 ± 5.0 (5) (32.3-59.3)	154.9 ± 12.5 (4) (122.0-182.7)	1.16 ± 0.15 (5) (0.80-1.66)
Kagugube	43.8 ± 3.5 (4) (43.8-3.5)	114.0 ± 19.1(3) (79.8-145.8)	1.05 ± 0.12 (4) (0.80-1.21)
Kyebando	39.0 ± 7.1 (5) (28.2-64.9)	176.8 ± 79.7 (5) (76.6-495.0)	1.12 ± 0.09 (4) (0.83-1.22)
Bunga	39.3 ± 4.7 (5) (28.1-49.9)	91.2 ± 17.9 (5) (48.5-145.8)	1.03 ± 0.13 (4) (0.80-1.30)
Greenhill	39.3 ± 4.4 (5) (28.3-40.2)	211.7 ± 54.8 (5) (78.2-376.5)	1.30 ± 0.15 (5) (0.80-1.62)
Komamboga	34.7 ± 2.6 (5) (28.9-40.5)	80.3 ± 14.9 (5) (44.7-134.2)	1.20 ± 0.10 (5) (0.81-1.44)
Namugoona	30.0 ± 2.3 (5) (24.2-36.1)	139.6 ± 23.1 (5) (53.4-190.7)	1.40 ± 0.16 (5) (1.21-2.01)
ICRCL ¹	50	25	1

¹ Mean of heavy metal limits in soil used for agriculture and recreation recommended by the UK Interdepartmental Committee for Restoration of Contaminated Land (ICRCL 1987).

Cd ranged from 0.80 at Banda to 1.40 mg/kg DW at Namugoona, with multiple other samples having Cd levels above the guideline value of 1 mg/kg DW of UK soil used in allotments and residential land with plant uptake (DEFRA & Environmental Agency 2002). Total Zn ranged from 78.4 at Busega to 265.6 mg/kg DW at Banda, all above the recommended guideline of 50 mg/kg (ICRCL 1987). Zn concentrations in soil were generally higher near busy urban roads than those at quieter sites further from the city center.

In general, metal concentrations in roadside soils increased exponentially with increasing proximity to roadways. Figure 7.2 illustrates this relationship for Pb. Interestingly, at Banda and Kyebando, soil Zn concentrations increased with distance from the road, likely due to other sources of Zn contamination from industrial emissions and waste dumping.

Figure 7.5 Pb concentrations by distance from roadway



The strongest correlation of traffic densities with soil and surface film Pb concentrations was observed with light traffic ($r = 0.73, p < 0.05$), consistent with the use of leaded gasoline, in contrast with heavy-duty vehicles ($r = 0.44, p > 0.05, t$ -test) that use un-leaded diesel fuel. Additionally, there was a positive correlation among Pb concentrations in surface films and in washed and unwashed *Amaranthus* leaves suggesting a common source of contamination, namely atmospheric deposition associated with vehicle traffic.

Pb concentrations in unwashed *Amaranthus* were highest 1 m away from the road. Concentrations at 5 and 10 m did not consistently vary with distance from the roadway.

In contrast, Zn concentrations in soil, surface films and *Amaranthus* leaves were not significantly correlated with traffic density. Significant correlations were observed between Pb and Cd ($r = 0.98, p < 0.05, t$ -test), and Pb and Zn in unwashed leaves of *Amaranthus* ($r = 0.80, p < 0.05, t$ -test). This suggests that industrial sources of metal were important in addition to vehicles, as in Kagugube for example, with its small-scale industries such as garages, welding and metal workshops. Important for public health was that washing slightly reduced Pb, Zn and Cd concentrations in *Amaranthus* leaves, though this was only significant for Pb ($p < 0.05, DF = 5, t$ -test). For two crop species, mean Pb concentrations in leaves were higher than those found in the roots, giving a leaf to root ratio greater than one (Table 7.6). *Brassica oleraceae* acephala group locally known as *sukuma wiki* had the highest leaf to root ratio indicating that this plant can effectively concentrate Pb from the atmosphere in its leaves, suggesting that *sukuma wiki* is more risky to eat than amaranthus.

Table 7.6 Pb and Cd in selected roadside crops

Plant type	Site	n	Pb in leaf (DW)	Pb in leaf (WW)	Pb in root (DW)	Pb in root (WW)	Pb in fruit (DW)	Pb in fruit (WW)	Pb in tuber (DW)	Pb in tuber (WW)	L/R	L/F & L/T
A: Leaf y vegetables												
<i>Amaranthus dubuis</i> L.	Busega	3	5.9	2.56	5.5						1.1	
<i>Amaranthus dubuis</i> L.	Najjanankumbi	2	8.7	3.78	7.5						1.2	
<i>B. Oleraceae</i> Acephala group	Kawempe	2	6.8	2.22	2.0						3.4	
<i>Beta vulgaris Cicla</i>	Kagugube	2	10.1	4.39	11.0						1.2	
<i>Beta vulgaris Cicla</i>	Greenhill	2	13	3.31								
<i>G. gynandra</i> (L.) Briq	Greenhill	2	2.8	1.22							1.9	
<i>Allium fistulosum</i>	Kyebando	2	18.7	7.64	64.1						0.3	
B: Fruit crops												
<i>Phaseolus vulgaris</i>	Kyebando	1	7.8	3.39	7.4		3.9				1.1	2.0
<i>Phaseolus vulgaris</i>	Bukoto	1	7.2	3.13			2					3.6
<i>Lycoperscon esculenta</i>	Greenhill	2	15	3.21			0.9	0.19				1.0
<i>Lycoperscon esculenta</i>	Banda	1	7.8	1.67	4.0		6	1.28			2.0	3.3
<i>Zea mays</i>	Busega	2	3	1.30	2.1		0.9	0.39			1.4	3.3
C: Root crop												
<i>Colocasia esculenta</i>	Kyebando	1	6	2.75	30.9				4	1.83	0.2	1.5
<i>Colocasia esculenta</i>	Najjanankumbi	2	6.6	3.03	12.5				5.9	2.71	0.5	1.1
<i>Ipomoea batatas</i>	Busega	1	6	2.30					0.9	0.41		4.6
<i>Ipomoea batatas</i>	Najjanankumbi	2	3.4	1.30	9.0						0.4	3.8
			Cd in leaf (DW)	Cd in leaf (WW)	Cd in root (DW)	Cd in root (WW)	Cd in fruit (DW)	Cd in fruit (WW)	Cd in tuber (DW)	Cd in tuber (WW)	L/R	L/F, L/T ratio
A: Leaf y vegetables												
<i>Amaranthus dubuis</i>	Banda	3	0.73	0.32	0.6	0.26						1.22
<i>Amaranthus dubuis</i>	Komamboga	2	0.55	0.24	0.5	0.22						1.10
<i>Amaranthus dubuis</i>	Najjanankumbi	2	0.8	0.35	0.75	0.33						1.07
<i>Brassica Oleraceae</i> Acephala group	Kawempe	2	0.8	0.26	0.3	0.10						2.67
<i>Beta vulgaris Cicla</i>	Greenhill	2	0.8	0.20	0.8	0.20						2.00
<i>Gynandropsis gynandra</i>	Komamboga	2	0.5	0.27								1.67
<i>Allium fistulosum</i>	Kyebando	2	1.87	0.81						0.3	1.2	
B: Fruit crops												
<i>Lycoperscon esculenta</i>	Greenhill	2	0.6	0.13			0.4	0.09				1.5
<i>Lycoperscon esculenta</i>	Banda	2	1.0	0.21	0.4	0.10	0.3	0.06			2.5	3.3
<i>Solanum melongena</i>	Greenhill	1	1.4	0.21			0.6	0.09				2.3
C: Root crops												
<i>Colocasia esculenta</i>	Banda	1	0.4	0.18	0.75	0.19			0.2	0.09	0.53	2
<i>Colocasia esculenta</i>	Kyebando	1	0.4	0.18	3.1	0.79			0.4	0.18	0.13	1.0
<i>Ipomoea batatas</i>	Busega	2	0.6	0.23					0.3	0.14		2.0
<i>Ipomoea batatas</i>	Najjanankumbi	2	0.24	0.09	0.68	0.17			0.1	0.05	0.35	2.4

L/T Leaf to root ratio, L/F=Leaf to tuber ratio based on dry weight, DW= dry weight, WW= wet weight. The recommended maximum Pb and Cd limits for vegetables is 0.3 mg/kg FW(FAO/WHO - CODEX Alimentarius Commission, 2001).

DISCUSSION

Wetlands

Wetlands in Lake Victoria region are at risk of chemical contamination resulting from waste disposal from industrial, municipal, domestic, agricultural and mining activities. Kampala wetlands have been receiving elevated levels of toxic chemicals such as Zn, Cu, Pb and Ni due to poor waste management and careless disposal, leading to concern about the safety of water and food crops grown in the City's wetlands. Previous studies have observed that the Kampala wetland soils of Katanga, Bukasa, Namuwongo, Bwaise and Murchison Bay are unsuitable for agriculture because their trace metal levels were above recommended limits for agricultural soils (Ewers 1991; ICRL 1997), while wetland waters have been found to contain higher concentrations of Cu than recommended for irrigation water (ICRL 1987). Cu is easily mobilized and transported in solution to downstream locations including the Lake Victoria (Lwanga *et al.* 2003), where metals are likely to enter the food chain through various pathways including accumulation in fish tissues (Denny *et al.* 1995).

Spatial examination of our findings from the wetlands indicates that Katanga soil, receiving wastewater from Mulago Hospital, Bwaise and Kawempe industries and Makerere University, was the most contaminated by Zn and Cu. It was followed by Bukasa and Namuwongo, which are sinks for effluents and chemical wastes from the industrial area. Butabika and Busega wetlands were least contaminated by metals, being far from industrial activities. Previous studies showed high Pb values in sediments associated with battery and metal fabrication and high Cu, Pb and Ni in sediments from a former Cu smelter in nearby Jinja (Muwanga & Barifaijo 2006).

Industry was the major source of heavy metal contamination of the wetlands with wastewaters released by these industries having metal concentrations above those recommended for use in agriculture, posing potential health risks. We found metal concentrations in industrial effluents and in some soils that were above international limits. The highest concentrations were of 5600 µg/L Pb, found at a battery assembling facility, compared to the lowest, 50 µg/L Cu and 50 µg/L Zn, in water discharged from a former dumpsite at Wakaliga. A study of water pollution affecting and caused by urban agriculture in Yaounde, the capital of Cameroun, found that over half the emissions coming from point sources causing water contamination were from manufacturing industries. Of a total of 2,687 such point sources, six large plants were the main contributors (Bopda *et al.* forthcoming). Our research confirms an immediate need for policy intervention in industrial waste management and implementation of appropriate mitigation measures to minimize possible food contamination and transfer into the Lake Victoria basin.

Our findings also suggest that uptake of metals is higher when plants are grown in soil contaminated by wastewater containing industrial effluents than those grown on municipal solid waste dumps. Further, the roots of wetland plants accumulated the highest concentrations of metals, with lower concentrations in the leaves. These findings have been confirmed by others (Taylor & Crowder 1983; Blake *et al.* 1987; Ellis *et al.* 1994). Dunbabin & Bowmer (1992) reported that under contaminated conditions, the greater proportion of metals taken up by plants was retained in the roots, with metal concentrations decreasing in

the following order: roots > rhizomes > non-green leaves > green leaves. Our finding that *Commelina* and water hyacinth are capable of bio-accumulating metals in their tissues confirms other studies reporting the metal-cleansing potential of water hyacinth due to its rapid growth in wastewater and capacity to absorb metals. Blake *et al.* (1987) demonstrated the tendency for water hyacinth roots to exhibit a high affinity for Cd. Therefore these non-edible plants are useful for cleaning up wetlands already contaminated by heavy metals.

Although the least amount of metals accumulated in plant leaves, accumulation in vegetable leaves is nevertheless of concern. Vegetables are reported to take up metals from contaminated soil as well as from aerial deposits on the aboveground parts exposed to polluted air. In Lagos, Nigeria, Yusuf *et al.* (2003) observed a higher degree of contamination in soils and higher concentrations of Ni in vegetables in industrial compared to residential areas, with the highest concentrations in *Corchorus* compared to other vegetable types. We found some vegetables accumulated higher levels of trace metals in the leaves than in the fruits. Pumpkin leaves (a local delicacy) accumulated the highest levels of trace elements from Namuwongo wastewater irrigated site which receives industrial effluents. Leafy vegetables grown in contaminated wetlands could therefore pose health risks to consumers. Fortunately, in the case of the popular Kampala root crop *colocassia esculenta* (cocoyam), metal concentrations accumulated in the order: Root > leaf > peel > tuber. Since the root is not eaten and the tuber is normally peeled before cooking, this decreases potential health risks to consumers.

Traffic

Pb contamination of roadside soils and *Amaranthus* leaves was clearly a function of traffic density and atmospheric deposition, mediated by distance from roads. Total Pb content in roadside soil was within the recommended maximum levels except for the three sites Banda, Najjanankumbi and Bukoto that also ranked highest in traffic density. Wheeler and Rolfe (1979) reported that Pb levels in vegetation increased linearly with traffic density. Exhausts from motor vehicles using leaded gasoline have been identified as one of the sources of Pb in the environment. Daines *et al.* (1980) reported that Pb in the urban environment is strongly related to traffic density. Studies on quantity and distribution of soil Pb have shown high soil Pb contamination in the inner city decreasing toward the periphery in several cities in the USA, e.g. New Orleans (Mielke 1994), Washington DC, (Elhelu *et al.* 1995) and New York (Johnson & Bretsh 2002), as well as Oslo in Norway (Tijhuis *et al.* 2002) and Ibadan, Nigeria (Sridhar *et al.* 2000). Total Zn content was above the recommended levels in soils only at Banda. Hence most roadside sites were found to contain Pb and Zn at concentrations considered acceptable for agricultural soil. In a similar study, Voutsas *et al.* (1996) observed low trace element content in agricultural soils in the greater industrial area of Thessaloniki, Greece, despite elevated concentrations of Pb, Cd and Zn in air particulate matter.

Metal contents in soil were observed to decrease rapidly with increasing distance from roads. Accumulation of Pb in soils above background levels took place up to a distance of 30 m comparable to the approximately 33 m found by Rodriguez-Flores & Rodriguez-Castellon

(1982). Motto *et al.* (1970) had similar findings for Pb although Ward *et al.* (1975) suggested a more conservative value of 100 m.

Atmospheric deposition was the dominant pathway for Pb contamination consistent with Pb concentrations in surface films. Elevated concentrations of Pb, Cd and Zn were found in all crops. In contrast to wetland findings, results from our traffic study showed higher levels of heavy metals were found in leafy vegetables and leaves of other plants, compared to roots, fruits and tubers. We found Pb and Cd concentrations for both washed and unwashed *Amaranthus* leaves were above the recommended maximum for vegetables set at 0.3 mg/kg and 0.2 mg/kg (FW) respectively by the FAO/WHO-Codex Alimentarius Commission (2001). Leafy vegetables are most vulnerable to airborne deposition of Pb although cereal grains have also been shown to accumulate substantial amounts (CCFAC 1995). Rodriguez-Flores & Rodriguez-Castellon (1982) also observed that Pb in soil and vegetation was through atmospheric transport while Cd reached the soil mainly through water runoff. Although we found that Cd concentrations in soils, surface films or vegetation were not significantly related to traffic density, Cd concentrations in surface films and unwashed vegetation were significantly correlated, suggesting a common airborne source. Our results also show that the use of surface films on window glass is a reasonable indicator of atmospheric deposition from road traffic and better than the use of vegetation which is influenced by leaf surface area.

Metal concentrations have been shown to vary with plant species and plant part, the highest Cd levels among edible plants being reported in *Lactuca sativa* and *Beta vulgaris*, and the outer leaves of cabbage showing higher Pb and Zn concentrations than the inner ones (John 1973). Washing lowers metal concentrations, indicating that much of the contamination is from particles that accumulate on plant surfaces, rather than being within the tissue. Fruits and seeds of fruit vegetables have lower metal concentrations than their leafy parts. Pb concentrations in fruit vegetables were in the order: leaves > root > fruit > seed with the lowest Pb content in fruits observed in grain from *Zea mays* (maize) and seeds of *Phaseolus vulgaris*, two of the most common roadside crops in East Africa.

In conclusion, our findings that leafy vegetables are most vulnerable to heavy metal contamination, especially Pb, from light-duty motor vehicle emissions, suggest that measures should be taken to reduce the health risk to consumers. It is recommended that leafy vegetables and other crops for human and animal consumption should not be grown within strips 30 m each side of roadsides, particularly heavily traveled roads. Roadside farmers should be encouraged to grow crops that have their edible parts protected from aerial deposition e.g. corn, pulses (such as beans and peas) and some storage roots and tubers such as sweetpotato and cassava. However, the leaves and peel of tubers and pods of beans should not be used. Shielding roadside food crops and vegetables from atmospheric deposition and washing them can also help protect consumers, as will national policy moves to phase out leaded gasoline. All vegetables should be washed thoroughly in plenty of clean water before consumption.

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CHAPTER 8

Estimating children's exposure to organic chemical contaminants

Shelby Yamamoto

INTRODUCTION

With more than half the world's population now living in cities and many relying on their own food production, there are concerns about the numerous potential pathways that exist for contamination of foods, especially in developing country cities with high levels of pollution. Unfortunately, little information exists on human exposure to contaminants via urban agriculture products in developing country cities, or any related potential adverse health effects (Lock & de Zeeuw 2003). Such information is needed to inform the development of protective regulations and other mitigation approaches. This chapter focuses on exposure to one class of chemical compounds known as polycyclic aromatic hydrocarbons (PAHs), ubiquitous urban pollutants of health concern. It is based on a study carried out in 2004 to assess the potential health risk to children from PAHs, which can find their way into air, soil, water and food, especially in urban areas where incomplete combustion products from vehicles and other sources are concentrated. First we will set the context of urban agriculture (UA) and contaminants in Kampala, followed by a description of PAHs and the process of exposure and health risk assessment.

Kampala is a booming city with important industries such as steel, brick and cement manufacturing, a chemical industry, tea and tobacco processing, textiles and coffee roasting. Mining, construction and vehicle repair are also found. The majority of the roads in Uganda (57 percent) are unpaved, contributing to high levels of dust in the atmosphere (UBOS 2003). Kampala City Council's Structure Plan encourages mixed urban planning, permitting industries, residences and commercial premises in the same neighborhoods. Low-income residents live in crowded informal settlements that generally lack services. Houses are most often made of brick, concrete and mud with corrugated tin roofs. Small windows are found in some homes but the majority has no glass in them. Gardens are common on properties and many households also rear animals. Small-scale industries, businesses, petrol stations and roadways often surround these properties.

Kampala's change in land-use from a small population and mainly natural vegetation to over a million people with many buildings and artificial surfaces has exerted pressure on the city's environment and far exceeded its infrastructure capacity (Matagi 2002). Environmental

degradation in Kampala stems mainly from insufficient sanitation, poor drainage, inadequate waste collection, increased traffic and largely unchecked industrial contamination. Unlike rural agriculture, urban agriculture faces problems of high population densities, waste generation and discharge within the city (Cole *et al.* 2003). Currently, some food is grown in areas inappropriate for agriculture such as old landfills, abandoned industrial sites and other polluted locations (see Chapter 8). Anikwe & Nwobodo (2002) found that long-term municipal waste disposal posed increased toxicological risks for those farming in areas where this practice was prevalent. However, a study done on rooftop produce grown in Russian cities found that the concentration of various contaminants in these products was up to ten times less when compared to produce from local markets or those grown on suburban plots (Armar-Klemesu 1998). Further, urban food production can eliminate the need for long-distance transportation, thus reducing air contamination.

Over 90 percent of the national fuel needs of Uganda are met through the burning of biomass fuels, particularly wood-fuel in the form of either charcoal or firewood. The majority of such wood-fuel consumption is domestic, although it is also used in lime, brick, tile, tea and tobacco production (UBOS 2003). Most domestic cooking in Uganda is done on traditional three stone fireplaces or stoves made of mud or metal. Typical foods include *matoke* (bananas), meat (beef, goat and chicken), *kalo* (millet), cassava (root), cocoyam (root) and rice, all cooked by means of stewing, roasting, boiling or steaming. Traditional stoves combined with inefficient fuels can result in increased exposure to air pollutants (Plate 11).

PAH EXPOSURE IN URBAN SETTINGS

PAHs are found everywhere in the environment, in soils, sediments, water systems, marine biota and the atmosphere. These semi-volatile, persistent organic pollutants (POPs) are of concern because they are carcinogenic, mutagenic, genotoxic and possibly teratogenic (Nguyen *et al.* 2002). As such, they have been placed on both the USEPA and European Community's lists of priority pollutants (Motelay-Massei *et al.* 2003).

PAHs are emitted into the atmosphere through incomplete combustion of organic matter such as gasoline, wood, coal or oil for domestic use and industrial power generation (Osborne & Crosby 1987). Traffic is also recognized as an increasingly important source (Wennrich *et al.* 2002). Smaller atmospheric contributions of PAHs also come from forest fires, printing industries, petroleum refineries and barbequed foods (Nguyen *et al.* 2002). Urban environments, in particular, are contaminated with PAHs because of the convergence of numerous point (e.g. industries) and non-point (e.g. traffic) emissions (Wong *et al.* 2004). Vehicular and industrial emissions are thought to be among the most important sources of PAH in both Nairobi, Kenya (Muthini *et al.* 2005) and Kampala (Uganda Bureau of Statistics 2003; Yamamoto 2005).

More than half of the world's population relies on coal or other forms of solid biomass for heating and cooking, a major route of PAH exposure (Suk *et al.* 2003). Domestic cooking is considered a serious health hazard especially for women, the elderly, children and those with compromised immune systems. Cooking and child-rearing, two of the most common activities of women in developing countries, are often performed simultaneously, with

women frequently carrying children on their backs, exposing both groups to high amounts of air contamination for several hours daily (Bruce *et al.* 2000; Mishra 2003). With approximately 95 percent of Uganda's energy needs being met through wood-fuels or other biomass, and most of this used for cooking, heating and other domestic energy uses, women and children are among those frequently exposed to high levels of PAH (Ayazika 2003). Little is known about the potentially increasing role of burning non-wood materials, such as plastics, as a component of indoor and outdoor air contamination, particularly in urban areas in countries like Uganda, although waste burning has been identified as one of the sources of PAH contamination in Kampala (UBOS 2003; Yamamoto 2005).

The combination of growth in population, vehicles, industries and waste generation has likely led to increasing ambient levels of PAH, especially in heavily urbanized areas of the developing world, yet little is known about the routes of exposure to PAHs in conjunction with farming activities in African cities.

SCREENING RISK ASSESSMENT APPROACH

To further our knowledge of the pathways of human exposure to PAHs associated with urban food production and potential health consequences, we assembled data from primary and secondary sources and applied a mathematical model to produce a screening level health risk assessment. The concentration of PAHs in soil, air, produce and water were first obtained and possible sources identified. These data were then used in a risk assessment to quantify the pathways of PAH exposure and to estimate likely health impacts among children between the ages of two and five. Modeling offers a relatively inexpensive, non-invasive and rapid way to obtain such estimates.

The screening level risk assessment applied 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) by researcher Heather Jones-Otazo. This model had already been successfully used to estimate the importance of PAH exposure pathways in a developed country city, namely Toronto, Canada (Jones-Otazo 2004). Regulatory agencies and health departments establish acceptable or tolerable levels of contaminant exposure using quantitative models like MUM-FAMrisk to estimate levels of exposure with negligible risk (Ponce *et al.* 2000). Screening-level human health risk assessments aim to provide relatively rapid, worst-case characterizations of exposure to chemical contaminants and identify pathways of concern for human populations (Jones-Otazo 2004).

PAH IN AIR AND SOIL

The first step was to measure the concentrations and spatial patterns of five PAHs in atmospherically derived surface films on windows and in surface soils in Kampala. Films can serve as convenient passive samplers for estimation of gas-phase air concentrations. Soils act as a sink for contaminants like PAH due to their large capacity for retaining hydrophobic chemicals (Howsam *et al.* 2001; Wild & Jones 1995; Diamond *et al.* 2001; Yamamoto 2005) and can be an important pathway of PAH contamination for vegetables, fruits, grains and forage.

Ten households engaged in urban food production were approached in five of Kampala's divisions (Plate 1). Locations included areas of high to low traffic, industrial and population densities and urban or peri-urban agriculture as classified by Kampala City Council. Samples of atmospherically derived surface film samples were collected from these households' windows during July, August and September 2004, allowing approximately 30 days of accumulation for the film samples after pre-cleaning the windows. Soils were sampled at random points within the same households' agriculture plots.

Laboratory analysis was for the following PAH compounds: phenanthrene (PHE), anthracene (ANT), fluoranthene (FLA), pyrene (PYR) and indeno[1,2,3-*cd*]pyrene (ICDP) (Yamamoto 2005). These PAHs were chosen from among the many organic chemicals that may be found in the city environment because they were found in samples taken across Kampala and come from major relevant sources, namely vehicles, biomass fuels and solid waste.

Air concentrations were back-calculated from the surface film samples collected using methods described elsewhere (Yamamoto 2005). The estimated air concentrations based on window samples ranged from the detection limit to 180 or 135 ng/m³ for indoors and outdoors respectively with a geometric mean of 1.57 ng/m³ for total PAH. These levels are similar to concentrations found for these same compounds in studies using different sampling methods and across different seasons for urban areas in Cairo, Stockholm and Evreux, France (Hassanien *et al.* 2001; Boström *et al.* 1994; Motelay-Massei *et al.* 2003).

Total soil PAH concentrations ranged from 86 to 270 ng/g wet weight in samples taken from the ten households (Yamamoto 2005), within the same range found in other tropical soils analyzed in studies in Brazil (Wilcke *et al.* 2002) and Ghana (Wilcke *et al.* 1999) as well as temperate soils collected from various sites in Europe (Motelay-Massei *et al.* 2004) and garden soils from contaminated sites in Germany (Wennrich *et al.* 2002).

Soil concentrations for each of the five PAH were fairly similar across sites, although some monthly variation was observed. Soil PAH concentrations were not correlated with rainfall, probably because the samples were collected from under heavy canopy cover. Soils typically receive inputs of PAH from the atmosphere, precipitation and runoff, as well as canopy drip (Diamond *et al.* 2001).

The overall arithmetic mean soil concentrations across all sites and contaminants for each month increased from July to September. This reflects trends observed by Wennrich *et al.* (2002) in temperate soils in Germany. In July and September indeno[1,2,3-*cd*]pyrene was found in the highest concentrations, although in August the lighter molecular weight PAH fluoranthene dominated.

Lower organic carbon, which could reduce the capacity of soils to hold PAH, was found in the Kampala soil samples. Findings were between 0.7 and 4.6 percent, compared to between 4 and 8 percent in forest soils in Toronto (Ribes *et al.* 2003; Wong *et al.* 2004). This could be due to leaching and climatic conditions in Kampala as well as to the presence of aged, lateritic soils that promote the degradation of organic carbon (Diamond pers. comm.).

The presence of the lower molecular weight compounds in outdoor and indoor air as well as soils strongly confirms the supposition that biomass burning and vehicle emissions could be important sources of contamination in Kampala. These lighter PAH, such as

phenanthrene, fluoranthene, anthracene and pyrene, are abundant in fossil fuel emissions (Khalili *et al.* 1995). In Copenhagen, traffic was estimated to contribute 80 percent of the PAH found in busy streets and 40 percent in parks (Nielsen *et al.* 1996). High traffic areas in Stockholm, Sweden, had an average concentration of 18ng/m³ for the 14 PAH compounds measured, while in locations with high numbers of diesel-burning vehicles this value jumped to 24ng/m³ (Boström *et al.* 1994). Registered vehicle numbers in Uganda have increased from 176,164 in 1998 to 209,278 in 2002 while the Average Annual Daily Traffic (AADT) volume on Kampala's road network was recently recorded as 25,000 vehicles, a traffic density of 128 vehicles per km² (Uganda Bureau of Statistics 2003; Matagi 2002).

Most of the vehicles driven in Kampala are over 10 years old, contributing to air pollution (Matagi 2002). In 2004 almost all of these vehicles lacked catalytic converters which, when coupled with traffic congestion, results in the release of large amounts of fine organic matter into the atmosphere and soil. Rogge *et al.* (1993) found a greater than 25-fold lower total PAH emission rate for automobiles with catalytic converters compared to those without. For this study, however, there was no clear association with the calculated total PAH air concentration for each site when plotted against the total number of vehicles per 12-hour period, indicating that other sources may be important.

Land use was another factor found to contribute to the overall level of pollution at some sites. For example, the highest soil and air concentrations of PAH were found at Kagugube, a densely populated area (13,000-16,999 persons per km²) situated at the junction of three major roadways. With residential, industrial, institutional and agricultural land-use, activities like slash-and-burn clearing and waste incineration, which account for approximately 4 percent of waste disposal in Kampala, could contribute to the level of PAH pollution observed in the film and soil samples at this particular location, as well as the high levels of biomass use for cooking or heating and household waste incineration. Nevertheless, a peri-urban area away from major roads and with a low population density (0-999 persons per km²) also had a fairly high air concentration.

HEALTH RISK ASSESSMENT APPROACH

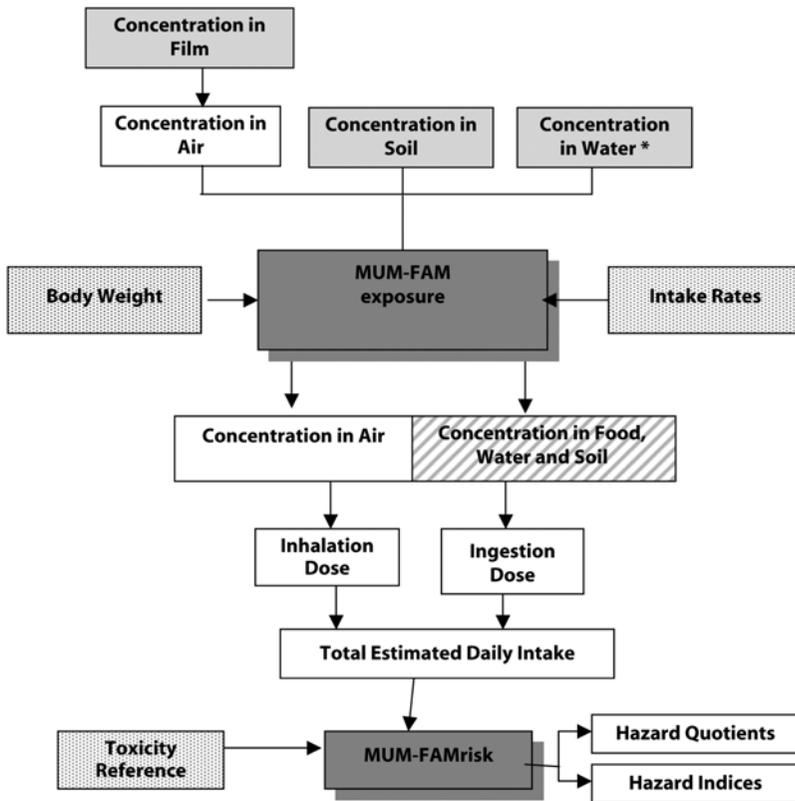
Population of interest

The focus was on children 2-5 years old because this is a period of rapid growth presenting vulnerabilities to PAH exposure. First, children have disproportionately high exposures to contaminants because they consume more food, soil and liquid and breathe more air per body weight than adults. Secondly, children's metabolic pathways are not fully developed, hindering their ability to metabolize, detoxify and excrete toxicants. Thirdly, rapid developmental processes occurring during the early stages of childhood can easily be disrupted by factors such as environmental contaminants. Lastly, children have longer to develop diseases triggered by exposures to carcinogenic or toxic contaminants early in life (Suk *et al.* 2003). Social stresses and malnutrition can also increase their vulnerability to toxic effects. The age range matched that of the complementary nutrition study (see Chapter 6 above), meaning nutritional benefits of urban food production could be weighed against the PAH health risks.

Routes of Exposure

The screening level human health risk assessment of PAH among pre-school children examined inhalation and ingestion as the two main routes of exposure. Dermal pathways were not considered to be a significant route based on previous work (Jones-Otazo, 2004). The MUM-FAMrisk assessment model requires input of a variety of data and assumptions concerning contaminant concentrations, body weights, intake rates, health endpoints and associated reference doses (RfD) (Figure 8.1).

Figure 8.1 MUM-FAMrisk MODEL (Modified Jones-Otazo 2004)



* Measured value taken from literature (Goodarzi & Mukhopadhyay 2000).

Contaminants

Three PAH contaminants of potential concern (COPCs), anthracene (ANT), fluoranthene (FLA) and pyrene (PYR), were chosen from among the five that were measured, based on levels detected in the window film samples, their potential health effects and the availability of reference dose data. The data used in the assessment were measured, modeled or derived from the literature. Measured and modeled values were also compared to the literature. Detailed technical data regarding modeled values are presented elsewhere (Yamamoto 2005).

Food concentrations

Types of foods considered were based on a nutritional intake study of children 2-5 years old in South Africa (Labadorios 2000), grouped according to the categories of the Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities by the U.S. EPA (1998).

For raw food concentrations, vegetation such as *matoke* (banana), cassava, parsley, millet and cocoyams were assumed to accumulate contaminants through atmospheric deposition of particle-phase and gas-phase contaminants and root uptake (U.S. EPA 1998). Each mechanism has different importance for different classes of vegetation, foods, contaminants and environments. The vegetation classes used in the MUM-FAMrisk model include: belowground vegetation (root vegetables), aboveground vegetation, cereals and grains, forage and silage, fruits and juices, nuts and seeds and vegetable oils and fats (Jones-Otazo 2004).

The vegetation in each class was further categorized as either protected or exposed. It was categorized as protected if the edible portion is not exposed to the atmosphere. For example, millet was classified as protected vegetation as the grain is enclosed in a husk and thus not exposed to atmosphere. Millet PAH concentrations were modeled using soil concentrations derived from samples taken from households based on the assumption that the only mechanism of contaminant accumulation is through root uptake. Vegetation was classified as exposed when the edible portion of the plant is open to atmospheric deposition (Jones-Otazo 2004). Exposed vegetation concentrations were modeled using air and soil concentrations based on the assumption that contaminant accumulation occurs both by atmospheric deposition and root uptake. Based on these, modeled food tissue concentrations (wet weight) were calculated for each vegetation class.

Ranges for modeled data concentrations of all three PAH for all food items were between 0.0-33 ng/g wet weight. This is slightly less than those found in other studies, e.g. 1-120 ng/g wet weight in Wennrich *et al.* (2002), which could be due to the higher rates of photo-degradation of PAH in Ugandan soils. PAH concentrations in other food classes such as beef, fish and dairy were taken from the literature.

Estimated Daily Doses (EDDs) of PAH by Exposure Pathway

Using the modeled and literature-derived food concentrations, the estimated daily dose (EDD) in g/kg body weight of contaminant impinging on children, according to year class (age 2 to 5), sex (girls or boys) and site (as per households above), was calculated using standard equations from Health Canada (1995) and food intake rates from a study of children 2-5 years old in South Africa (Labadorios 2000). Separation by sex was done to account for differences in body weights, activities and dietary patterns. Since previous studies have shown that substantial amounts of purchased foods in Kampala are locally grown, that is, they are products of urban agriculture, the dietary assessments for the children did not differentiate between home-grown or purchased items (CIAT 2004; Maxwell 1995; SIUPA 2003¹). The EDDs for each food class were calculated as the product of intake rates and food PAH concentrations, normalized for weight in kilograms.

¹ SIUPA was renamed Urban Harvest in 2003

EDDs via soil and water were also calculated. Soil ingestion and water intake rates of 0.08 g/day and 0.8 L/day respectively were used, again based on the data available from Health Canada (2004) for the age groups of interest. The soil ingestion rate may have been an underestimate since there are many unpaved roads in Uganda (57 percent) and there is a lot of visible dust in Kampala's atmosphere (Uganda Bureau of Statistics 2003). Likewise, water ingestion rates could also be higher than in Canada among children from Kampala due to the warmer temperatures. However, there was no data in the literature to confirm these possibilities.

Inhalation rates for Canadian children ($5\text{m}^3/\text{day}$) were also used to calculate the EDD from inhalation, as no data currently exists for African children (Health Canada 1995). The EDD was calculated using both indoor and outdoor air concentrations multiplied by the inhalation rate. The frequency and duration of indoor and outdoor air exposures varied by household but children in this study typically spent more time indoors (14.1 hours) than out (9.9 hours). The proportion of time spent indoors and outdoors was used to weight the EDD from inhalation indoors and out for each sampling site. Nonetheless, windows were observed to be open for a considerable time during the day, likely minimizing any differences.

For this study, soil EDDs were found to be low (e.g. 2.09×10^{-14} g/kg wet weight per day for fluoranthene), compared to inhalation EDDs (e.g. 1.64×10^{-12} g/kg per day) and food EDDs (e.g. 8.95×10^{-12} g/kg wet weight per day for belowground vegetables).

Estimated Daily Intakes of PAH

Estimated daily intakes (EDI) (in g/kg/day) were obtained by totaling EDDs for both ingestion and inhalation pathways. The EDIs for all three PAH compounds were found to be higher for ingestion than for inhalation, echoing those from the Toronto study examining the risk posed by selected PAHs which also used the MUM-FAMrisk model (Jones-Otazo 2004). Differences between inhalation and ingestion EDIs varied by site and ranged from three (anthracene) to seven (fluoranthene) orders-of-magnitude for the different compounds. On average, ingestion EDIs were about five orders-of-magnitude greater than inhalation EDIs. EDI differences tended to be larger for the mid-to-high molecular weight compounds such as fluoranthene and pyrene, indicating their relative scarcity in air as opposed to soil. Higher molecular weight PAHs are generally particle-bound and more likely to settle out of the atmosphere. Lower molecular weight compounds are expected to achieve equilibrium and be involved in ongoing soil-air exchanges over time (Wong *et al.* 2004).

Non-significant ($p > 0.05$) patterns observed were that boys' EDIs were lower than girls', likely due to comparable dietary intakes between the sexes but girls' lower body weights. Similarly, children ages 2 to 3 had higher EDIs than those aged 4 to 5, again likely related to lower body weights for similar food intakes.

The total EDI for all routes of exposure for each PAH was also calculated as the sum of both ingestion and inhalation EDIs. The densest urban area, Kagugube, tended to have the highest total model food concentrations and EDIs for all compounds and Kawaala II, a peri-urban area, consistently had the lowest. As the EDIs for inhalation were comparatively low, the driving pathway of concern in terms of PAH exposure is ingestion.

Reference Doses used, Calculation of Hazard Quotients and Hazard Indices

For different PAHs, different health endpoints and pathways form the basis for the reference dose (RfD) (U.S. EPA 1988, 1989, 1989b), which is needed to convert the EDIs into risks, expressed as hazard quotients and hazard indices. Reference doses are toxicity reference values used as a benchmark to determine the level at which adverse toxicological effects will occur. They are defined as the exposure levels NOT likely to create adverse health effects in the human population, including sensitive subgroups (U.S. EPA 1998). The higher the RfD, the lower the toxicity effect of the compound. In general, inhalation RfDs are larger than ingestion RfDs. Additionally, lower molecular weight compounds (e.g. anthracene) tend to have larger RfDs. The higher molecular weight compounds like fluoranthene and pyrene are associated with more serious health effect endpoints and hence smaller RfDs, representing a higher level of toxicity (U.S. EPA 1988; U.S. EPA 1989b; U.S. EPA 1990).

The endpoints chosen for the contaminants were all non-carcinogenic, given the age group studied and length of exposure. Endpoints included nose, throat and lung irritation, increased carboxylesterase activity, decreased immunity and kidney problems. Characterizing the risks of non-carcinogenic effects involved calculating a hazard quotient (HQ) using inhalation and ingestion EDIs and dividing by the appropriate RfD for each contaminant, sex and year class. HQ can be calculated for one or many pathways contributing to the same route of exposure. The HQ approach for non-carcinogens assumes that there is a certain toxicity threshold below which no appreciable adverse health effects are anticipated (U.S. EPA 1998). HQs above 1 indicate a risk level at which adverse health effects are more likely (U.S. EPA 1989).

Another measure of risk, Hazard Indices (HIs), was also calculated as the sum of HQs from all routes of exposure, for example ingestion plus inhalation (U.S. EPA 1998). If the HI for non-carcinogens exceeds unity, there is an increased likelihood of the exposures causing adverse health effects (U.S. EPA 1989). However, the likelihood relationship is not linear because of the non-linearity of many dose-response curves for non-carcinogens (U.S. EPA 1989).

There are certain values of the HQ and HI at which regulatory agencies start to take action to reduce the level of exposure to a contaminant. Agencies typically set the action level for HQ or HI = 1 (Suter *et al.* 1999; Jones *et al.* 1999; Sample & Suter 1999; Baron *et al.* 1999) for the protection of human health e.g. U.S. EPA (1989c) and European Commission (2002). An action level of less than 1 is sometimes chosen when regulatory agencies need time to work with stakeholders to implement risk mitigation techniques or if additional exposures are known about but not yet quantified. For the purposes of this study, a conservative action level of 0.2 for HQ and HI was selected for Kampala. HQ and HI exceeding this level act as an early risk warning, giving researchers and other stakeholders time to investigate the problem further and work towards possible solutions before exposures reach levels at which adverse health effects are expected to occur. If either HQ or HI is greater than the action level, the contaminant under consideration can be labeled a contaminant of potential concern, or COPC (Jones-Otazo 2004).

CALCULATED HAZARD QUOTIENTS AND INDICES

Calculated Hazard Quotients

The range of ingestion hazard quotients for fluoranthene, pyrene and anthracene are presented in Figures 8.2, a, b and c. Between sites, no statistically significant differences were observed. Children aged 2-3 had higher HQs (though non-significant at $p > 0.05$), owing to their relatively higher levels of food, water and soil intake per kilogram body weight. Similarly, HQs for girls were marginally higher than for boys (also not significant at $p > 0.05$).

Fluoranthene had the highest HQs of all PAHs. Although fluoranthene concentrations in air and soil were among the lowest of the selected PAHs, its higher RfD and the bio-transfer factors for heavily consumed foods (fruits, vegetables and grains) being higher for fluoranthene than other PAHs, both EDI and HQ were higher. Conversely, anthracene, as a lower molecular weight compound with a lower RfD, had the lowest HQs of all three compounds. Nevertheless, all compounds were below the conservative action level of 0.2 chosen for MUM-FAMrisk, indicating minimal risk from these levels of exposure.

Driving Pathways of Exposure

In terms of pathways, the dominant or driving risk pathways in terms of HQs for anthracene were the ingestion of belowground vegetables and the inhalation of indoor and outdoor air for all age groups and both sexes (Figure 8.2a). For pyrene the dominant pathways were ingestion of belowground vegetables and cereals and grains (Figure 8.2b) and for fluoranthene, the ingestion of fish and shellfish (Figure 8.2c).

Figure 8.2 Pathways of average exposure for children aged 2-5 in Kampala

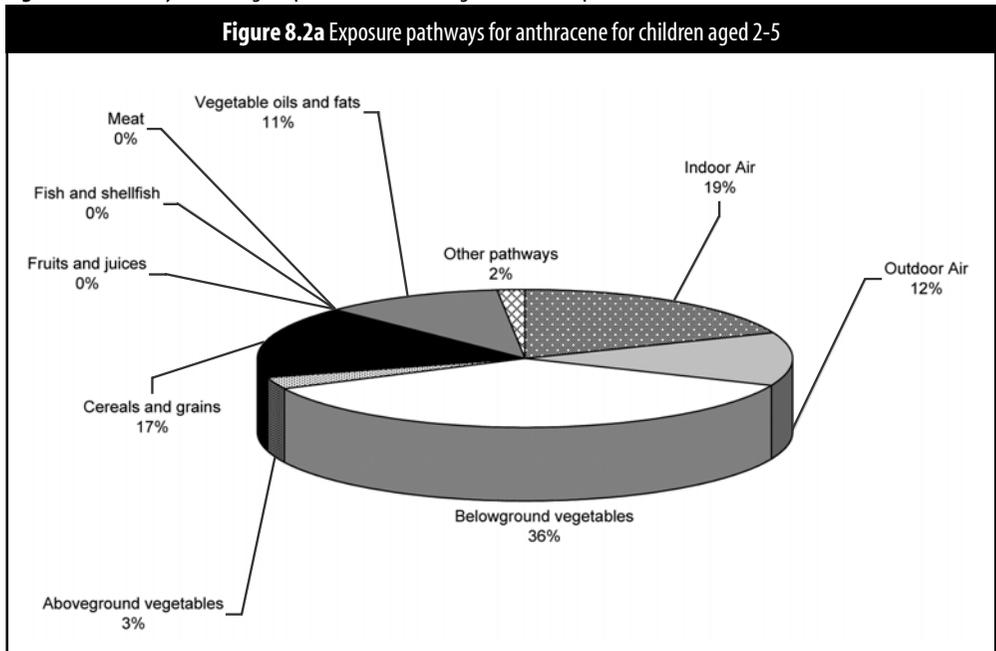


Figure 8.2b Exposure pathways for pyrene for children aged 2-5

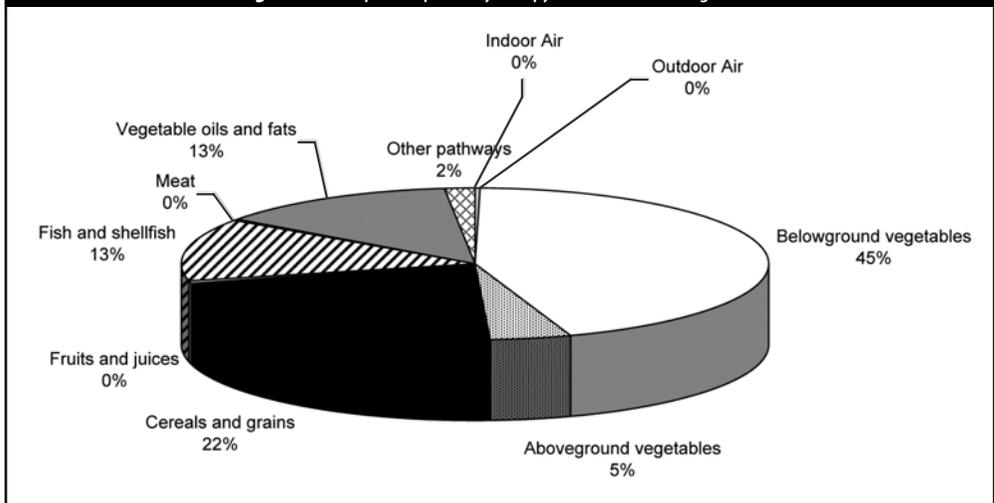
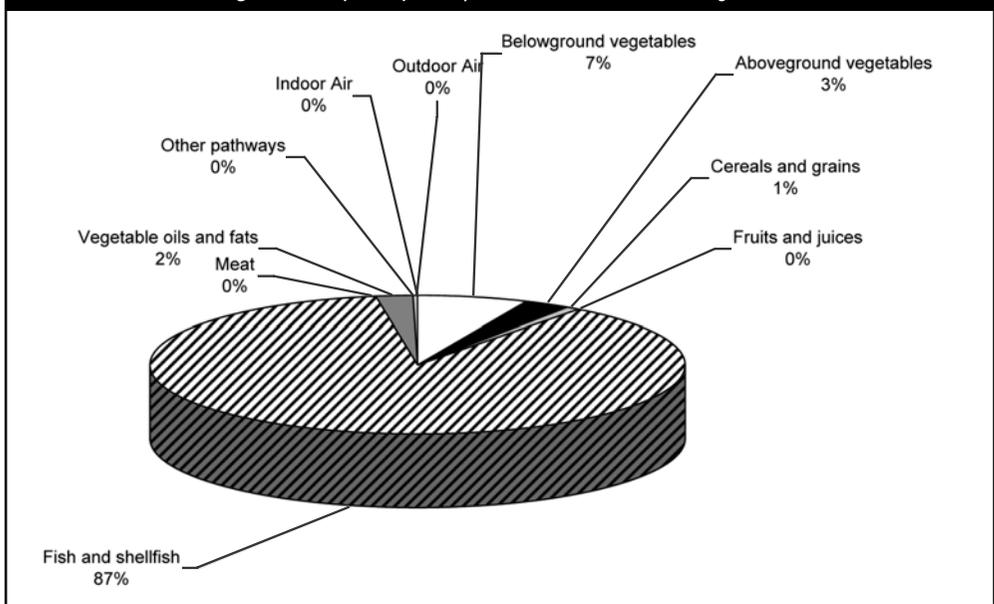


Figure 8.2c Exposure pathways for fluranthene for children aged 2-5



The risk stemming from ingestion of belowground vegetables ranged between 7 – 45 percent for all three compounds, with a mean of 29 percent. In the case of anthracene and pyrene, over 35 percent of the risk could be attributed to the consumption of belowground vegetables. For cereals and grains, the percentage risk range was between 1 – 22 percent with a mean of 13 percent. The greater risk associated with these food classes can be attributed partly to higher intake levels. On average, among the South African children whose data were used in diet modeling, belowground vegetables plus cereals and grains comprise just over 18 percent of the total dietary intake. Another reason for this trend could stem

from soil contamination, which is the primary uptake pathway for belowground vegetables and cereals and grains, especially for the higher molecular weight PAHs. Indoor and outdoor air together was also a significant risk pathway for anthracene, comprising just over 31 percent of the total risk. This could be due to the fact that anthracene is a lighter molecular weight compound more likely to remain in air.

The next most prominent pathways for all three compounds varied by site and included vegetable oils and fats as well as aboveground vegetables. Together, these results are consistent with those of other studies, which also found that vegetables and cereals were important dietary sources of PAHs (Phillips 1999; Ramesh *et al.* 2004).

Calculated Hazard Indices and Action Levels

The HIs for all three compounds were also below the action level of 1 set by the U.S. EPA (1989c) and the European Commission (2002). This means that exposure to anthracene, fluoranthene and pyrene should contribute little to nose, throat and lung irritation, increased carboxylesterase activity and the decreased ability to fight diseases, as well as to kidney problems among children in Kampala. However, when considered as part of complex mixtures that include other PAHs and organic compounds, additive effects of multiple exposures could occur (Groten 2000; Warshawsky 1999). This could result in the action levels being exceeded although it is hard to tell given the small subset of PAH compounds for which we were able to conduct laboratory analysis.

CAUTIONS AND UNCERTAINTIES

There are a number of things that should be noted as cautions when dealing with risk assessments in general and this study in particular. In general, current approaches to risk assessment modeling involve numerous assumptions that provide conservative estimates of the hazards posed by exposure to certain chemicals (Vostal 1994). Data used in risk assessments and hence the risk estimates often tend to be associated with a high level of uncertainty. For example, soil and window wipe samples were not refrigerated after collection so some of the lighter molecular weight compounds like phenanthrene and anthracene might have volatilized, affecting measured concentrations. The small sample size used in the study meant distributions could not be described nor great precision achieved.

One of the uncertainties associated with deterministic risk assessments like MUM-FAMrisk, or those that involve the use of point estimate calculations, is that no range of risk values is given. Probabilistic risk assessments may be a way in which to reduce this uncertainty through risk ranges modified by confidence levels and these have been suggested as a way to deal with exposure to non-carcinogenic compounds, given multiple endpoints (Poulter 1998). However, probabilistic methods also require extensive data that may be hard to obtain, as was the case in the work reported here. Additionally, risk assessment models also generally assume that all of the pollutant found in the environment is available to the receptor and will affect it to the same degree, which may not necessarily be the case, thus further contributing to the levels of uncertainty. Finally, risk assessments can only predict the

likelihood of health outcomes due to exposure to specific chemicals and cannot be used alone to judge the threat posed to an exposed population or individual.

We did not have the resources to directly ascertain the concentration of PAH in all foods likely to be consumed. Instead, this risk assessment relied on measures of soil and back-calculated air concentrations to obtain expected levels in groups of vegetables, meats and grains. When values pertaining to the study area were unavailable, measured values from elsewhere were used, affecting model outputs. The study assumed that dietary foods and intake rates from children in South Africa were close to those of children in Kampala. However, dietary intake of maize is greater among South African children, while the consumption of bananas and roots like cassava tend to be higher in Kampala (Labadarios 2000; Nakabo-Ssewanyana 2003). The model could therefore have overestimated the PAH exposure risk from the consumption of foods such as cereals and grains and underestimated the risk from above- and below-ground vegetation. Additionally, food preparation methods could have affected the PAH concentrations found in different food items taken from the literature, and these may differ from food preparation methods typically observed in Uganda, which include more boiling and stewing than broiling and baking. This not only increases uncertainties associated with the risk values generated but also affects the level of conservatism associated with the risk assessment in unknown ways.

Another uncertainty was introduced in assuming that dietary intakes for children aged 2-5 do not vary by age. In the absence of more detailed data, we cannot be sure that we have not overestimated the risk in younger children and underestimated risk in older children. Another implicit assumption of this risk assessment was that children spent all of their time at their place of residence, which is not necessarily the case as children can have different activity or exercise patterns (Vostal 1994).

Perhaps the greatest uncertainty stems from the bio-transfer factors used to calculate how much of the contaminant is expected to be consumed or inhaled, based on intake rates. Many of the biotransfer factors used in this risk assessment were obtained or modified from the U.S EPA (1998). Because of a lack of data, many of these factors stem from just one study, Travis and Arms (1988), which could affect the robustness of the derived bio-transfer factors and, consequently, children's calculated exposure to contaminants through different pathways.

CONCLUSIONS

What can we conclude from this screening level risk assessment from Kampala? It is necessary to examine what we know as we try to decide what can and should be done.

Things that we do know are that estimated daily intakes (EDIs) for ingestion were much higher than those for inhalation for all the PAHs measured. Thus ingestion can be considered the driving pathway of PAH exposure. The driving ingestion pathway was belowground vegetables and cereals and grains, except in the case of fluoranthene exposure, where the driving ingestion pathway was primarily fish. Thus, an important vegetation uptake pathway is through contaminated soils.

We found that all the hazard indices (HIs) fell below the conservative action level chosen for MUM-FAMrisk for the compounds studied, as well as the levels set by the U.S. EPA and European Commission. Thus, it was expected that the risk of toxicological effects stemming from exposure should be low. On the other hand, we observed that the treatment of exposure to mixtures of compounds by MUM-FAMrisk is inadequate and should be further investigated.

Finally, the low potential for health risks associated with urban food production must be carefully considered in light of the benefits of this activity including food security, nutrition and additional income (see other chapters in this volume). Quantitative risk assessments alone are not adequate for developing public health advice, especially when exposure is concomitant with beneficial exposure or when a compound leads to both toxic and beneficial responses, as in the case of fish and fruit consumption. There is currently a lack of quantitative methods for simultaneously assessing both the risks and benefits of a given exposure. This constrains the health policy assessments that can be conducted: public health recommendations are usually made using quantitative risk estimates along with a qualitative evaluation of their benefits. Overall, this study's findings have to be considered both in light of the uncertainties associated with screening-level risk assessments and the need for the ranking of risks and benefits across the entire farm-to-table spectrum, thus facilitating the prioritization and the appropriate allocation of resources for risk reduction.

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CHAPTER 9

Biological hazards associated with vegetables grown on untreated sewage-watered soils in Kampala

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WASTEWATER AND BIOLOGICAL CONTAMINANTS

Water is a natural resource critical to human health. The urban poor depend on its availability for domestic use as well as depending on wastewater to irrigate agricultural plots important to their livelihoods (Binns & Lynch 1998). Wastewater contains plant nutrients, allowing farmers to reduce or even eliminate the purchase of chemical fertilizers and organic matter that serve as soil conditioners (Lock & de Zeeuw 2001). Widely prevalent in urban agriculture, particularly in arid and seasonally arid zones, this practice has deep roots in human culture and a place in the history of both cities and agriculture as mentioned in our introductory chapter. Yet wastewater also carries biological hazards that can cause infectious disease, as distinguished from other health impacts of toxic chemical hazards (see previous chapters 7 and 8). Both types of contaminants can be hazardous to human health and they may be found in the same body of water, area of soil or in crops. The principal infectious agents found in domestic wastewater are classified as bacteria, viruses and parasites (both protozoa and helminths) all of which can cause gastrointestinal infections in human beings and animals. The organisms and infections concerned are presented in Table 9.1.

In the developing world 2.4 billion people lack access to basic sanitation (UN 2006) while 300 million mainly low-income urban residents have no access to sanitation infrastructure (Giles & Brown 1997). About two-thirds of the population in the developing world has no hygienic means of disposing of excreta, and an even greater number lack adequate means of disposing of wastewater (Niemczynowicz 1996). Since most cities in low-income countries lack the capacity to treat more than a modest percentage of the wastewater produced in their jurisdictions, urban wastewater farming persists because of its role in the livelihood and economic strategies of the urban poor, despite regulation and quality standards for irrigation water (Perera & Amin 1996).

Sources of microbial pathogens on fresh produce at the pre-harvest stage include fecal material, irrigation water and human handling (Beuchat 1996; Buck *et al.* 2003). Human and animal intestinal flora can also enter the food chain when polluted water is used to wash raw products or when such water is used for irrigation. Outbreaks of food borne diseases are caused by foods that are contaminated during growth, harvesting, processing or preparation

(Torok *et al.* 1997; Amoah *et al.* 2006). Contamination of food by livestock feces has been implicated in a number of food borne outbreaks due to *E.coli* O157:H7 infection (Morgan *et al.* 1988; Besser *et al.* 1993; Mead & Griffin 1998). *E.coli* O157:H7 on vegetables can occur with irrigation by water contaminated with cattle feces or contact with surface runoff (Solomon *et al.* 2002).

Table 9.1 Infections caused by organisms in raw domestic wastewater

Organisms	Disease	Remarks
Bacteria Escherichia coli Salmonella typhi Salmonella Shigella Vibrio cholerae Helicobacter pylori	Gastroenteritis Typhoid fever Salmonellosis Shigellosis Cholera Gastritis and other	Diarrhea High fever, diarrhea, ulceration Food poisoning Bacillary dysentery Very heavy diarrhea, dehydration
Viruses Adenovirus Enteroviruses e.g. polio Rotavirus Hepatitis A	Respiratory disease Gastroenteritis, meningitis Gastroenteritis Infectious hepatitis	Jaundice, fever
Protozoa Balantidium coli Giardia lamblia Entamoeba histolytica	Balantidiasis Giardiasis Amoebiasis(amoebic dysentery)	Diarrhea, dysentery Diarrhea, nausea, indigestion Prolonged diarrhea with bleeding
Helminths Ascaris lumbricoides Enterobius vericularis Taenia saginata Trichuris trichiura	Ascariis Enterobiasis Taeniasis Trichuriasis	Roundworm infestation Pinworm Beef tapeworm Whipworm

Sources: WHO 2006; Stanier *et al.* 1986; Feachem *et al.* 1983.

Seo & Frank (1999) showed that lettuce leaves dipped in a suspension of *E. coli* O157:H7 absorbed the pathogen through the stomata and cut surfaces on the leaves. Experiments have also demonstrated that *E. coli* O157:H7 can enter the lettuce plant through the root system and migrate to the edible portion of the plant. Bacteria can also enter leaves of plants through the stomata and enter fruit through the stem, stem calyx or calyx (Zhuang *et al.* 1995; USFDA CSFAN 1999). Cells of *E. coli* O157:H7 were shown to penetrate into the stomata and junction zones of the cut lettuce leaves, becoming entrapped 20 to 100µm below the surface of the cut edge (Solomon *et al.* 2002). Once in foods, this pathogen can survive well under refrigerated conditions and it is acid tolerant (NACMCF 1999).

CONTEXT AND AIMS OF THE KAMPALA STUDY

Kampala hills and valleys provide natural drainage into low-lying wetland areas, channel catchments and ultimately Lake Victoria. The city's wetlands have been used as disposal grounds for both municipal and industrial waste. Its numerous formal and informal industrial

areas contribute to pollution in several ways including wastewater discharge (Droruga 1990; Matagi 2002). And, as in other low-income countries, most of the high-density urban areas where poor people live lack sanitation, leaving residents to develop their own onsite systems for excreta treatment or disposal. Studies of these areas in Kampala have shown that while well-off people can afford to invest in services, the poor prioritize finding a place to sleep and only then try to construct or identify a latrine. While aware of health risks associated with human waste, people are constrained from protecting themselves by other factors, mainly their lack of power or control over the slum conditions. Most slum residents resort to the “wrap and throw” method for disposing of human waste (Kwagala 1999; Lee-Smith 2006), with the result that paper and plastic bags containing human fecal matter are found in both solid waste heaps and in drainage canals. Water-borne diseases such as typhoid and dysentery are prevalent and persistent among the city’s population (Matagi 1993), while diarrheal diseases are the third most frequently reported after malaria and respiratory tract infections and have been linked to sewage contamination of water and food (Matagi 2002). A cholera outbreak was reported in the city newspapers in 2005.

Some urban farmers produce crops on sewage irrigated soils including swampy areas where intentional and accidental sewage collects, areas near main sewage channels that are intentionally watered with the sewage by farmers, or congested communities without proper sanitation. Crops and vegetables growing in such areas are harvested for human consumption. Although the presence and sources of pathogenic bacteria found on fresh produce is well documented in general (Beuchat 1996), information on the microbiological quality of crops grown in sewage contaminated urban areas of Kampala was lacking. Policy makers and the public in Uganda wanted such information so the work reported in this chapter aimed to fill the gap.

Specifically, we set out to determine the presence and levels of selected indicators of biological contamination in wetland water and soils used for production of vegetable crops, as well as of bacterial and helminth pathogens on the surfaces and in the tissues of crops grown on sewage watered soils at a smaller number of contaminated sites. For comparison, the same data were collected on crop surfaces and in their tissues at two sites not contaminated with sewage water. Having assembled this basic data we aimed, with the purpose of generating evidence as a guide to policy, to provide an analytical approach for policy-makers who are charged with taking measures to protect public health.

METHODS

Study areas

In 2004, 11 urban wetlands study sites were selected, based on the presence of waste discharge, including municipal, sewage or toxic waste disposal and with wastewater irrigation activities taking place. These were the same sites as those studied for heavy metal contamination as described in Chapter 7 above, namely Busega in Rubaga Division, Bwaise and Kyebando in Kawempe Division and Katanga in Central Division – all on contaminated wetlands on the upper reaches of the drainage basin of Lake Victoria – as well as Banda and Kiwanataka in Nakawa Division and Namuwongo and Bukasa in Makindye Division – all on

contaminated wetlands around the Nakivubu and other major drainage channels – and Butabika and Murchison Bay in Nakawa Division, and Munyono in Makindye Division – all on the lower reaches of the drainage basin of Lake Victoria (Plate 12). Soil and water were sampled from each of these sites.

For the study of plant parts in 2005, three sites irrigated by untreated sewage were selected for study and considered as contaminated sites. Two of these were the same wetlands, Kanyogoga zone in Namuwongo and Katanga slum area in Wandegya, and the third was Natete, adjoining Busega in Rubaga Division. Kanyogoga zone is located along the main Nakivubu channel that drains most of the sewage of Kampala urban area. Katanga area is located in the valley between Mulago Hospital and Makerere University and the sampling site was located along a drain that joins the main Nakivubu channel. In all these areas, flood irrigation is practiced in the wet season when the channel overflows while drainage canals are used in the dry season to tap water from the main channel. Additional soil and water samples were collected along with the plant samples.

Two sites were selected as places where urban farming was considered not to be contaminated with sewage (uncontaminated sites): Kyambogo gardens and Ministers' village, both located in Nakawa Division. These sites are on hilly areas and cultivation is not near any drains. As with the contaminated sites where plants were collected for analysis, soil and water samples were collected in addition to plant samples. For the purposes of this chapter, the results of the plant analysis from the three contaminated sites have been combined and compared with the aggregated results from the uncontaminated sites. While an oversimplification, this enables us to provide some idea of the magnitude of hazard associated with consuming plants grown in contaminated sewage-watered sites as compared to plants grown at uncontaminated urban farming sites.

Sample collection

In August – November 2004, at each of the 11 wetland sites, replicate samples of soil and water were collected from each of six plots measuring 25 m² randomly selected from a larger number of plots located 20 m apart along a line transect cut across each wetland. Soil samples were collected from a depth of 20 cm using a soil auger at various locations in each selected plot to form a composite sample. Replicate water samples were collected in sample bottles from pits dug 30 cm deep at the same locations.

The following year, during the end of the wet season (May–June 2005), crop plants in the category of fruit, leafy vegetable and root crop were sampled. The crops selected for study were tomato (a fruit), dodo (*Amaranthus lividus*) (a wild leafy vegetable) and cocoyam (a root crop). Permission was sought from owners of the vegetable gardens to sample two plants in each category from their gardens, giving a total of six locations at each site, and the crops were paid for. Edible parts of each sample were separated into root, stem, leafy parts and fruit (in the case of tomato) using a sterile size 22 scalpel blade. Each set of parts was placed in a labeled and sterile sample (Stomacher) bag and transported under ice in a cold box to the laboratory.

Water was collected aseptically in 250 ml sterile glass flasks taken from the same six points in each site where the plant samples were collected and those from each site were pooled. These were sealed using sterile paraffin wax and the bottle labeled to indicate the site, date and time of collection. Soil was scooped using a sterile small shovel at the same six points and pooled to make a sample of approximately 300 g for each site, and this was placed in a sterile sample bag made of polythene and appropriately labeled. After sampling at each site the soil-sampling shovel was washed with clean potable water and soap, and sterilized using 70 percent alcohol. Each soil sample was bulked up and a sub sample obtained aseptically for testing.

Crop Sample Preparation

Laboratory preparation was done on each of the samples of water, soil and crop plants within 6-8 hours of collection (AOAC 1990; Eaton *et al.* 1995).

All crop samples were first surface-washed for bacterial isolation. For each crop sample, 10 g each of the leaves, stem and roots for *Amaranthus spp* (dodo) and tomato were placed into 90 mls of buffered peptone water (Difco) as diluent while for yam, 25 g of each plant part was weighed into 225 mls of peptone water representing a 1/10 or 10^{-1} dilution. The sample was homogenized in a pulsifier for 2 minutes. For tomato fruit, washings were done in peptone water in order to obtain the surface contamination, which also represented a 10^{-1} dilution. Serial dilution up to 10^{-3} was done for each sample.

For laboratory preparation of internal tissue, the plant parts of dodo and tomato were each weighed and thoroughly washed to remove any soil or debris. The clean crop part was then placed in sodium hypochlorite 2 percent for 4 minutes for surface disinfection. After disinfection, the part was rinsed four times in sterile distilled water to remove the disinfectant. Then 10 g of the disinfected plant part was placed in a stomacher bag to which 90 mls of peptone water (Difco) was added. The sample was pulsified for 1 min to homogenize making a 10^{-1} dilution or, in the case of tomato fruit flesh, up to dilution 10^{-3} .

Bacterial laboratory analysis

Total aerobic plate counts and total coliforms indicated the level of gross bacterial contamination. *E. coli* serves as an indicator of fecal contamination and *Salmonella* was chosen because of the potential health hazard it poses to humans and cattle. In 2004, *Shigella* and *Vibrio Cholerae* were also tested as important human pathogens. All prepared samples were analyzed within 24 hours after collection and analyzed according to standard methods (APHA 1992 in the 2004 work).

Total Coliforms

The Total Aerobic Plate Count (TPC) was determined in 25 ml of water sample. The sample was added to 225 ml of pre-sterilized peptone water and the two were thoroughly mixed by repeated inversions of the culture bottle to make the solution homogeneous. The sample was diluted by ten times its volume (10^{-1}). A serial dilution of the sample was then carried out through a series of 9 ml peptone water tubes up to the dilution of 10^{-5} . Then 1 ml of the

sample from each of the subsequent dilutions was inoculated in 15 ml of sterile standard plate count agar (Oxoid UK) using the power plate method. The inoculated plates were then incubated at 37 °C for 24-48 hours for the bacterial cells to grow and form visible colonies which were enumerated using a colony counter and expressed as colony-forming units per cm³ (CFU/ml). In the case of plant tissues, aerobic plate counts (APC) were made using the same method on Petri plates followed by incubation at 37 °C for 24 hours. Bacterial colonies stain in various shades of red because of their interactions with the TTC indicator dye. All colonies were counted and recorded as cfu/g or cfu/ml (AOAC 1990).

For Total Coliform Count (TCC) 1 ml of the diluted sample (up to 10⁻⁵) was inoculated into approximately 10-15 ml of molten Violet Red Bile Agar (VRBA) by the pour plate method. Incubation was similar to TPC but pink colonies were considered and expressed as colony forming units per square centimeter (cfu/cm²).

E.coli

In 2004, a 10 ml sample was centrifuged at 2000 revolutions per minute for 5 minutes, the supernatant discarded and deposits retained. These were inoculated on MacConkey and *Salmonella* - *Shigella* agar plates with a sterile cotton swab (Oxoid, UK) and the plates incubated at 44.5 °C for 24 - 48 hours. *E.coli*-suspect colonies were then grown in peptone water for Indole production and those that were pink, medium sized, flat convex and shiny with entire margins on MacConkey were tentatively considered *E. coli* colonies. These were then tested for the ability to produce sufficient Indole Acetic Acid (IAA) in the methyl red test and positive cultures taken to be *E. coli* isolates.

In 2005, 1 ml of each dilution was inoculated by pipette into the center of 50 mm Petri plate containing a pad saturated with a layer of medium. The inoculum was distributed evenly over the surface and the inoculated Petri plate incubated at 37 °C for 18-24 hours. Fecal *E. coli* was enumerated by counting only blue-green colonies surrounded by gas bubbles.

Salmonella and Shigella

In 2004, 10 ml of a water sample was measured in a sterile measuring cylinder and pre-enriched with 90 ml of 1 percent peptone water for 24 hours. 1 ml of the sample was then enriched in 9 ml Selenite broth for 24 hours at 42 °C. A loopful of the enriched sample was plated on xylose dextrose agar (XLD) and *Salmonella*-*Shigella* agar (Oxoid, UK). The plates were incubated at 37 °C for 24 – 48 hours and colonies identified based on colonial characteristics.

In 2005, *Salmonella* spp. were detected in four successive steps (AOAC 1990). Pre-enrichment was done in buffered peptone water (Difco) at 37 °C for 24 hours, followed by selective enrichment. 1 ml of crop homogenate (see Crop Sample Preparation above) was added to 10 ml of selenite cystine broth and Brilliant Bile broth. The broth was incubated at 37 °C for 24 hours. The isolation of *salmonella* was then performed on two selective media: brilliant green agar (BGA) and Xylose Lysine Deoxycholate (XLD) agar at 35 °C for 24 hours (Hitchins *et al.* 1998). *Salmonella*-suspected colonies on BGA media that appeared slightly pink (white opaque surrounded by brilliant red medium), or had the same color as the culture

medium (translucent, sometimes with a black center on XLD) were inoculated on slants of Triple Sugar Iron (TSI) agar. Confirmation of the presence of *Salmonella* spp. was by the appearance of red slant and yellow butt, with or without blackening of the butt.

Vibrio cholerae

In 2004, 10 ml of a water sample was added to 90 ml of 3 percent sodium chloride broth using a sterile measuring cylinder, thoroughly mixed and incubated at 37 °C for 24 hours. 10 ml of the enriched broth was then added to 90 ml of alkaline peptone water at pH 8.4. The culture was then incubated at 37 °C for 6-8 hours and 1 loopful of the culture was then separately inoculated on thiosulphate citrate bile sucrose agar (TCBS) and MacConkey agar (Merck, Germany) and incubated at 37 °C for 24-48 hours. *Vibrio cholerae* colonies were identified based on colonial characteristics and later confirmed with sugar fermentation and biochemical tests.

Parasite laboratory analysis

Following Garcia (2001), the technique most commonly used to determine parasitic counts is the flotation test, parasite eggs being less dense than the fluid flotation medium and thus floating to the top of a container where they can be collected for microscopic evaluation. 5 g/ml of each specimen were mixed with the flotation solution (NaCl specific gravity 1.20). The plant parts were ground with a mortar and pestle with some water added to facilitate grinding. The mixture was strained through a commercial tea strainer into a test tube. The filtrate was dispensed into a test tube, which was filled to the brim and covered with a cover slip for 20 minutes. If worm eggs and coccidial oocysts or other protozoan oocysts are present, they float upward until they rest directly beneath the cover slip. The cover slip was removed from each test tube and placed on a glass slide, which was then examined under a light microscope using x10 objective lens.

The modified McMaster Technique (Garcia 2001) was used to quantify egg or oocyst concentrations. Briefly, 4 g/ml of the specimen material was mixed with 56 ml of flotation solution, saturated NaCl as above, to yield a total volume of 60 ml. After thorough mixing, the suspension was filtered through a tea strainer. Immediately, the two chambers (0.51 ml volume each) of the McMaster slide were filled with the mixture using a Pasteur pipette. Any visible air bubbles present were removed and the chamber refilled. The slide was allowed to sit for a few minutes and placed under the x10 objective of binocular light microscope. The objective was focused on the top layer, which contains the air bubbles. At this layer, the lines of the grid were also in focus. The eggs and oocysts were then counted in each lane of both chambers. Each type of parasite was counted separately. By adding the results of both chambers, one obtains the count of eggs present in 0.3 ml, or 1/200th of the total volume of 60ml. Therefore, the number of eggs counted was multiplied by 200. Starting with 4 g of specimen or 4 ml of suspension, the result was divided by four to yield eggs per gram (epg). Dividing by four was also equivalent to multiplying the number of eggs counted by 50.

Centrifugal sedimentation (Garcia 2001) was used to isolate eggs of flukes and some other tapeworms and nematodes whose eggs do not readily float. 1 g or 1 ml of sample was

mixed with about 10 ml of 10 percent formalin and the mixture poured into a centrifuge tube (with cap) until it was one-hand to three-quarters full. Ethyl acetate was added until the tube was almost full. The tube was capped and gently shaken about 50 times. The sample was then centrifuged for 2-3 minutes at 1500 rpm. When the tube was removed from the centrifuge it had three layers:

- an upper layer containing ethyl acetate, fat and debris,
- a middle layer containing formalin and fine particulate matter,
- a bottom layer of sediment.

Using an applicator stick, the top debris plug sticking to the side of the tube was loosened and the supernatant decanted leaving only the bottom sediment. The sediment was then re-suspended in a few drops of formalin or water. One or two drops of sediment were placed on a slide and examined under x10 of the microscope. The sediment was then screened, the number of eggs or larvae counted and expressed per g or ml of sample.

RESULTS

Bacteria

Table 9.2 shows the aerobic plate, total coliform and e-coli counts for water at different wetland sites in 2004 (with some repeats in 2005). Although bacterial contamination in general was present at all sites, *E.coli* was present in a sub-sample, though the repeat tests in 2005 were positive in two of the sites that were negative in 2004 (Namuwongo & Busega). The soil tests revealed the presence of *E.coli* in Kyebando and Murchison Bay and *salmonella* in soil at Banda and Bwaise. Neither water nor soil showed any presence of Shigella and Vibrio cholera in the wetlands investigated at the time.

Table 9.2 Bacterial concentrations in water from wetland sites

SITE	Aerobic Plate Count (CFU/ml)	2004		2005	
		Total Coliform Count (CFU/cm ²)	<i>E.coli</i> Count (CFU/100ml)	Total Coliform Count (CFU/cm ²)	<i>E.coli</i> Count (CFU/100ml)
Banda	51000	3100000	2900	5,100 to 7,900	9 to12
Namuwongo	34000	32000	0		
Bukasa	1600000	4000	7	970	0.1 to1.3
Bwaise	1800000	1200	0		
Busega	310000	250000	0		
Katanga –Mulago	230000	190000	2	30,000	300
Katanga – Makerere	150000	890000	2400		
Kyebando	140000	0	0		
Murchison Bay	510000	180000	420		
Munyonyo	9200	130000	360		
Kiwanataka	93000	14000	3		
Butabika	430000	77000	170		

The high levels of contamination in Banda slum, an area described in Chapter 2 above, can be attributed to flooding by water containing sewage from the adjoining Kiwanataka wastewater channel as well as to the absence of local sanitation and a high water table, the shallow latrines being emptied into the wetlands during the rainy season. The readings were slightly lower at Namuwongo, a very similar area on the Nakivubo channel. Bukasa wetland is an extension of Namuwongo wetland situated on the lower part of the Nakivubo channel towards Luzira. There is less contamination from human waste than at Namuwongo because the population is less dense, with vast areas of cocoyam gardens. Bwaise is another similar area, and it has experienced cholera outbreaks during severe rains. Busega, on the other hand, a natural wetland where people mostly go to harvest papyrus, has no settlements close to the wetland, although a wastewater channel from Nalukolongo industrial area runs through it. It is situated on the border between Kampala and Mpigi districts, along the Masaka road.

Katanga and Kyebando are both seasonal wetlands contaminated by uncontrolled solid waste disposal. Katanga is in a valley between Makerere University and Mulago Hospital, separated by a wastewater channel that runs between the two hills. The Makerere side is also flooded by untreated sewage from Makerere University staff accommodation and some small-scale industries, while Katanga-Mulago receives waste from the hospital, incineration and motor vehicle garages.

Murchison Bay wetland receives most of the waste entering Lake Victoria from the Nakivubo and other wastewater channels as well as untreated sewage from Luzira Prisons. Munyonyo, on the other hand, is a sparsely populated peri-urban wetland where residents have their own latrines. No wastewater channel discharges into it and there were no signs of waste disposal. Kiwanataka and Butabika wetlands are both former KCC waste-dumps now partly settled, with farming in the wetland part of Kiwanataka and brickmaking in Butabika. Residents have no latrines, using the wetland and waste-dump instead.

In 2005, bacteria were observed both in crops and plant parts for contaminated sites (Table 9.3) and control sites (Table 9.4). The values for soil and water vary by plant type because not all plants were found at all sites e.g. tomatoes were rare. The ranges are given for the sites where they were found.

Coliforms and *E.coli* were present in appreciable numbers in the water and soil and on the surface of plants with total coliform counts of up to 2.3×10^3 CFUs. Tomato samples picked from one contaminated site had the surface of the root and stem contaminated with coliforms between 9×10^1 and 14×10^1 . Internal contamination of crop tissues by these pathogens was also seen, although at low levels (<10 CFU/g or ml). Generally, the control sites were less contaminated with coliforms and *E.coli* compared to the sewage-contaminated sites. Only one sample, the leaf surface of *Amaranthus* (dodo) from a contaminated site, was positive for *Salmonella*.

Table 9.3 Bacterial counts by crop, plant part and surface or inside from the sewage contaminated sites.

Crop	Plant part	Part tested	Range of CFU/g or CFU/ml		
			APC	Coliforms	E.coli
Yam <i>Xanthosoma</i> spp	Leaves	Inside tissue	*<1 at 10 ¹ to 4.9 x 10 ³	*<1 at 10 ¹ to 16 at 10 ¹	<1 at 10 ¹
	Stem	Surface	NA	8 at 10 ¹ to 7.8 x 10 ²	1 to 7 at 10 ¹
		Inside tissue	<1 at 10 ¹ to >300 at 10 ¹	<1 at 10 ¹ to 7.2 x 10 ²	<1 at 10 ¹
	Root	Surface	NA	<1 at 10 ¹ to 1.6 x 10 ³	3 to 22 at 10 ¹
		Inside tissue	2 at 10 ¹ to > 300 at 10 ¹	4to8 at 10 ¹	<1 at 10 ¹ to 1 at 10 ²
		Surface	NA	2.0 x 10 ³	1 at 10 ¹ to 6.7 x 10 ³
	Soil		NA	4.4 – 5.3 x 10 ³	4to7 at 10 ²
Water		NA	<1 at 10 ¹ to 1.6 x 10 ³	12 at 10 ² to >300 at 10 ²	
Dodo <i>Amaranthus</i> <i>dubius</i>	Leaves	Inside tissue	<1 at 10 ¹	<1 at 10 ¹	<1 at 10 ¹
	Stem	Surface	2 at 10 ¹ to 5.3 x 10 ²	2.6 to 3.7 x10 ²	2 to3 at 10 ¹
		Inside tissue	3 – 7 at 10 ¹	<1 at 10 ¹ to 3.0 x10 ³	<1 at 10 ¹
	Root	Surface	NA	12 at 10 ¹ to 7.3 x 10 ³	<1 at 10 ¹
		Inside tissue	<1 at 10 ¹ to 10 at 10 ¹	<1 at 10 ¹ to 4 at 10 ¹	<1 at 10 ¹
	Soil	Surface	NA	3.6 x 10 ² – 1.6 x 10 ³	3to4 at 10 ¹
Water		NA	5.3 – 7.3 x 10 ³	<1 at 10 ¹ to 13 at 10 ²	
**Tomato (Wakaliga contaminated site)	Leaves	Inside tissue	<1 at 10 ¹ to 3 at 10 ¹	<1 at 10 ¹ to 1 at 10 ¹	<1 at 10 ¹ to 1 at 10 ¹
	Stem	Surface	NA	<1 at 10 ¹ to 1 at 10 ¹	<1 at 10 ¹ to 1 at 10 ¹
		Inside tissue	<1 at 10 ¹ to 9 at 10 ¹	<1 at 10 ¹ to 1 at 10 ¹	<1 at 10 ¹ to 1 at 10 ¹
	Root	Surface	NA	<1 at 10 ¹ to 9 at 10 ¹	<1 at 10 ¹ to 1 at 10 ¹
		Inside tissue	<1 at 10 ¹ to 1 at 10 ¹	<1 at 10 ¹ to 1 at 10 ¹	<1 at 10 ¹ to 1 at 10 ¹
	Fruit	Surface	NA	<1 at 10 ¹ to 14 at 10 ¹	<1 at 10 ¹ to 1 at 10 ¹
		Inside	<1 at 10 ¹ to 1 at 10 ¹	<1 at 10 ¹ to 1 at 10 ¹	<1 at 10 ¹ to 1 at 10 ¹
	Soil	Surface	NA	<1 at 10 ¹ to 1 at 10 ¹	<1 at 10 ¹ to 1 at 10 ¹
Water		NA	<1 at 10 ¹ to 13 at 10 ¹	<1 at 10 ¹ to 13 at 10 ¹	

*<1 at 10¹ means no bacteria were isolated at that dilution

**Sampling was done at only one contaminated site

NA – Laboratory testing not performed for test item

Table 9.4 Bacterial counts by crop, plant part and surface or inside from the non-contaminated sites

Crop	Plant part	Part tested	Range of CFU/g or CFU/ml		
			TPC	Coliforms	E.coli
Yam <i>Xanthosoma</i> spp	Leaves	Inside tissue	ND	<1 at 10 ¹ to 9 at 10 ¹	<1 at 10 ¹
		Surface	NA	<1 at 10 ¹ to 2.3 x 10 ³	<1 at 10 ¹
	Stem	Inside tissue	2.6 – 2.8 x 10 ²	<1 at 10 ¹	<1 at 10 ¹
		Surface	NA	2.6 – 3.2 x 10 ²	<1 at 10 ¹ to 4 at 10 ¹
	Root	Inside tissue	<1 at 10 ¹ to 3 at 10 ¹	<1 at 10 ¹	<1 at 10 ¹
		Surface	NA	300 at 10 ¹	<1 at 10 ¹
	Soil		NA	4.4 – 7.0 x 10 ³	<1 at 10 ¹
	Water		NA		<1 at 10 ¹
Dodo <i>Amaranthus</i> <i>dubius</i>	Leaves	Inside tissue	<1 at 10 ¹ to 3 at 10 ¹	<1 at 10 ¹	<1 at 10 ¹
		Surface	NA	<1 at 10 ¹	2 to 3 at 10 ¹
	Stem	Inside tissue	<1 at 10 ¹ to 3 at 10 ¹	15 to 16 at 10 ¹	<1 at 10 ¹
		Surface	NA	19 at 10 ¹ – 6.5 x 10 ²	<1 at 10 ¹ – 4.0 x 10 ¹
	Root	Inside tissue	<1 at 10 ¹ to 13 at 10 ¹	8 to 16 at 10 ¹	<1 at 10 ¹
		Surface	NA	8 at 10 ¹ to 2.3 x 10 ²	<1 at 10 ¹
	Soil		NA	18 at 10 ¹ to 2.3 x 10 ³	<1 at 10 ²
	Water		NA	<1 at 10 ¹ to 5.3 x 10 ³	<1 at 10 ²
Tomato <i>Lycopersicon</i> <i>esculentum</i>	Leaves	Surface	NA	<1 at 10 ¹	<1 at 10 ¹
		Inside tissue	<1 at 10 ¹ to 21 at 10 ¹	<1 at 10 ¹ to 3 at 10 ¹	<1 at 10 ¹
	Stem	Surface	NA	<1 at 10 ¹ to 3.2 x 10 ²	<1 at 10 ¹
		Inside tissue	<1 at 10 ¹ to 2 at 10 ¹	<1 at 10 ¹	<1 at 10 ¹
	Root	Surface	NA	<1 at 10 ¹ to 13 at 10 ¹	<1 at 10 ¹
		Inside	<1 at 10 ¹	<1 at 10 ¹ to 3 at 10 ²	<1 at 10 ¹
	Fruit	Surface	NA	<1 at 10 ¹ to 7 at 10 ¹	<1 at 10 ¹
		Inside	9.5 at 10 ²	<1 at 10 ¹	<1 at 10 ¹
	Soil		NA	<1 at 10 ¹ to 6.9 at 10 ¹	NA
	Water		NA	NA	<1 at 10 ¹ to 2 at 10 ¹

*<1 at 10¹ means no bacteria were isolated at that dilution.

Parasites

In 2004, Klebs eggs were found in water from Katanga, Murchison Bay, Kinawataka, Kyebando, Busega and Bwaise wetlands and in soil from Bwaise.

In 2005, the vast majority of samples from all sites showed no helminths eggs, amoebal cysts or larvae in the soil or plant crop parts, either surface or inside tissue. Gastro-intestinal (GIT) parasite eggs at a count of 6/ml were found in the water from Katanga. *Entamoeba histolytica* were recovered from one water sample at a count of 24/ml in Kanyogoga. Parasite larvae were recovered in one water sample from Natete at 3/ml.

DISCUSSION

Findings in relation to the literature

Sewage-watered crops contained *E.coli*, *Salmonella* and other fecal coliforms on the surface of the crops and, to a lesser extent, inside the plant tissues. Bacteria have been shown to enter produce including vegetables through various pathways. These include leaves of plants through the stomata and fruits through the stem, stem scar or calyx (Samish & Etinger-Tulczynska 1963; Samish *et al.* 1963; Zhuang *et al.* 1995).

A recent study in Ghana that monitored microbiological water and crop contamination on urban vegetable farms recorded high fecal coliform and parasite egg levels that exceeded guidelines for food quality (Amoah, Drechsel and Abaidoo – Personal communication). The critical element is to understand that, even with untreated or partially treated wastewater, the WHO guidelines allow re-use if there are other barriers to break pathogen transmission. These barriers may take the form of treatment or non-treatment options both on-farm and off-farm at market and food preparation level.

The factors controlling transmission of disease are agronomic, such as the crop grown, the irrigation method used to apply the wastewater and the cultural and harvesting practices used. Pathogenic microorganisms may reach the surface of plants from wastewater through splashing, post harvest washing and unhygienic handling. Absorption through the root appears very limited except in the case of tomato, where evidence of uptake of pathogenic microorganisms through the roots has been found. Surface damage to plant parts also makes them prone to uptake of pathogens where these are present.

The total coliform counts obtained from the analysis of plant parts were in the range of 10^1 - >300 at 10^1 /g. Although their presence does not necessarily indicate that pathogens are present, coliforms are a good indicator of fecal contamination and poor hygiene. The World Health Organization (WHO 1989) has recommended that when crops are likely to be eaten raw, water or effluent used for their irrigation should have been disinfected to achieve a coliform level of not more than 1000 coliforms/ 100 ml in 80 percent of the samples. International guidelines or standards for the microbiological quality of irrigation water used on particular crops are not available, as crop-specific contamination data and disease transmission or infection data are not often collected.

The range of fecal coliforms for the water samples analyzed was between 1.0×10^3 to >300 at 10^2 , much higher than even the current WHO guidelines (2006). To avoid the risks of pathogen exposure, it is important to reduce contact excreta and decrease the number of

pathogens in the material. It has been observed that untreated feces should not be used for vegetables, fruits or root crops that will be consumed raw (WHO 1989).

Fecal *E.coli* was isolated both on the surface and inside plant tissues. Higher contamination levels were recorded on the surface of plants studied to the level of >300 at $10^1/\text{g}$ wet weight. Amoah and other workers (2006) reported mean values of fecal coliforms from the surfaces of vegetables studied ranging from 4.0×10^3 to $9.3 \times 10^8 \text{ g}^{-1}$ wet weight, exceeding recommended standards for fecal coliforms and fecal *E.coli* in food.

Some studies have shown that surface treatments may substantially reduce surface contamination but are ineffective in reducing microbial populations that have been internalized in produce. Pao & Davis (1999) found that immersing inoculated oranges in hot water or various chemical solutions (200 ppm chlorine, 100 ppm chlorine dioxide, 200 ppm acid anionic sanitizer, 80 ppm peroxyacetic acid, or 2% trisodium phosphate) was effective at reducing generic *E.coli* populations by 1.8 – 3.1 log cycles on surface areas. However, Zhuang & Beuchat (1996) demonstrated that a 15 percent solution of trisodium phosphate completely inactivated *Salmonella* on the surface of tomatoes but will only result in a 2-log reduction of internal populations. Besides being only partially effective, these are not practical measures that can be widely recommended for public health application in Kampala.

Several studies have shown that human pathogens can survive and grow in tomatoes and tomato products (Zhuang *et al.* 1995; Zhuang & Beuchat 1996; Tsai & Ingham 1997). Coliforms were found in *Amaranth* (10 and 35 units/gm) and eggplant (35 units/gm) grown with sewage water in the peri-urban interface of Hubli-Dharwad, India (Brook *et al.* 2001, p.57). Investigations done by Jablasone *et al.* (2004) revealed that *Salmonella* can survive inside tomato tissue up to the fruits. Although this was not the case with results obtained in the Kampala sewage watered area where *Salmonella* were less commonly recovered, the results from elsewhere suggest this to be a matter of public health concern.

Likewise the minimal recovery of helminth eggs, parasite eggs or larvae from the crops, water and soil samples in our study does not mean that these are not matters for concern regarding health risk. While these pathogens did not prevail at the time of our study it does not mean that they might not at another time, given the patterns of excreta disposal and dispersion. A recent study in Ghana reported mean parasite egg levels of 1.1, 0.4 and 2.7 epg from lettuce, cabbage and spring onion, respectively (Amoah *et al.* 2006). The survival period of these parasites can vary from a few days to several weeks but they may also die off due to environmental conditions like high temperature or salinity.

Analytical approach and directions

Developing a public policy response to these findings from Kampala and elsewhere entails not only an assessment of the risks posed to human health by pathogen levels found but also a realistic assessment of which of a feasible set of mitigation measures are likely to be effective in reducing risks of exposure for different groups of persons. While this study was insufficient for a full risk assessment, our approach to the data produced may benefit from insights from recent publications examining health effects of wastewater use in agriculture and their mitigation. Blumenthal & Peasy (2002) suggest measures based on a critical review

of a wide range of evidence, while others (Keraita *et al.* 2006; Drechsel *et al.* 2008) attempt to define the complex array of hazards and pathways of transmission, coming up with key entry points for risk reduction.

The WHO 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

From this perspective it can be seen that the widespread dispersion of sewage in Kampala's wetlands and agricultural areas represents considerable risks to human health that may be interrupted at various points by specific approaches.

Factors such as heat, moisture, pH, solar radiation, nutrient availability and presence of other microorganisms affect the survival of pathogens (Winblad & Simpson-Herbert 2004). They survive longer in the soil than on crop surfaces where they can be rendered harmless by sunlight and desiccation. Almost all excreted pathogens can survive in soil long enough to pose potential risks to farm workers (WHO 1989). Sometimes they survive long enough to pose potential risks to crop handlers and consumers, especially in the case of vegetables with short growing cycles. The length of time since the last irrigation is also important.

There is evidence that irrigating vegetables with untreated wastewater can lead to increased helminth infection (*Ascaris lumbricoides*), bacterial infections (typhoid, cholera, *Helicobacter pylori*) and symptomatic diarrheal disease in consumers. There is also evidence of risk of enteric infections (bacterial and viral origin) from consumption of some types of uncooked vegetables irrigated by water exceeding the WHO guideline of 1000 FC/100ml by a factor of ten (Blumenthal & Peasy 2002). However, since the heat of cooking destroys most pathogens the risk of consuming cooked foods grown in wastewater is considerably reduced (Keraita *et al.* 2006, p. 68). Quoting Shuval, Keraita *et al.* note that helminths (the intestinal nematodes – *Ascaris*, *Trichuris*, hookworm and *Taenia*) survive the longest and represent the highest human health risk from wastewater irrigation, while viruses represent the lowest (Keraita *et al.* 2006, p. 63).

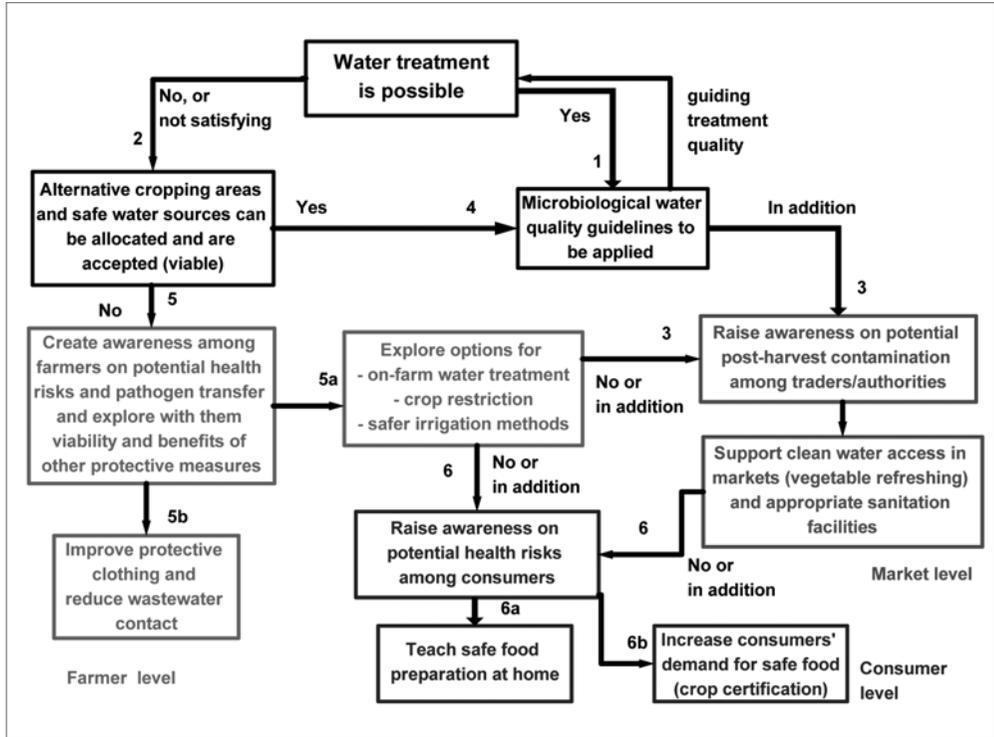
A new fecal coliform guideline of =105 FC/100 ml has been set by WHO to protect farm workers, their children and nearby populations from enteric viral and bacterial infections where wastewater irrigation is practiced. Farmers' children under 15 years who are regularly exposed (through farm work or play) are considered more vulnerable and health promotion measures are also needed to help adult farm workers and children improve hygiene measures post wastewater contact (WHO 2006). Guidelines for *Ascaris* of =1 nematode egg/liter were set for farm workers' safety but children may be at greater risk because of their undeveloped immune systems. Further studies are needed, especially into the accumulation of eggs in the environment (such that repeated watering could result in increasing exposure) (Blumenthal & Peasy 2002).

WHO proposes that, where adequate municipal wastewater treatment is not a realistic option in the short to medium term because of resource constraints and where wastewater is used for urban agriculture, a decision strategy is needed on how to apply these recommended standards in conjunction with other public health measures. Entry points for risk reduction are indicated in Figure 9.1 (reproduced from Keraita *et al.* 2006, pp.66-68). The following measures might be considered when working with wastewater use in urban agriculture:

- Looking for alternative (cleaner) water sources for farmers and negotiating with them on relocation (e.g. groundwater).
- Safer crop selection, such as excluding vegetables consumed raw.
- On-farm water treatment options such as sedimentation tanks.
- Working with farmers on ways to reduce health risks to themselves and their children (e.g. safer ways of fetching and applying water).
- Working with farmers on ways to reduce health risks to consumers (e.g. using surface instead of overhead irrigation, avoiding “refreshing” crops with contaminated water).
- Controlling post harvest contamination at markets (e.g. providing clean water supplies, education on not “refreshing” crops with contaminated water).
- Consumer education on the risks of uncooked foods and how to wash them (Keraita *et al.* 2006, pp.66-68).

Protection of public health is achieved by reducing concentrations of pathogens and limiting peoples’ exposure through contact, inhalation or ingestion. With the detection of fecal pathogens both on the surface and inside crops in Kampala, we can conclude that bacterial pathogens do penetrate plant tissues, probably through the vascular system. If such crops are eaten raw as salads, there is a risk of infection to the consumer even when good post harvest handling methods are practiced. Thorough washing of the surface of these vegetables should rid them of parasites but may not eliminate microbes established inside the tissues. This implies that growing crops like tomatoes, lettuce, onions and cabbage should be avoided in sewage areas to minimize the risks of contamination, especially when they are eaten raw. Alternatively, such vegetables require treatment, e.g. by blanching or use of effective salt concentrations, to make them safe to eat uncooked (Amoah *et al.* 2007). Research on the effectiveness of feasible alternatives needs to continue.

Figure 9.1 Entry points for risk reduction related to wastewater use (reproduced from Keraita *et al.* 2006)



However, if the foods are cooked thoroughly before being eaten, the high temperatures will destroy pathogens making the food safe for consumption. This applies to the popular cocoyam in Kampala which is produced in sewage-watered soils. Regardless of contamination, this food is only eaten cooked and is therefore not a risk to human health through pathogenic contamination.

However, cooking makes certain nutrients unavailable to the consumer due to destruction or transformation by heat. Crops normally processed by heat or drying before human consumption (grains, oilseeds, sugar beet, yam) should be recommended for growing in contaminated areas. More refined studies are required, however, to fully understand contamination levels in various vegetables grown in sewage contaminated soils in the region as well as the factors that lead to pathogens penetrating vegetable tissues.

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Healthy horticulture in cities

Editors' Commentary

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EDITORS' COMMENTARY

WHAT DO WE KNOW?

Chemical Contaminants: Heavy Metals

Industry was the major source of heavy metal contamination of the wetlands. Wastewaters released by these industries had metal concentrations above those recommended for use, posing potential health risks. Plants grown in industrial wastewater-contaminated wetland soil showed higher uptake of metals than those on municipal solid waste dumps.

The roots of wetland plants accumulated the highest concentrations, with less in the leaves. Our finding that *Commelina* and water hyacinth can bio-accumulate metals in their tissues confirms their cleansing potential. Fortunately cocoyam accumulated metal in the order of concentration: root > leaf > peel > tuber. Since the root is not eaten and the tuber is normally peeled before cooking, there is less potential health risk to consumers. However, some vegetables accumulated higher trace levels of metals in the leaves (e.g. pumpkin) than in the fruits, indicating possible aerial deposition rather than root uptake and some risk from consumption of the leaf as a vegetable.

Heavy metals were also associated with traffic pollution in food gardens close to roads. In contrast to wetland findings, higher levels of metals were found in leaves in our traffic study, compared to roots, fruits and tubers, consistent with atmospheric deposition being the dominant pathway for metals to leafy vegetables. Although policy measures have been taken to shift from leaded to unleaded fuels, there is still possibility of risk of metal contamination from vehicular traffic.

Chemical Contaminants: Complex Organic Compounds

For organic compounds such as PAHs, ingestion of foods grown in contaminated soil is a concern. The driving ingestion pathway was via belowground vegetables and cereals and grains, except in the case of fluoranthene exposure, where the driving ingestion pathway was primarily fish. Nevertheless, it was expected that the health risk of toxicological effects stemming from PAH exposure should be low.

Biological Contaminants

The levels of pathogenic microorganisms in the water and soils on UA sites using sewage water were high, resulting in contamination – mostly on the surface of crops, which is of greatest concern – but also in the tissue of some crops.

WHAT CAN BE DONE?

General Principles

Chemical contaminants should be treated distinctly from biological contaminants in policy, regulation and management. Discharge of chemical contaminants into wastewater and organic solid waste must be curtailed. Treatment of these wastes, where it exists, only deals with pathogens, and both solid and liquid waste streams are highly likely to enter the food chain through fish or re-use in agriculture.

Improved sanitation and public awareness of health risks from contaminated water are both essential. However, for many poor subsistence urban farmers, stopping farming due to potential biological or chemical hazard exposure is not a viable option. Where UA is a lifeline for the urban poor, making an informed health trade-off is the preferred solution, with site-specific information as available and education of farmers in risk minimization.

Given the primacy of the Right to Food as a policy principle and the need to protect consumers, the sequence of measures working with poor farmers using hazardous sites should be: information / awareness, participatory development of mitigation strategies (see below), remediation of toxic contamination using alternative crops and provision of alternative sites.

Policy Priorities

Chemical Contaminants:

- a. Discharge of potentially harmful quantities of heavy metals and combustion by-products into air, soil and water especially by large industries, the main source of heavy metals, should be regulated. This would strengthen provisions included in the KCC Urban Agriculture Ordinances, published in 2006.
- b. Vehicle emissions should be regulated to reduce combustion by-products including PAH concentrations, plus continued phase-out towards prohibition of leaded fuel.

Biological Contaminants:

- a. Improved sanitation in Kampala is a high policy priority in keeping with the Lake Victoria initiative on Water and Sanitation among other activities.
- b. Results from ongoing research and development into ecological sanitation alternatives involving waste re-use in UA should be reviewed for potential policy application. Research is being done in Kampala as well as seven West African cities.
- c. Given that the considerable health risk represented by biological contaminants may be interrupted at various points, an array of strategies is proposed based on our findings and other sources (see Chapter 9, above, and Keraita *et al.* 2006, pp.66-68):

- Provision of clean water in markets or where market produce is “refreshed”, usually with contaminated water. This may be a critical factor in reducing risks from pathogens;
- Working with farmers on ways to reduce health risks to themselves and their children. (e.g. safer ways of fetching and applying water);
- Controlling post harvest contamination at markets (e.g. providing clean water supplies, education on not “refreshing” crops with contaminated water);
- Working with farmers on ways to reduce health risks to consumers (e.g. using surface instead of overhead irrigation, avoiding “refreshing” crops with contaminated water);
- Safer crop selection, focusing on crops that are used cooked, or ornamentals, and excluding vegetables consumed raw;
- Consumer education on the risks of uncooked foods and how to wash them;
- Looking for alternative (cleaner) water sources for farmers and negotiating with them on relocation (e.g. groundwater); and
- On-farm water treatment options such as sedimentation tanks.

General:

Promote a multi-channel communication strategy, involving health centers, schools, markets and street food vending points. Public information and awareness programs are needed, see key messages below. This has already begun, with conferences and meetings of various stakeholders including industrialists, government officials, policy makers and farmers and in collaboration with the Uganda National Association for Community and Occupational Health (UNACOH).

Key Messages

Chemical Contaminants:

- a. Do not throw batteries into pit latrines as this will contaminate the soil and water with heavy metals that are poisonous;
- b. Leafy vegetables can absorb lead (Pb) from the atmosphere and should not be grown within a 30 m distance from the edge of any road, regardless of traffic density. Some indigenous leafy vegetables such as *amaranthus* are safer than *brassicas* such as the popular kale (*sukuma wiki*) and cabbage;
- c. Crops recommended for roadside farming include those where the edible part is protected from aerial deposition such as root crops like sweetpotato and cassava and coarse grains like corn and legumes like pulses beans and peas;
- d. Vegetables that can accumulate heavy metals in their skins or pods, such as tubers and beans, should be peeled or the pods discarded if they are grown near roads; and
- e. All vegetables should be washed thoroughly in clean water before consumption; washing can reduce lead and cadmium on the surface of many of them. Soapy water should also remove some PAHs and other combustion by-products from vegetable surfaces.

Biological Contaminants:

- a. Sewage water is hazardous to health. 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. Children should not be allowed to play with sewage water;
- b. Crops normally processed by cooking, heating or drying before human consumption (grains, yams, oilseeds, sugar beet) are recommended for growing in contaminated areas;
- c. Fears of pathogenic contamination of cocoyams – a popular staple in Kampala – are misplaced as any biological contamination would be killed by prolonged cooking;
- d. Growing crops that may be eaten raw, like tomatoes, lettuce, cabbages and onions, should be avoided in sewage-watered areas;
- e. Avoid contaminating food with pathogenic microorganisms: do not use dirty water to “refresh” market produce, but use only water from a clean source that is safe for drinking;
- f. Cooking vegetables grown using dirty water destroys most bacteria and the majority of parasite larvae, making them relatively safe to eat; and
- g. Produce can also be treated by blanching or disinfection with bleach or chlorine tablets to reduce bacterial loads.

WHAT COULD WE UNDERSTAND BETTER?

Ongoing environmental monitoring to identify potentially toxic and elevated trace metal concentrations in foods could be improved. Further, given the high levels of metals relative to existing health-based guidelines, quantitative risk assessments of neuro-toxic and other health outcomes among children should be undertaken.

The treatment of exposure to mixtures of compounds should be further investigated as should methods for concurrently quantifying both the risks and benefits of given exposures. This would better inform ranking or weighing of risks and benefits across the entire farm-to-table spectrum.

Further studies are needed, especially into the accumulation of parasite eggs in the environment (such that repeated watering could result in increasing exposure). Also, the factors that lead to penetration of pathogens into vegetable tissues need further study, along with follow-up studies to the work of Amoah *et al.* on the relative effectiveness of feasible alternatives for treatment of surface-contaminated vegetables.

Regarding Kampala farmers' and consumers' perceptions of poor taste of cocoyams under certain growing conditions in the wetlands, these should be investigated through further agronomic research.

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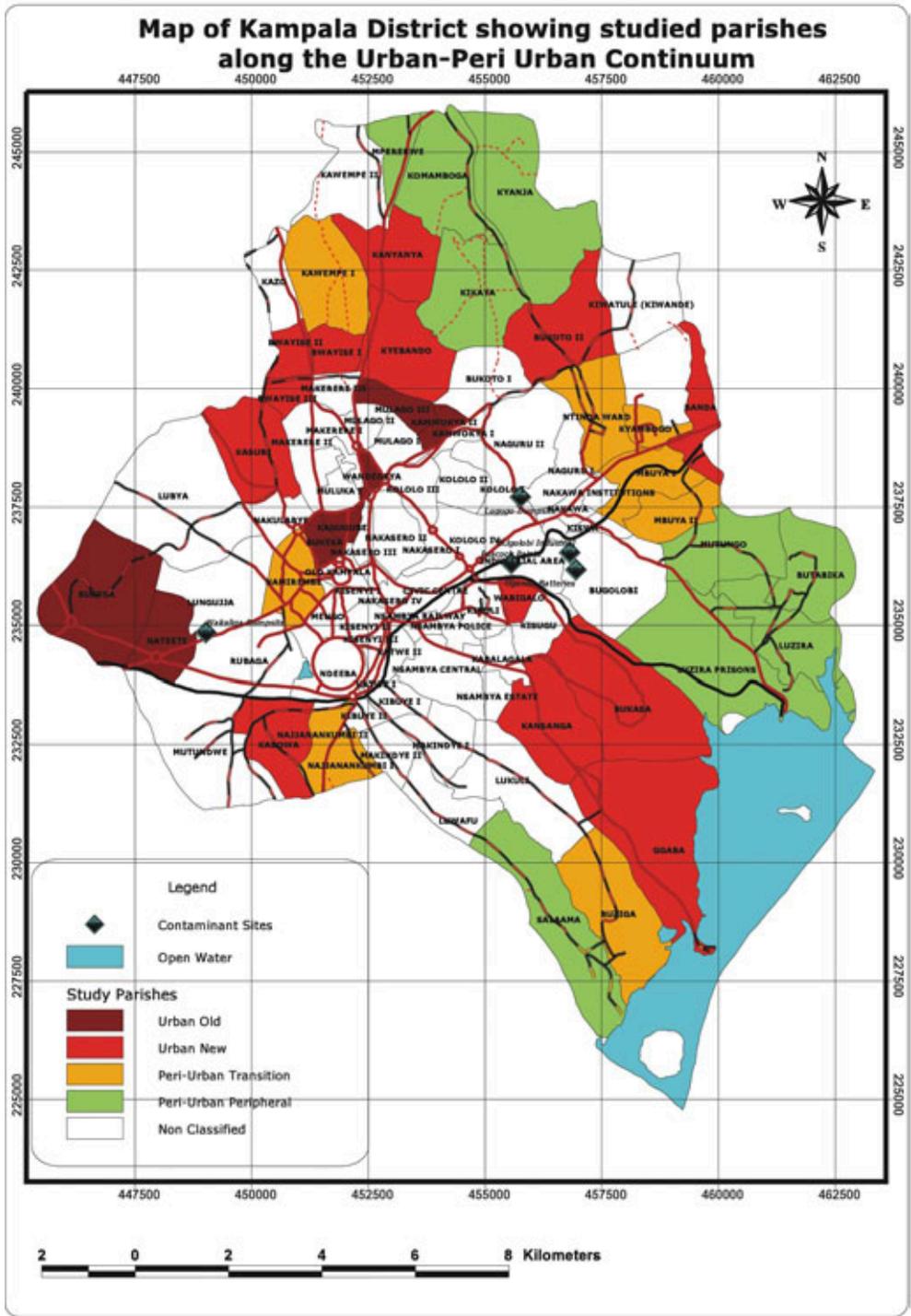


Image: Urban Harvest



Plate 3. Older urban residential area, with agriculture - Image: Urban Harvest



Plate 4. Mixed urban new housing with agricultural plots - Image: Renée Sebastian



Plate 5. Preparing vegetables - Image: Renée Sebastian



Plate 6. Demonstrating healthy food choices - Image: Renée Sebastian



Plate 7. Taking anthropometric measures -weight - Image: Renée Sebastian



Plate 8. Taking anthropometric measures - height - Image: Renée Sebastian



Plate 9. Taking anthropometric measures - mid-upper arm circumference - Image: Renée Sebastian



Plate 10. Crops growing near heavy traffic - Image: Shuaib Lwasa



Plate 11. Preparing food with traditional fuels - Image: Renée Sebastian



Plate 12. Intensive, space-constrained chicken rearing
Image: Urban Harvest



Plate 13. Problem of solid waste contamination
Image: Urban Harvest



Plate 14. Cattle grazing near contaminated land - Image: Urban Harvest



Plate 15. Small-scale dairy production - Image: George Nasinyama



Plate 16. Discussions on the new Ordinances - Image: Margaret Azuba

Managing urban D Section

Managing urban livestock for health

Overview

This section presents the results of studies on the two most common types of livestock in Kampala, chickens and cattle. As in many other towns and cities in sub-Saharan Africa, chicken rearing is practised mainly by women in middle and high-income households, responding to growing urban demand and markets. Chapter 10 documents protective practices in chicken rearing and risk factors associated with enteric illness (diarrhea) among chicken-rearing and neighboring households. Chicken-raising per se was not associated with illness, though consumption of raw eggs was. Interestingly, consumption of animal sourced foods, including chicken, was also associated with less enteric illness, due either to better overall diet (meat eating) or to greater intake of essential minerals bolstering resistance to infection. There were gaps in chicken farmers' and consumers' knowledge about disease risks that need to be addressed with public health messages. Chapter 11 is a peer reviewed study on the benefits and harms of city dairying. It is a multifaceted examination of livestock-related practices, potential health risks and current mitigation strategies used by households keeping cattle in Kampala. A rich variety of farmer and consumer risk management strategies were revealed to be already in place, preventing or reducing many food safety hazards when used at critical control points along the pathway of milk from cow to consumer. A linear regression model revealed which factors influenced farmers' use of these strategies.



Managing urban livestock for health

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Household risk factors associated
with chicken rearing and food
consumption in Kampala

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City dairying in Kampala:
integrating benefits and harms

CHAPTER 10

Household risk factors associated with chicken rearing and food consumption in Kampala

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• Sally Humphries • George W. Nasinyama

INTRODUCTION

As in many other towns and cities in sub-Saharan Africa, chicken rearing is the most common form of livestock production in the city of Kampala (see discussions of the situation in Yaounde, Cameroon and Nairobi, Kenya in Prain *et al.* forthcoming). A study in 1994 showed that urban poultry producers were meeting 70 percent of the city's poultry needs (Maxwell 1994). Livestock rearing is one of the urban agricultural practices that accompanies rapid urbanization and is now a part of metropolitan life in developing countries, changing the kinds of risks to which urban dwellers are exposed (McMichael 2000). Because of the varying contexts in which it takes place, the resources involved and the socio-economic conditions of people undertaking it, urban livestock keeping is difficult to characterize in general terms. In this study, urban and peri-urban livestock systems were defined as the rearing of livestock in and around densely populated areas. Specifically in Kampala, this means the areas within the city boundary, for which Kampala City Council (KCC) has developed its own classification system of urban and peri-urban agriculture areas.

Zoonoses are infections naturally transmitted between vertebrate animals and humans either directly or indirectly usually through the consumption of contaminated foods (WHO 1998). Livestock-related zoonotic diseases are still a cause of morbidity and mortality in humans and animals living in developing countries (Wastling *et al.* 1989). Because of high population densities, different management practices and challenges with solid and liquid waste disposal, the risks of acquiring such diseases are purportedly amplified in urban centers and their incidence is expected to rise (Mougeot 1999). While zoonotic diseases are a matter of concern in developing countries, little empirical work has been done to demonstrate their extent and impact in relation to urban and peri-urban livestock systems (Flynn 1999; Lock & de Zeeuw 2001). It is only recently that substantial research has been conducted on urban dairying in Nairobi, Kenya (Kang'ethe *et al.* 2007).

Food borne diseases, which encompass a variety of clinical and etiologic conditions and describe a subset of enteric illnesses, are a widespread public health problem both in developed and developing countries. The global incidence of food borne disease is difficult to estimate, but the World Health Organization (WHO) reported that in 2005 alone 1.8 million

people died from diarrheal diseases (WHO undated). A great proportion of these cases can be attributed to contamination of food and drinking water. Foods contaminated by pathogenic organisms, especially those of animal origin, play a significant role as risk factors for diarrheal disease. Methods of food handling and storage, personal hygiene and household water sources also contribute to the potential risk of developing diarrhea (Hamer *et al.* 1998; Nasinyama *et al.* 2000). It must be emphasized however, that the risk factors for food borne diseases are multiple, including interactions and changes in pathogens, food distribution, food consumption and population immunity (Lammerding & Paoli 1997).

This chapter and the next address the human health risk factors associated with keeping chickens and dairy cattle, the two most common forms of livestock kept in the city of Kampala. Both studies were part of the livestock component of the Kampala Urban Agriculture Health Project, developed in collaboration with the International Livestock Research Institute (ILRI) to evaluate urban and peri-urban livestock production-to-consumption systems.

A cross-sectional study was carried out between May and August 2003 to assess the human disease risk factors associated with commercial chicken rearing in urban and peri-urban areas of Kampala, Uganda. The specific research objectives were to:

- (i) characterize chicken rearing and non-chicken rearing households;
- (ii) document local knowledge and terminology for risk assessment;
- (iii) determine the prevalence of enteric illness among chicken rearing and non-chicken rearing households; and,
- (iv) to identify risk factors associated with enteric illness in both chicken rearing and non-chicken rearing households, and the role of protective measures in reducing risk.

METHODS

Selection of study parishes and parish focus groups

A two stage sampling method was used, involving the selection of parishes followed by the selection of study households. As described in previous chapters, Kampala is divided into five divisions comprising approximately 20 parishes each, with each parish further divided into zones. Ten parishes were purposively selected, based mainly on a past history of good relations with local actors, presence of urban livestock activity and confirmed or suspected presence of zoonotic disease. The final sample presented a range of urban and peri-urban parishes using Kampala City Council's classification system as indicated on the map (Plate 1).

Participatory Urban Appraisals (PUAs) in the form of focus group discussions were held with urban livestock keepers brought together by local leaders in each of the ten parishes. Roughly equal numbers of women and men were recruited to each focus group. The objectives were to determine the perceived benefits and hazards associated with urban livestock production, using ranking and proportional piling methods, to identify risk pathways, and to ascertain farmer perceptions of various non-farmer stakeholders. Discussion of benefits included income and food security while potential hazards included contact with farm waste. Substantial discussion of marketing methods and challenges also occurred, as both were a pre-occupation of many livestock keepers and, in keeping with food chain frameworks (COA 2003), as the method by which infection may be spread from animals to consumers.

Selection of study households for survey

During the second stage of sampling both chicken rearing and non-chicken rearing households were selected. For chicken rearing households, the focus was on households that raised chickens (either local, broiler or layer types) primarily for sale in order to evaluate marketing pathways as well as to detect associations between chicken production practices and enteric illness at the household level. Based on a diarrhea two-week prevalence of 20 percent derived from an earlier study on diarrhea and *Salmonella* infections in Kampala (Nasinyama 1996), we estimated an initial sample size of 477 but this was reduced to 192 study households due to limited resources and time. Local representatives of KCC at parish level (LCII) identified commercial chicken-rearing households in each study parish and created lists used to select households for structured interviews. Some parish lists were incomplete with very few farms identified prior to data collection. Additional chicken rearing households were identified by local farmers and leaders during data collection. For comparison of key variables we selected a number of neighboring non-chicken rearing households in each parish, defined as households that did not raise chickens or livestock, although they may have engaged in crop production.

Survey data collection

Questionnaires were based on information obtained from the PUAs, guidelines for investigating particular pathogens (WHO 1998) and items found useful by researchers working in similar contexts (Nasinyama 1996). Open-ended and close-ended questions elicited information about household livestock production, rural linkages, food preparation, consumption and storage techniques, water sources and usage, income sources, assets and household episodes of enteric illness. Enteric illness was defined as an episode of diarrhea and/or two or more symptoms of vomiting, headache, fever, abdominal cramps or blood in the stool in the two weeks preceding the survey. Combinations of only fever and headache symptoms were excluded. A household was classified as a "case" if at least one person in that household experienced enteric illness during the two weeks preceding the survey.

Research assistants were qualified veterinarians who spoke the predominant local language (Luganda) and English fluently. They were trained to administer the questionnaire in a classroom setting, followed by field pre-testing, de-briefing and revisions of items for comprehension. The primary caretaker of household chickens was identified in each chicken rearing household and verbal consent was obtained prior to study participation. The main respondent in non-chicken rearing households was selected based on familiarity and knowledge of household activities related to the questionnaire. All study interviews were conducted in Luganda and transcribed into English while the questionnaire was being administered.

The proportional piling technique (Mariner 2000) was used to ascertain the proportion of household income derived from chicken production. For this exercise, respondents were presented with 100 beans and asked to divide them into two piles, one for chicken production and another for other income sources. Proportional piling was used to further subdivide the chicken production category into the following income generating activities: sale of broilers, local chickens, layers, manure and eggs.

A wealth classification approach was used based on criteria and categories developed during the PUA (David 2003). Local criteria for poverty and wealth were obtained through discussions with community members and applied to determine a set of useful groupings that made sense in local discourse. The wealth ranking, again using proportional piling, incorporated information about housing characteristics, ownership of assets, food consumption patterns, type of healthcare system(s) used, employment, and the size of livestock enterprises. The exercise resulted in the creation of three wealth categories: rich, middle class and poor.

This study was reviewed and approved by the University of Guelph and Makerere University Human Ethics Review Committees and by the Ethics Committee of the Uganda Council on Science and Technologies.

Statistical analysis

All data were entered into Excel (Microsoft Corp., Redman, WA), validated by double-checking each entry and analyzed using SAS version 8.0 (SAS Institute Inc., Cary, NC). Univariate analyses were used to examine the characteristics of chicken rearing and non-chicken rearing households and to assess the association of household risk factors with enteric illness. All identified variables were entered into two separate logistic regression analyses with household enteric illness as the outcome:

- (i) among chicken rearing households only; and
- (ii) among both chicken rearing and non-chicken rearing households. Manual stepwise, backward elimination was used to reduce variables in the final models to those for which $p < 0.07$. Pair-wise interaction terms were evaluated for all variables in the final models but none were found to be significant. Goodness of fit of the final models was calculated using the Hosmer-Lemeshow statistic.

RESULTS

Household characteristics

Overall, 142 chicken rearing households and 50 non-chicken rearing households participated (Table 10.1). Respondents were predominantly female in both chicken rearing (63 percent) and non-chicken rearing households (72 percent). Proportions experiencing at least one episode of enteric illness were similar for chicken rearing (21 percent) and non-chicken rearing (18 percent) households as were age distributions of household members experiencing enteric illness: chicken rearing households, mean 21 years, range 0.25-60 years; non-chicken rearing households, mean 22 years (range 1.5 to 70 years).

It was the woman household head that primarily owned (55 percent) and decided when to sell (58 percent) household chickens and products. Male household heads only owned in 20 percent of households and made the decision to sell in 22 percent of households. Some chicken rearing households also raised other livestock such as cattle (24 percent), pigs (21 percent) and goats (19 percent), with the primary caretaker of household chickens also responsible for other household livestock in 46 percent of households. A few households also raised ducks (6 percent) and/or turkeys (6 percent). Chicken rearing households engaged

Table 10.1 Key characteristics of chicken rearing and non-chicken rearing households

Household characteristics	Chicken rearing households	Non-chicken rearing households
No. of respondents	142	50
No. of female respondents	89 (63%)	36 (72%)
Average age (years)	39 (15-73)	33 (18-76)
Average no. of people living in the household	8 (1-20)	5 (1-23)
Average time (years) household has lived in Kampala [†]	22 (1.5-64)	19 (1.5-54)
Average time (years) household has been raising chickens [‡]	6 (2mon-20)	-
No. of households with enteric illness [‡]	30 (21%)	9 (18%)

[†]Based on 126 chicken rearing household and 49 non-chicken rearing household responses.

[‡]Based on 140 responses.

in chicken production primarily for

- (i) income generation (92 percent), in keeping with the selection criteria used,
- (ii) providing additional food for the household (52 percent) and,
- (iii) as a source of manure (38 percent) (categories were not mutually exclusive).

Households raised layers such as Rhode Island Red, broilers such as Hubbard breed, and/or local indigenous chickens. Most broilers and layers (97-100 percent) were reared under housed conditions. The majority of local chickens were free range during the day (60 percent) but housed at night (90 percent) due to fear of theft. Chicken interactions included contact with neighboring chickens, household and neighboring cattle, pigs, turkeys and/or goats in 15 percent of households.

Non-chicken rearing households recognized the positive effects of urban chicken production. Overwhelmingly, non-chicken rearing households said that they benefited (70 percent) from farmers raising chickens in Kampala, allowing for easy access to chicken meat and/or eggs and manure for their gardens. One respondent stated, "Friendship is formed because chickens scavenge on my land". Other respondents commented that having chicken farmers contributed to the development of the area, especially by getting improved transportation routes. Non-chicken rearing households however also acknowledged that they did experience some problems (40 percent) as a result of chicken rearing activities in the city. Conflicts among neighbors were cited, as well as the smell associated with chicken rearing (Plate 13).

For chicken-rearing households, an estimated 38 percent of all household income came from chicken production although the larger part (62 percent) came from other business or employment activities. The most substantial contributions to chicken-rearing household income came from the sale of broilers (40 percent) and the sale of eggs (34 percent). Other sources of household income were derived from the sale of off-layers (17 percent), sale of local chickens (5 percent) and the sale of manure (4 percent).

Table 10.2 Additional household characteristics and chicken rearing practices among chicken rearing households

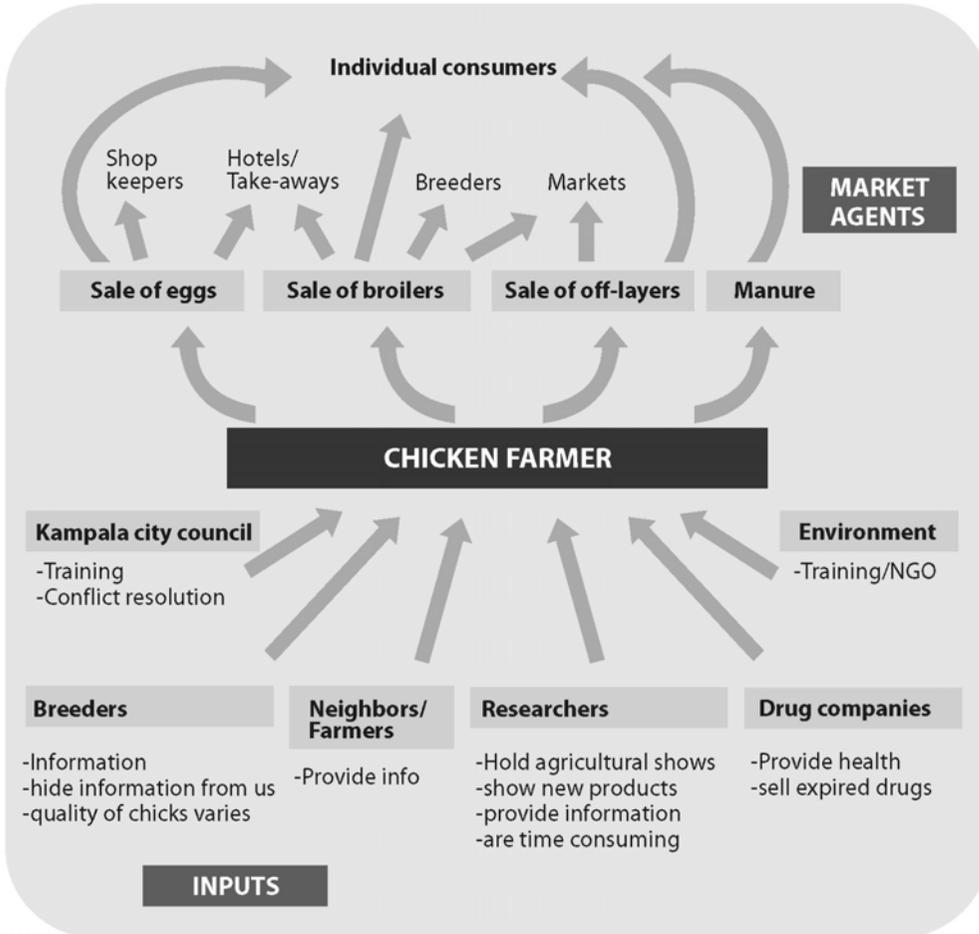
Domain	Characteristic/practice	No. (%) of households
Chicken caretaker characteristics	Primary caretaker of household chickens	
	Woman household head	71/142 (50%)
	Man household head	18/142 (13%)
	Houseboy/girl	12/142 (8%)
	Other occupation of respondent	
	None	64/137 (47%)
	Farming (other than raising chickens)	25/137 (18%)
Business owner	19/137 (14%)	
Chicken production characteristics	Household reasons for raising chickens	130/142 (92%)
	1. Income generation	67/128 (52%)
	2. Provide additional food for household	35/91 (38%)
	3. Source of manure	(mean, range)
	Average number of chickens raised per household	
	Layers (n = 74)	463 (10-6000)
	Broilers (n = 65)	195 (2-800)
Locals (n = 45)	17 (2-76)	
Chickens raised year round	115/138 (83%)	
Chicken raising practices	Chickens interact with other livestock	22/142 (15%)
	People share living quarters with chickens	15/142 (11%)
	Wear protective clothing while handling chickens	40/138 (29%)
	Remove protective clothing before entering living quarters	39/40 (98%)
	Vaccinate chickens	130/141 (92%)
	Against: Newcastle disease	100/130 (77%)
	Infectious bursitis (Gumboro)	73/130 (56%)
Typhoid	40/130 (31%)	

Focus group discussions yielded information on farm inputs and marketing agents. Stakeholders involved and marketing pathways were similar across parishes. Hence, those from one parish, Buziga, are presented in Figure 10.1.

Based on wealth ranking procedures described, the majority of both chicken-rearing (66 percent) and non-chicken rearing households (84 percent) were classified as middle-class. By contrast, 23 percent of chicken rearing households and only 8 percent of non-chicken rearing households were considered rich, while only 11 percent of chicken rearing households and 8 percent of non-chicken rearing households were classified as poor.

During the 30-day period preceding the interview, 64 percent of chicken farmers experienced mortality in their flocks, with 39 percent of those households not knowing the reason for death. Such chicken carcasses were disposed of in the garbage (37 percent), buried (33 percent) or used as feed for other household animals (21 percent). Chicken manure was mainly used for household crops (53 percent), sold to others (14 percent) or dumped in locations such as garbage heaps (22 percent). Chicken rearing had been learned originally

Figure 10.1 Farm inputs and marketing pathways of chicken producers in Buziga parish, Kampala



from a friend or local farmer (39 percent), from a family member (17 percent), self-taught (25 percent) or from formal training (8 percent). Only a small proportion had been taught how to raise chickens in a rural area (14 percent), and 42 percent of households had received some form of training or upgraded their management skills by taking training courses, attending seminars or workshops since they began raising chickens.

With reference to food consumption in the two weeks preceding the survey, 80 percent of chicken rearing households had consumed cooked eggs and 62 percent had consumed chicken meat. Nine percent consumed raw eggs, primarily for therapeutic (67 percent) rather than for nutritional purposes (25 percent). One of these respondents said her child was too young to eat cooked eggs but not too young to consume raw eggs. In the same specified period, 74 percent of non-chicken rearing households consumed cooked eggs, 56 percent chicken meat and 16 percent raw eggs, again mainly for medical reasons. Non-chicken rearing households purchased eggs primarily from the local market (44 percent) and local farmers (16 percent) while chicken meat was also mainly bought from the local market (44 percent) and local farmers (38 percent). In general, chicken rearing households consumed leftover

eggs (cooked)(14 percent) and leftover cooked chicken meat (61 percent). Non-chicken rearing households tended to consume fewer leftover eggs (cooked) (5 percent) and more leftover cooked chicken meat (69 percent) than chicken rearing households. Beef and fish consumption in both types of households was high; 88 percent of chicken rearing and 90 percent of non-chicken rearing households consumed beef while 70 percent of chicken rearing and 90 percent of non-chicken rearing households ate fish. Goat and pork contributed to chicken rearing (16 and 15 percent respectively) and non-chicken rearing household (12 and 18 percent respectively) diets as well.

Regarding risk perception, almost half of chicken rearing (45 percent) and non-chicken rearing households (51 percent) were aware that chickens could transmit diseases or illnesses to humans. When asked if diseases acquired from chickens had a significant negative impact on household health, 25 percent of chicken rearing and 23 percent of non-chicken rearing households responded affirmatively, while 33 percent of chicken rearing and 30 percent of non-chicken rearing households were unsure if chickens had a significant impact on household health. Within chicken rearing households, 13 percent of respondents claimed that household members had at one time or another actually suffered from a disease or illness due to their involvement in raising chickens. Forty-three percent of chicken rearing households thought that illnesses such as flu or influenza were acquired from chickens; however, only 8 percent believed that they could experience diarrhea when exposed to chickens. Fewer chicken rearing (40 percent) and non-chicken rearing households (28 percent) were aware that humans could acquire diseases from eating chicken meat or eggs, with only 4 percent of chicken rearing households believing that humans can experience diarrhea after consuming chicken meat or egg products. 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".

Regarding health risk mitigation strategies, almost all households vaccinated their chickens (92 percent, Table 10.2). Some chicken rearers also wore protective clothing while handling chickens (29 percent) and almost all of these households removed it before entering their living quarters (98 percent). Household milk was predominantly boiled or pasteurized in both chicken rearing (80 percent) and non-chicken rearing households (81 percent). Household drinking water primarily came from municipal sources (taps) in 72 percent of chicken rearing and 76 percent of non-chicken rearing households. Boiling was the main method used to treat household drinking water in 95 percent of chicken rearing and 80 percent of non-chicken rearing households. Hands were "always" washed before preparing meals in 96 percent of chicken rearing households and in 84 percent of non-chicken rearing households. Another respondent said that her household does not share living quarters with chickens and they do not consume dead chickens or chickens undergoing treatment for disease in order to decrease the health risks associated with raising chickens.

In addition, one chicken rearing household stated, "We are only trying to learn about this (*health risks*) now and don't know exactly what to do unless you advise us." 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!"

Analytical Results

Results of the univariate analysis for chicken rearing households are presented in Table 3. Two food consumption variables, consumption of chicken and beef in the last 2 weeks, and six management practices and rural linkage variables were associated with enteric illness. Of these, only consumption of beef in the last two weeks was significant at $p < 0.05$.

Table 10.3 Potential risk factors associated with enteric illness in chicken rearing households of Kampala

Farming Household (HH) Characteristics	Proportion (%) of HH with characteristic that have enteric illness	Proportion (%) of HH without characteristic that have enteric illness	Relative Risk	95% CI	p-value
Food consumption					
Consumption of raw eggs in last 2 weeks	3/12 (25%)	26/126 (21%)	1.21	0.43-3.42	0.72
Consumption of cooked eggs in last 2 weeks	24/112 (21%)	6/28 (21%)	1.00	0.45-2.21	1.00
Consumption of chicken in last 2 weeks	15/85 (18%)	15/52 (29%)	0.61	0.33-1.15	0.13
Household consumes leftover cooked eggs	4/19 (21%)	25/118 (21%)	1.00	0.39-2.54	0.99
Household consumes leftover cooked chicken meat	18/85 (21%)	12/55 (22%)	0.97	0.51-1.85	0.93
Consumption of beef in the last 2 weeks	22/123 (18%)	8/16 (50%)	0.36	0.19-0.66	0.0034
Consumption of fish in the last 2 weeks	22/97 (23%)	8/41 (20%)	1.16	0.56-2.39	0.68
Consumption of pork in the last 2 weeks	3/21 (14%)	27/118 (23%)	0.62	0.21-1.87	0.38
Consumption of goat in the last 2 weeks	3/22 (14%)	27/117 (23%)	0.60	0.20-1.78	0.33
Management practices and Rural Linkages					
Sharing of living quarters with chickens	2/15 (13%)	13/127 (10%)	1.30	0.32-5.23	0.71
Remove clothing and footwear before entering living quarters	9/39 (23%)	17/85 (20%)	1.15	0.57-2.36	0.70
Wear protective clothing while handling chickens	5/40 (13%)	24/98 (24%)	0.51	0.21-1.24	0.12
Primary caretaker handles other household livestock	14/63 (22%)	16/76 (21%)	1.06	0.56-1.99	0.87
Household chickens interact with other livestock	7/22 (32%)	21/118 (18%)	1.79	0.87-3.69	0.13
Household chicken died in last 30 days	11/64 (17%)	19/77 (25%)	0.70	0.36-1.35	0.28
Primary caretaker learned to raise chickens in rural area	6/18 (33%)	21/114 (18%)	1.81	0.85-3.87	0.15
Parents of primary caretaker raised chickens	16/67 (24%)	12/65 (18%)	1.29	0.66-2.52	0.45
Parents of primary caretaker raised chickens in a rural area	10/52 (19%)	5/14 (36%)	0.54	0.22-1.32	0.19
Wealth					
Rich vs. Average income households	5/28 (18%)	21/72 (29%)	0.67	0.28-1.64	0.37
Poor vs. Rich income households	4/12 (33%)	5/28 (18%)	1.65	0.51-5.32	0.41
Poor vs. Average income households	4/12 (33%)	21/72 (29%)	1.11	0.45-2.80	0.83

Within chicken rearing households (Model 1, Table 10.4), raw egg consumption in the last two weeks preceding the survey (OR = 3.05, 95% CI = 0.96-10.18, $p = 0.029$) and household chickens interacting with other livestock (OR = 3.07, 95% CI = 1.06-10.44, $p = 0.019$) were significant risk factors associated with enteric illness in the household. The following factors were all significant and negatively related to household episodes of enteric illness: consumption of chicken (OR = 0.39, 95% CI = 0.14-1.06, $p = 0.054$), local chicken (OR = 0.32, 95% CI = 0.10-0.94, $p = 0.022$), or beef in the last two weeks (OR = 0.24, 95% CI = 0.06-0.96, $p = 0.022$), and households that prepared food primarily for one meal (OR = 0.39, 95% CI = 0.13-1.11, $p = 0.053$). The overall goodness of fit of this model determined by the Hosmer-Lemeshow statistic was good ($p = 0.20$).

Given the lack of difference in the prevalence of enteric illness among chicken rearing and non-chicken rearing households (Table 10.1), data were combined for common questions. Among both chicken rearing and non-chicken rearing households (Model 2, Table 10.4), raw egg consumption in the last two weeks preceding the survey (OR = 2.26, 95% CI = 0.85-6.050, $p = 0.061$) tended to be a risk factor associated with experiencing an episode of enteric illness. Household consumption of local chicken (OR = 0.42, 95% CI = 0.18-0.99, $p = 0.036$) and consumption of beef in the last two weeks (OR = 0.22, 95% CI = 0.07-0.65, $p < 0.01$) were significant and negatively related to the outcome of enteric illness. The overall goodness of fit of this model determined by the Hosmer-Lemeshow statistic was also good ($p = 0.92$).

Table 10.4 Final logistic regression models of risk factors associated with household episodes of enteric illness in chicken rearing households and in all households

Factors associated with enteric illness	Odds ratio	95% CI	p-value
Model 1: Chicken rearing households			
Chickens interact with other livestock	3.07	1.06-10.44	0.019
Consumption of raw eggs in last two weeks	3.05	0.96-10.18	0.029
Consumption of chicken in the last two weeks	0.39	0.14-1.06	0.054
Household consumes local chicken	0.32	0.10-0.94	0.022
Consumption of beef in last two weeks	0.24	0.06-0.96	0.022
Household food is primarily prepared for one meal	0.39	0.13-1.11	0.053
Model 2: Chicken rearing and non-chicken rearing households combined			
Consumption of raw eggs in last two weeks	2.26	0.85-6.05	0.061
Household consumes local chicken	0.42	0.18-0.99	0.036
Consumption of beef in last two weeks	0.22	0.07-0.65	0.0025

DISCUSSION

This study provided a unique opportunity to gain insight into local knowledge of zoonotic disease risks, to determine the prevalence of households experiencing enteric illness and to assess the risk factors for household enteric illness associated with urban chicken production practices. As highlighted above, an important principle of this study was to incorporate local people's knowledge into program planning and implementation (Mariner 2000). Local knowledge was primarily integrated through meetings with KCC local agents (LC II) and via focus group discussions that involved urban livestock farmers, researchers and city officials.

Discussions with local stakeholders enabled us to compile a survey that was culturally and contextually relevant to chicken production in Kampala. Although it was an initial concern, we did not face respondent fatigue in parishes where participatory urban appraisals were previously conducted; households were generally cooperative in joining focus group discussions and responding to questionnaires. Women in particular played a central role in the research process, consistent with their differentiated roles from men in urban livestock rearing (Kimani *et al.* 2007). They attended and contributed to focus group discussions and were the primary respondents in both chicken rearing and non-chicken rearing households. Women had an intimate knowledge of their animals and contributed valuable information about the farming systems in which they operated.

In contrast to an earlier study (Nasinyama 1996; Nasinyama *et al.* 2000), our findings did not indicate that commercial chicken production was a significant determinant of enteric illness. One explanation may lie in our focus on more commercial poultry households, which meant that chicken rearing households were predominantly 'rich' and average-income households. The neighbors of chicken rearing households were primarily classified as average-income earners as well. Hence these households would tend to have better health, with less vulnerability to enteric disease.

Further, many of the chicken rearing households had received some training, were aware of potential health risks associated with close contact with chickens (even before widespread awareness of "bird flu") and a substantial minority engaged in preventive practices to reduce their likelihood of infection. Nevertheless, households that allowed their chickens to interact with other livestock such as cattle, goats, pigs and turkeys or neighboring chickens, were more likely to experience episodes of enteric illness than those that did not allow for livestock interactions. It is quite possible that birds acquired diseases from other household or neighboring livestock via contaminated feed or water, and transmitted such diseases to their human counterparts (Oriss 1997). In spite of our inability to specify which livestock interactions accounted for household symptoms of enteric illness, keeping chickens separate from other livestock may reduce the risks associated with disease acquisition.

Food consumption behaviors were associated with episodes of enteric illness, particularly consumption of raw eggs during the two weeks preceding the survey, as in prior research (Nasinyama 1996; Nasinyama *et al.* 2000). Anecdotal information suggested that raw eggs are administered to children with respiratory health conditions and also used as a remedy for excessive alcohol consumption (treatment reasons). Given the difficulties in interpreting temporality with the cross-sectional study design, we remain uncertain as to whether consumption of raw eggs was primarily for treatment purposes including for enteric illness. Recall bias can also occur in cross-sectional surveys that rely on eliciting information on past occurrences. Although different recall periods have been used, a two-week recall period (used in this study) has been recommended as optimal to minimize errors of misclassification of both consumption food borne illness in household surveys (Ross & Vaughan 1986; Boerma *et al.* 1991; Nasinyama 1996; Nasinyama *et al.* 2000). In addition, *salmonella* and other enteric pathogens are known to be transmitted via raw eggs, hence the prudent food safety approach is to avoid raw egg consumption altogether.

We also found that households that prepared foods primarily for one meal and did not consume leftovers, were less likely to experience enteric illness. This finding likely reflects the difficulties in storing cooked food safely when refrigeration is not readily available and is consistent with previous research in Kampala (Nasinyama 1996; Nasinyama *et al.* 2000). Appropriate food storage facilities such as refrigeration units and closed containers are important barriers to pathogenic organisms and, where possible, should be considered in preventing episodes of enteric illness.

Household consumption of beef and local chicken in the last two weeks preceding the survey was protective for enteric illness in both logistic models. Consumption of chicken during the two weeks preceding the survey had a protective influence in chicken rearing households only. Nutrition, immunity and disease are intricately linked to one another (Chandra 1987). Nutritional status can have profound effects on immune functions and resistance to infections in humans. Nutrients can either enhance or depress immune function depending on the nutrient and level of its intake (Harbige 1996; Amati *et al.* 2003). For instance, it is well accepted that protein calorie malnutrition is strongly associated with impaired host immunity to infectious diseases (Harbige 1996; Chandra & Kumari 1994). A deficiency of zinc, an essential mineral found in beef and chicken meats, has also been shown to result in abnormal immune function and higher rates of infectious diseases (Hambidge 1992). Zinc-supplemented children, for example, have been found to have lower rates of diarrhea when compared to children that do not ingest zinc supplements (Black & Sazawal 2001; Bhan *et al.* 1996; Bhutta *et al.* 1999). Households consuming beef and chicken meat may have had better nutrition and hence increased immunity to food borne diseases. Further, local (free range) chickens might consume higher levels of zinc and other micronutrients from soils with these benefits being passed on to consumers.

For middle-income households, urban livestock keeping can be described as a response to growing urban demand and markets (Guendel & Richards 2002). Considering the complexity associated with examining household wealth within a regional and ethnic context, we recognized that household wealth could not be represented by a set of fixed quantifiable variables. The wealth ranking approach used in this study was developed from previous participatory urban appraisal exercises conducted by Urban Harvest in Kampala (David 2003). Based on local information pertaining to household assets, healthcare, and livestock enterprises, the wealth ranking criteria were not identical; in particular, the wealth ranking approach used in this study incorporated household information pertaining to food consumption, number of household occupants and presence of hired labor. Wealth ranking exercises conducted by Ossiya *et al.* (2002) resulted in similar categories of wealth among commercial farmers in Kampala. The overall strength of this methodology was its ability to incorporate local criteria for classifying wealth, and therefore adapting to local circumstances. An important limitation of this approach is that it has not yet been standardized as it pertains to examining wealth in developing countries (Adams *et al.* 1997).

It is a commonly held view among urban planners, city officials, citizens and researchers alike, that urban agriculture poses a serious health risk to humans (Atukunda & Maxwell 1996). The results of this study, however, showed that episodes of enteric illness were not significantly

more prevalent in chicken rearing households when compared to non-chicken rearing households living in Kampala. Our findings should contribute to curbing general fears of zoonotic disease acquisition as they relate to chicken production in Kampala and support policy makers' moves to sanction and inform urban agriculturalists (see Chapter 12).

Chicken rearing households not only demonstrated some preventive practices already, but expressed interest in further guidance on safe practices to both improve their production and maintain their health. Urban agriculture therefore challenges urban planners and administrators in developing countries to discover new approaches to city development since conventional western approaches appear increasingly incongruent with the socio-economic realities that ultimately overshadow zoonotic health concerns (Mlozi 1996). Chickens play an important role in incomes for producing families, generate social capital among neighbors and are important foods in the diets of urban families. Continuing epidemiological studies are therefore required to further determine which chicken rearing practices provide opportunities to reduce health risks and assist urban producers.

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CHAPTER 11

City dairying in Kampala: integrating benefits and harms

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INTRODUCTION AND CONTEXT

In developing countries, urban agriculture is not limited to growing of crops for food and sale or keeping of small stock such as poultry. Thousands to tens of thousands of cattle are kept in cities and peri-urban areas, sometimes for transport and meat but more often for milk. Poor but aspiring urban populations constitute a rapidly growing and relatively indiscriminating market for dairy products. On the supply side, readily available inputs, ability to transform the by-products of urban society and low transaction costs allow urban farmers to successfully compete with industrial producers and capture a considerable share of the lower-price milk market.

Urban dairies provide income, employment, nutritious food and valuable by-products; they also pollute soil and water, use scarce resources (water, feed) and generate biological, physical and chemical hazards, the more important of which are listed in Box 1 (Birley & Lock 2000; Campbell *et al.* 1999). While the environmental impacts of dairying are considerable and highly visible – one dairy cow, for example, produces 35 kg of semi-liquid feces per day, compared to 1.5 kg of dry feces from a goat and 100 g from a hen – it is typically the human health impacts that are of most concern to policy makers, often leading to attempts to suppress city dairies. But despite this concern, little empirical work has been done to determine the extent and impact of zoonotic and food borne diseases and other public health risks associated with livestock keeping in urban and peri-urban areas (Mougeot 1999; Lock & de Zeeuw 2001).

The magnitude and visibility of both benefits and harms make urban dairying a test case for exploring the trade-offs of urban agriculture. This chapter presents a case study from Kampala where a stakeholder assessment (described in Chapter 2) identified cattle as the second most common type of livestock kept (David *et al.* forthcoming). We briefly review the literature on dairying in Kampala, and then summarize the benefits of dairying as perceived by urban small holders and the risks derived from our analyses of milk safety. Conventionally, public health studies focus on the risks of informally produced food; we focus on the spontaneously practiced strategies that mitigate risk and introduce the concept of 'indigenous risk mitigation'. We argue that this could under-pin a bottom-up risk

management to replace or complement the existing ineffective top-down, command-and-control regulatory system. Finally we synthesize lessons from the case study on best-practice assessment of benefits and risks of dairying in developing country cities.

Box 11.1 Hazards which may be associated with dairying in developing countries

Hazards in manure

- Aesthetic: smell, attraction of flies, visual disturbance
- Chemicals: ammonia, nitrates, hydrogen sulfide, methane, carbon monoxide
- Xenobiotics¹: antimicrobials, pesticides, heavy metals
- Pathogens:
 - Virus: reoviruses, rotaviruses, enterovirus, caliciviruses
 - Bacteria: *Listeria monocytogenes*, *Escherichia coli* serotypes, *Salmonella* spp., *Campylobacter jejuni*, *Campylobacter coli*, *Aeromonas hydrophila*, *Yersinia enterocolitica*, *Vibrio* spp., *Leptospira* spp., *Clostridium perfringens*
 - Parasites: *Cryptosporidium parvum*, *Giardia lamblia*, *Fasciola* spp., *Taenia saginata*, *Trichostrongylus* spp., *Schistosoma* spp. and *Balantidium coli*

Hazards in milk

- Xenobiotics: antimicrobials, pesticides, hormones, mycotoxins, blue-green algae toxins, polychlorinated biphenyls, heavy metals, perchlorate, plant alkaloids and glucosinolates, chlorodibenzofurans
- Pathogens:
 - Virus: Foot and mouth disease virus, rabies virus, bovine leukemia virus
 - Bacteria: as above plus *Brucella* spp. *Staphylococcus aureus*, *Streptococcus* spp., *Coxiella burnetii*, *Mycobacterium* spp.
 - Parasite: *Cryptosporidium parvum*
- Allergens, lactose (for people with lactose intolerance)

Zoonotic diseases transmitted by direct contact, aerosol or other routes

- Anthrax, actinomycosis, babesiosis, Congo-Crimean fever, cowpox, dermatophilosis, echinococcosis, dermatomycosis, fascioliasis, foot and mouth disease, hydatidosis, leptospirosis, milkers nodes, new variant Creutzfeldt Jakob disease, nocardiosis, Q fever, rabies, rhinosporidiosis, Rift Valley fever, schistosomiasis, tetanus, trichostrongylosis, tuberculosis, vesicular stomatitis

Other hazards associated with cattle

- Robberies and cattle rustling
- Traffic accidents
- Injuries to people from aggressive/frightened animals
- Destruction of crops and gardens by cattle leading to conflict
- Creating an environment suitable for pests and disease vectors

BACKGROUND: DAIRYING IN KAMPALA

Interest in small-scale dairying in developing countries is a new phenomenon; industrialization and modernization were long seen as both desirable and inevitable (Schiere & den Dikken 2003) and Uganda is no exception. Since the 1980s, more than \$25 million was granted or loaned for large-scale dairy development (Okwenye 1994), but despite these investments, all major milk-processing plants in the country are operating much below their capacities (overall only 23 percent of capacity is met) while the biggest plants are suffering losses (Aliguma & Nyoro 2004). Under-utilization of capacity keeps operating overheads high

¹ Substances not normally present in the reference organism

in relation to output, resulting in increased milk prices and, as a result, nearly all is purchased by well-off (and over-supplied) urban consumers.

But as industrial development failed to take off, a quiet revolution has been taking place in city and country. Seven hundred thousand smallholder farmers selling raw milk through informal channels have now captured 90 percent of the milk market (DDA 2006). Marketing chains vary from single intermediaries sourcing directly from farmers and selling to consumers to complex channels involving some processing and an organized system of milk vendors (Dannson *et al.* 2004). And while pasteurized milk is sold to a restricted clientele of shoppers in large supermarkets (just three in Kampala), local stores and petrol stations, raw milk is sold by many thousands of small shops, kiosks, ambulant vendors and hotels (for consumption on the premises). In a market driven by price rather than quality, informal sector traders offer better prices to farmers and in turn lower prices to consumers, making them more competitive than the formal sector.

Dairying as an urban phenomenon first came to attention during the civil unrest of the 1970s and 1980s when urban wages declined precipitously in the face of social breakdown and explosive inflation (Maxwell & Zziwa 1993). The availability of urban and rural land allowed urban households to survive by retreating into subsistence, with an estimated 90 percent of Uganda's population involved in subsistence cultivation and urban farming becoming a persistent feature of the capital's landscape (Amis 1992). Cattle keeping has increased in Kampala since the 1970s. Official figures of 6500 cattle in Kampala District in 2002 are thought to be too low by a factor of 12: other sources estimating 74 000 in 2001 (Muwanga 2001; Nasinyama *et al.* 2008). About 25 percent of urban households and between 38 up to 90 percent of peri-urban households in Kampala are involved in farming, and from 8 to 39 percent of these keep cattle (David *et al.* forthcoming).

Farms typically keep two to five cattle and zero-grazing (cut-and-carry) is common, with cattle confined in stables and brought fodder crops, household waste and concentrates. Tethering, grazing derelict land and verges and, to a lesser extent, keeping cattle in fenced enclosures, are also practiced. The majority of dairy cows are improved breed² and give around 10-15 liters of milk per day. Milking is by hand, and is carried out twice a day; sometimes the calf is allowed to suckle for a few minutes to encourage milk let-down. Cattle keeping is profitable; one study reported annual sales of \$1614 per cow for zero-grazed cattle (Tumutegereze 1997), another reported a cow in a zero-grazing enterprise produced \$1327 worth of milk sales (CNRIT 1999) which, after the costs of production are deducted, generated an income of \$495; in contrast a study in peri-urban dairies showed total farm profits (1-3 cows) were only \$52 (Fonteh *et al.* 2005).

Major constraints reported by farmers include cattle disease, theft, disposal of manure and high cost of inputs (Atukunda *et al.* 2003; Mwiine 2005). On the other hand, constraints noted by external analysts include predominance of middlemen resulting in adulteration and spoiling of milk, asymmetries of information leading to over-priced inputs and under-priced outputs, a weak formal sector, lack of credit and delayed payments to farmers (Dannson

² This value-laden term is commonly used for exotic cattle originating in Europe and bred for high milk production, but often lacking resistance to African diseases and tolerance of African environmental conditions. It will be used for the sake of clarity.

et al. 2004). The constraints of a disabling policy environment currently faced by the Ugandan and African smallholder sector have interesting parallels in the history of dairy development in America and Europe (see Box 11.2).

Box 11.2 The struggle continues: lessons from the dairy development history

Milk is a culturally loaded commodity and its symbolic value as wholesome goodness and purity made it a favored organizing tool for social reformers. In America, urban dairying grew rapidly after the 1850s when breast-feeding fell out of favor for cultural reasons (Du Puis 2002). Cattle were kept in unhygienic and over-crowded “swill dairies” and fed on hot brewers wastes straight from the still. Temperance leagues joined with physicians to campaign against these filthy conditions and resultant “white poison,” and call for “pure country milk” (Shaftel 1978). Consolidation and concentration of dairies was actively encouraged by (an otherwise non-interventionist) government. As Roosevelt’s director of public health said in regard to the dairy sector “One of the real sources of trouble in the milk industry is that the great bulk of the milk comes from the small farm.... It is evidently much easier to control, educate, and regulate a few large contractors than hundreds of small independent dealers” (Rosenau 1912). Farmers both questioned the effectiveness of new technologies being imposed and stressed that the expense of implementing them would drive small local producers out of business and thus raise the price of milk beyond what working class families could afford (Koslow 2004), but ultimately lost the battle. The last century has seen a steady exodus from family farming and increasing dominance of industrial producers; dairies with more than 500 cattle now produce nearly half the milk in America, and less than 1 percent of the population are farmers.

OBJECTIVES, APPROACH AND METHODS OF THE CASE STUDY

Researchers from Makerere University and the International Livestock Research Institute (ILRI) designed and implemented the study. Its objective was to assess both qualitatively and quantitatively the benefits to urban livestock-keepers’ livelihoods and associated risks to their health and public health more generally to show how evidence-based decisions on appropriate policy and action for these activities can be made. The approach is of an information-rich case, combining participatory and conventional surveys, that manifests the phenomenon of city dairying intensely but not extremely³ (Patton 1990).

An innovative and important part of our urban dairy case study was the risk-based approach to investigating hazards of dairying. A major challenge to food safety epidemiologists in developing countries is selecting from the universe of hazards (see Box 1 above), those that are of most importance to the health of communities. Selection of the four hazards for biological testing was based on public health importance as well as anecdotal information. This choice, though to some extent informed by existing knowledge, may have led to biases given the incomplete knowledge of the importance of hazards in developing countries. The four hazards selected were:

- *Brucella abortus* in milk, the cause of undulant fever, a serious disease with a wide variety of symptoms which may include fever, neuro-psychiatric problems and testicular pain.
- Total bacteria and total coliforms present in milk, a rough indicator of milk hygiene and cow health

³ This sampling strategy “permits logical generalization and maximum application of information to other cases because if it’s true of this one case it’s likely to be true of all other [similar] cases” (Patton 1990)

- *E.coli* O157:H7, a cause of gastro-intestinal disease and, less frequently, serious kidney disease and blood disorders
- Antimicrobial residues in milk, which may disrupt the normal gut bacterial flora which acts as a barrier against infection and rarely cause allergic reactions in susceptible people⁴.

As described in the previous chapter, ten of Kampala's 98 Parishes were purposively chosen for the study, presenting a range of urban and peri-urban parishes using Kampala City Council's classification system. Livestock-keeping households were selected from a list drawn up in each parish or identified by local partners. The selection of households was non-probabilistic, since comprehensive sampling frames were not available and some leader-based or self-selection occurred (with resultant implications of decreased generalizability beyond the sample). Using different sources to identify farmers increased sample comprehensiveness. Participatory Urban Appraisals (PUA) with, on average, seven participants were carried out using a checklist in each of the ten parishes. Next, questionnaire-guided interviews were conducted in 150 cattle-keeping households and 50 neighboring households without livestock, with the livestock manager (cattle-keeper) and household head respectively. Questions covered education, income and awareness of policy related to urban dairying. For cattle-keepers questions on husbandry and hygiene practices as well as production and health were included; the age, sex and breed details on 713 animals, of which 357 were adult cows, were reported.

We collected 165 milk samples and 245 serum samples from the 150 cattle-keeping households. Blood was tested for *B. abortus* antibodies using the serum agglutination test (SAT) and milk was tested for *B. abortus* antibody using the milk ring test (MRT) (Morgan *et al.* 1978). In addition, milk was cultured in a medium which permits growth of bacteria and total bacterial counts and total coliform counts were estimated using petrifilms (3M Petrifilm™) and positive samples tested for specific 'O157' and 'H7' antibodies (Denka Seiken Co. Ltd, USA). Milk was tested for common antimicrobial residues by the Charm Farm-960 and Charm Rosa Test (Charm Sciences Inc., USA) according to manufacturer's recommendations.

We investigated risk management by constructing a 'stable to table' pathway model starting at the cow and ending with the consumer. For each step we identified practices that were likely to mitigate risk. Next a linear regression model was developed to predict the number of different strategies practiced, using variables from the questionnaire with theoretical or empirical bases for inclusion. Some households could not be included as too many data were missing, so the final sample size was 121 of the original 150 households. Robust standard errors were used to account for clustering of respondents by parish. A checklist (Ryan 1996) was used to ensure the assumptions of linear regression were met; diagnostic tests conducted did not reveal problems that would invalidate the model.

⁴ There is reasonable evidence to suggest that use of antimicrobials in farm animals may contribute to the development of antimicrobial resistance in pathogens affecting humans, although scientists generally agree that the problem is largely due to misuse of drugs used to treat humans. On the other hand, there is very little evidence of actual harm from ingestion of veterinary antibiotic residues, and it has been argued that levels found in animal products are unlikely to cause ill effects (Gomes & Demoly 2005).

BENEFITS OF CATTLE-KEEPING

The focus group discussions showed that agriculture was the main occupation for most cattle keepers (64 percent) and over a third of participants claimed cattle keeping was their principal occupation, suggesting that dairying is a specialized occupation. This is consistent with other studies of urban farming in neighboring Kenya (Kang'ethe *et al.* 2007 a & b), which find livestock keepers are more likely to farm for commercial reasons than those growing crops, and that cattle keepers are the most commercially minded. Only 13 percent of the questionnaire respondents (hereafter referred to as respondents) were formally employed; employment generation was considered an important subsidiary benefit of urban dairying.

The PUA found milk was by far the most important benefit of dairying, with manure, cattle sales and employment playing subsidiary roles (see Table 11.1). However, cattle contributed less than a quarter of household income for half the respondents, while only 15 percent obtained more than half their income from dairying. Again, this is consistent with other studies of urban farming (Prain *et al.* forthcoming), indicating a diversified portfolio of livelihood strategies. Farmers also cited benefits from household consumption of milk production. Milk and dairy products are important sources of protein and micro-nutrients, some of which are found only in animal products, and this is an important health benefit (see Chapter 6). Milk consumption in Uganda has doubled in the last decade to around 30 liters (or kilograms) per capita annually (40 liters in urban areas), but is still far below the levels internationally recommended (e.g. FAO recommends 200 kg and the US Department of Health recommends 248 kg per year, USDH 2005).

Table 11.1 Benefits accruing from cattle production in ten urban and peri-urban parishes in Kampala using proportional piling

Parish	Type of parish	Mean proportion of specific benefits associated with cattle production			
		Milk sold/ consumed	Manure sold/ used in own fields	Employment	Cattle and calves sold
Bukesa	Urban	.....	..	...	.....
		10 (9-13)	2 (2-5)	3 (2-5)	5 (1-4)
Kamwokya	Urban	.....	.	...	.....
		10 (8-16)	1 (0-3)	3 (2-5)	6 (1-8)
Ggaba	Urban transition	.....	....	...	..
		11 (9-13)	4 (2-5)	3 (2-3)	2 (1-4)
Banda	Urban transition	.....	...	...	...
		12 (9-13)	3 (2-5)	2 (2-4)	3 (2-4)
Bukasa	Urban transition	.....	...	...	.....
		11 (9-13)	3 (2-5)	3 (2-3)	3 (1-4)
Bukoto	Urban transition	.....	.	...	...
		13 (10-16)	1 (0-3)	3 (2-5)	3 (1-7)
Buziga	Peri-urban transition	.....	..	.	..
		15 (12-20)	2 (0-3)	1 (0-3)	2 (1-4)
Kyanja	Peri-urban	.....	...	...	..
		12 (9-13)	3 (2-5)	3 (2-4)	2 (1-4)
Mpererwe	Peri-urban	.....	...	...	.....
		12 (5-17)	3 (0-6)	0 (0)	5 (0-12)
Komamboga	Peri-urban	.....	.....	.	.
		9 (0-12)	9 (5-13)	1 (0-6)	1 (0-3)
Total score		115	31	22	32

Note: The numbers show the mean (and range) of five cattle-keeping farmers per Parish distributing 20 beans to represent the total household income.

The importance of milk is not surprising given the urban context, but contrasts sharply with the situation in agro-pastoral farming systems which predominate in Africa and much of Asia. In those systems, traction and manure are the dominant reasons for cattle keeping (Sere & Steinfeld 1996). In urban farming, like intensive farming of industrialized economies, manure is often regarded as a problem rather than a product. Dutch farmers, for example, pay up to \$30 a ton to dispose of manure, and European countries now have legislation strictly limiting the amount of animal manure that can be applied to land (Oenema 2004). In contrast, developing countries typically suffer from a scarcity of organic fertilizer and manure is regarded as a valuable output rather than a problem. Indeed, a study among agro-pastoralists in West Africa found that manure was ranked above milk in terms of benefits provided by cattle (Grace 2005). It would appear that urban dairy farms in Kampala are sufficiently small and dispersed that manure is a source of profit rather than cost.

The household sample survey showed there were on average four cattle per household, 73 percent of them of the improved, high-yielding type. This proportion, higher than official estimates of 50 percent, is again supported by other studies (Ossiya *et al.* 2003; Fonteh *et al.* 2005; Staal & Kaguongo 2003); cattle represent a considerable embodied value given that the price of an improved dairy cow in Uganda is as much as USD \$500-1000. The official under-estimation both of the number and productive potential of city cows leads to similar under-estimation of their importance to livelihoods and local economies and consequently deficiencies in institutional support (credit, health delivery, input supply and distribution) and technical advisory services. It is also easier to take action against an activity if it is perceived as minor and affecting very few people; until recently, the keeping of cattle in Kampala was illegal, although in practice action was rarely taken.

Farmers reported an average milk yield of 10 liters per cow per day, considerably more than the 1-2 liters per day produced by indigenous African cattle (Agyemang *et al.* 1987), but considerably less than the 25 liters average daily production in industrial farms in, for example, Great Britain (MDC 2006). This production short-fall is partly genetic (the cross-bred cows used in Kampala have lower potential than pure dairy breeds found in the UK) and partly environmental (heat stress and endemic diseases of tropical countries lower output) but the fact that farmers in this study obtained lower yields than reported from agricultural stations and from neighboring Kenya suggests that farmers are choosing to produce at less than maximum levels (Staal & Kaguongo 2003). High production increases input costs and places metabolic stress on the cow, increasing susceptibility to disease; as such it may be a rational management strategy. Lameness, mastitis, retained placenta, milk fever, displaced internal organs and keto-acidosis have all been conclusively linked to high production in dairy cows; for western cattle, like western humans, the main diseases are now 'life-style' rather than infections (Le Blanc *et al.* 2006). Faced with higher health risks, as well as input costs and given the easily-saturated Ugandan milk market, farmers' decisions not to maximize production seem both rational and conducive to dairy cow welfare.

In countries with poorly performing financial markets, livestock act as savings, insurance and collateral, allowing consumption smoothing and decreased household risk. Farmers

recognized the sale of cattle and calves as a major benefit, but unlike in commercial farming where animals are sold at fixed intervals dictated by the production cycle (reflected in dedicated markets for day-old calves, in-calf heifers, cull cows etc.), farmers in this study typically accumulated cattle and then sold them to meet planned or unplanned household needs. Examples of the former are school fees and bride-price payments, while examples of the latter are sickness and funerals.

HEALTH RISKS ASSOCIATED WITH URBAN DAIRYING

Perceived health risks associated with urban cattle production in Kampala were assessed using proportional piling (a participatory appraisal technique) in the focus groups. Zoonoses or infectious diseases transmissible from cattle either directly or via milk, specifically tuberculosis and brucellosis, were ranked highest, followed by accidents caused by cattle roaming in the city.

When milk samples from the surveyed households were tested using the milk ring test (MRT), 44 percent of the households had milk containing antibodies to *B. abortus*. Individual cow prevalence based on the serum agglutination test (SAT) was 42 percent. These tests are often regarded as preliminary and indicate that a cow has been exposed to *brucella* by infection or vaccination and its immune system has mounted an attack, rather than confirming that the milk contains *brucella* organisms, per se. For example, using an enzyme linked sorbent immunoassay (ELISA), Kang'ethe *et al.* (2007a) found *brucella* antibodies in only about 1 percent of Nairobi milk samples, from dairy and non-dairy households. Another type of brucellosis, *B. melitensis*, a known and serious zoonosis of small ruminants and emerging cattle disease (CDC 1997), was not investigated in this study.

Brucellosis is certainly a problem for people in Kampala; a study among hospital patients with chronic fever found 13 percent had antibodies to *B. abortus* and 26 percent antibodies to *B. melitensis* (Natala 2003). Eight previous studies from Uganda report cattle *brucella* prevalences ranging from 3 to 33 percent with most results towards the lower end; comparing our results suggests brucellosis might be more prevalent in urban dairying. However, a pan-African review of brucellosis in cattle found no relation between farming system and prevalence (Mangen *et al.* 2002).

Depending on the parish, from 0 to 33 percent of milk samples had unacceptably high levels of bacterial contamination of milk (as defined by the East African community standards) while from 0 to 23 percent had unacceptably high levels of coliforms. Total bacterial counts are an imprecise measure of poor milk hygiene as counts may be high because of mastitis (inflammation of the udder) or other factors. One study in Uganda found that nearly half the cows had sub-clinical mastitis, suggesting that this might be a more important source than poor hygiene (Muhumza 2001). Interestingly, the bacterial loads of smallholder milk compare well with those of milk in the formal sector in Uganda where a study found from 27 to 77 percent of packaged, pasteurized milk had unacceptably high bacterial counts (Lukwago 1999). Poor microbiological quality of pasteurized milk was also reported by studies in neighboring Kenya (Omore *et al.* 2005).

Of the 165 samples examined for *E. coli* O157:H7, 18 out of 69 isolates were suspect when cultured on specialized growth medium, but only two were serologically confirmed as positive (1.8 percent). Such low prevalence is similar to that found among Nairobi milk samples from urban dairying and non-dairying households (2.2 percent, Kang'ethe *et al.* 2007b). Despite under-developed surveillance systems in Africa, there are many reports of *E. coli* O157:H7 (Raji *et al.* 2006). Cattle are the major reservoir of *E. coli* O157:H7, e.g. 5.2 percent of pooled cattle fecal samples among Nairobi urban cattle (Kang'ethe *et al.* 2007b). Infection is via oral ingestion of pathogens from cattle feces that contaminate food, water or environment, while person to person transmission can be important in institutional settings. The levels of infection in cattle milk found in this study are similar to those of initial studies in the North but later investigations there suggested prevalences ten times as high, so further investigation is warranted.

A total of 165 milk samples were screened for the presence of some broad-spectrum antimicrobials in milk and 14 percent tested positive for residues above the recommended maximum residue limits. Milk samples that tested positive for residues on screening were tested specifically for beta-lactam drugs (popular antibiotics related to penicillin) at levels above maximum residual limits and 13 percent were positive. Antibiotic use is higher in industrial dairies in the North because intra-mammary antibiotic treatments are given routinely, whereas in smallholder systems antibiotics are only used if infection is suspected.

The presence of hazards does not always imply harm to human health. Of the two pathogens present, *E. coli* O157:H7 was found at low levels in cattle milk, and though *Brucella abortus* was not detected directly, the high level of antibodies suggest this disease may be common in the cattle population. Both pathogens have multiple potential exposure pathways (ways of getting from animals to humans) including food, water, environment, cattle to person and, for *E. coli*, person to person. Milk is a major route of transmission for brucellosis and a minor route for *E. coli* O157:H7. 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. As with brucellosis, consumer practices (93 percent boil their milk) have a major role in decreasing the risk of adverse effects: boiling is completely effective at eliminating *E. coli* and partially effective at eliminating antibiotic residues (see risk mitigation below).

For urban agriculture policy makers it is necessary to distinguish between the negative externalities associated with the product and those associated with the place of production. Some dangers to human health in milk are present no matter where it originates, others are more frequent in milk from rural areas, and still others more frequent in milk from urban dairies. For example, tuberculosis is considered a disease of confinement while leptospirosis is more associated with extensive farming. Because this study focused only on urban dairies, it was not possible to answer the question empirically as to how much harm is associated with urban as opposed to generic dairying, but review of the literature would suggest that, in Uganda, health externalities are not especially associated with city dairies: among the

hazards examined in the present case study, brucellosis is thought to be more prevalent in extensive African farming systems than urban areas (Mangen *et al.* 2002). Risk factors for *E.coli*O157:H7 in cattle include age, breed, season, housing, herd management and feeding, but there is no information on their relevance in the East African context which would allow us to judge whether city or rural farms are more affected. Some studies have shown that antibiotic residues are higher in milk coming from rural dairies (Omore *et al.* 2005). Hence, for the hazards examined, there is no evidence yet to suggest that they present relatively greater risk in urban versus rural settings.

INDIGENOUS RISK MITIGATION STRATEGIES

Having identified possible hazards in milk, the case study went on to examine how production, marketing and handling factors affected milk safety and how risk might be better managed. Risk management, the key to moving from a zero-sum mentality to one where win-win situations are the mutually agreed objective, is most highly developed in, and for, situations that are linear and hierarchically organized, as in a meat processing plant, for example. This case study offers an analysis of risk mitigation strategies in the urban smallholder sector where production and informal marketing systems are non-linear, shifting, probabilistic and self-organized. By highlighting the spontaneous achievements of farmers and consumers, it opens the door to new approaches to managing health risks of urban dairies, based on empowering stakeholders to assure the safety and wholesomeness of the food they produce or buy.

We analyzed the extensive information on the practices of dairy farmers and consumers obtained during the study from a risk assessment perspective, first developing a pathway model describing the movement of milk from the cow to the consumer. This had six critical control points where interventions may prevent or eliminate a food safety hazard or reduce it to an acceptable level (FAO & 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 per farmer found on the pathway from stable to table showed a rich variety of farmer and consumer risk management strategies already in use, as shown in Figure 11.1

Figure 11.1 Practice of risk mitigation strategies for decreasing hazards associated with milk by actors in Kampala at different Critical Control Points along the stable to table pathway

Hazard Transmission		Risk mitigation strategies currently practiced (%)			
	Ecosystem to cow	Keep only one species	29%	Treat cattle often	31%
		Zero-graze	38	Don't keep calves	39
		Use own land only for feed	41	Use Artificial insemination	44
		Avoid common grazing	56	Vaccinate against brucellosis	1
		Keep local breeds	27		
	Milk shed to cow	Use feed/water trough	94	Stack manure	11
		Have concrete/stone floor	96	Have a waste disposal strategy	96
		Use bedding	41		
	Milk shed / dairy to milk	Have washable shed wall	100	Use just metal/ glass vessels	19
		Have metal/tin roof	96	Use piped water	75
		Store containers off floor	29	Keep premises clean	51
		Keep milk bar dry	45	Depose waste >5m away	38
	Milk handler to milk	Use hot water to clean	18	Have no discharges/ wounds	97
		Use soap to clean	81	Have clean hands	79
		Wear protective clothing	1	Have clean/short nails	81
		Wash hands with soap before handling milk	59	Access to latrine	98
				Good personal hygiene	49
	Transport to milk	Don't drink unsold milk	10	Don't sell/store unsold milk	90
				Sell milk quickly (=6 hrs)	82
	Milk to consumer	Treat milk	50	Don't consume milk until withdrawal period passed	64
		Avoid drinking raw milk	93		
		Check milk quality by smell/taste	48		

Most were used at the milk processing premises (five strategies), followed by the milk handler (three strategies) and cow shed (three strategies). Some strategies used are completely effective, such as boiling milk for managing risk from *B. abortus* or observing milk withdrawal for managing risk from antibiotic residues, while others reduce but do not eliminate specific risks, such as the effect on coliform bacteria of selling milk within six hours of milking.

Some limitations of our study are that we did not check on application of some other risk mitigation strategies identified in developing countries, such as disinfection of the cowshed, teat dipping, tail-hair trimming, feeding calves colostrum, using calf pens to reduce calf-to-calf contact, exposing dairy vessels to sunlight, composting manure, wearing gloves or protective clothing while handling manure, washing hands after contact with animals etc. (FAO 1990). These could usefully be investigated in future studies. Further, we lacked information on the motivation or cultural context for risk mitigating practices, some of which may be carried out for other reasons than milk safety. For example, cows may be kept permanently in stables because of their high value or land scarcity rather than to decrease their exposure to pathogens, and milk might be boiled because it is consumed in tea

(customarily prepared by boiling milk, tea and water together), rather than to destroy bacteria. Socio-cultural and anthropological information could provide insight on the stability of practices and on how they can be built on, informed and improved to sustain and enhance their risk mitigating effect, while public health messages could be tailored to local understandings.

Table 11.2 Factors associated with the number of household risk mitigation strategies used

Factors	Descriptive statistics	Coef.	Robust se	p	95% Conf. Interval	
Farmers believe UA is legal	54 farmers	2.169	0.802	0.024	0.355	3.983
Number of household appliances	mean 2.08	2.429	0.649	0.005	0.960	3.897
Productivity orientation (l milk/herd size)	mean 1.78	0.702	0.225	0.012	0.194	1.210
Farmers have experienced harassment over UA	4 farmers	-3.693	1.818	0.073	-7.806	0.420
Farmers consider disease the major constraint	84 farmers	-1.604	0.736	0.057	-3.269	0.062
Access to electricity and water	86 farmers	2.602	0.581	0.002	1.287	3.916
Constant		12.356	1.081	0.000	9.910	14.802
Number of clusters	10	R squared=0.335				
Number of observations	121					

The regression model demonstrated that access to services, belief that urban farming was legal, wealth and productivity orientation were associated with higher use of mitigation strategies, while those reporting cattle disease incidence were associated with lower use of mitigation strategies. The model explained 34 percent of the variation in the dependent variable (number of risk mitigation strategies used by farmers).

Access to services (water and electricity) makes the use of hygiene related mitigation measures easier. Cleaning the cow shed and the milk processing area as well as washing hands and utensils are facilitated by the availability of running water. Electricity may be directly used in processing and selling, but good lighting also makes cleanliness or its absence easier to inspect.

Many of the risk mitigation strategies used require information, effort and time as well as money, and farmers invest in disease mitigation when they feel more secure through believing their activities are recognized as legal. Another finding (significant at $p < 10\%$) was that farmers who had been harassed by officials used fewer risk mitigation strategies.

Wealth, as measured by a proxy index of possession of household appliances such as televisions and phones, had a highly significant relation with the use of mitigation strategies. The capacity to invest in resources such as soap, electricity, water, vaccines and so on is increased by wealth, which may also be associated with higher education, another factor usually positively linked to hygienic practices. Wealthier people may also be influenced by their community status to adopt some practices while poorer farmers, with less 'face' to lose, may be more inclined to cut corners on hygiene, suggesting special supports may be needed for lower-income producers.

Productivity orientation was measured by the proxy of liters of milk divided by number of cattle. Farmers producing more milk from fewer cows – representing more intensive systems – were linked with greater use of mitigation strategies. This is probably both because the farmers tend to be more professional and because there is greater need for mitigation, intensively kept animals being more vulnerable to disease.

Although it may seem paradoxical that farmers reporting cattle disease as their major constraint were less likely to use mitigation strategies (significant only at $p < 10\%$), it is possible that those with less capability to invest in risk mitigation may take a more fatalistic or defeatist attitude. This is consistent with our findings presented in Chapter 2, that some farmers who perceive risks may be powerless to implement mitigation strategies due to their poverty.

The practical conclusion we drew from the model was that providing infrastructure and legitimization of 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 and so reduce the risk from consumption of their products. Adoption of risk mitigation varied from farm to farm, suggesting a role for farmer-to-farmer extension in improving milk safety (Plates 14 and 15).

GENERAL DISCUSSION AND CONCLUSIONS

For Kampala stakeholders, our study shows the many significant contributions of smallholder dairying to income generation, household nutrition, employment generation and soil fertility. The findings also confirm the presence of hazards that harm human health. Importantly, it identifies the practices of actors along the milk value chain that reduce risk. A finding of profound implication for policy is that banning urban dairying may decrease milk safety through reducing risk mitigation practices. This paradoxical effect of food safety legislation was also found in a Brazilian study of the meat sector: the rationale being that illegality chills investment, blocks access to information on, and reduces social incentives to follow, good practices (Azevedo & Bankuti 2002).

For the wider audience of urban agriculture, veterinary and public health stakeholders, our study offers additional insights. Public health studies typically focus on health problems and their resolution. Our dual approach of assessing benefits as well as harms, and looking at what people are doing right as well as wrong, captures more of the system under study as well as being more farmer friendly. The following concepts that could radically enlighten the management of food safety in poor countries also emerge from our case study:

1. **Risk based resource allocation.** Resource allocation should be based on risk, meaning the probability of adverse consequences and their severity. This departs from current non-evidence based management (e.g. the regulation in Tanzania which permits the keeping of four cows but not of five). Similarly, it is better to tackle first the problems that cause most harm when resources are scarce. This requires identifying all hazards present and indicating their relative importance. Out of the 160 or so biological and many thousand chemical hazards potentially present in milk, our study looked at only two and one respectively. We have no way of knowing if these three are among the most important hazards in Kampala, although they were identified as such by stakeholders. Worldwide, E.

coli O157:H7 is considered among the 50 most important infectious diseases (WHO 2002) but there are many, more important, diseases that we did not assess. Globally, brucellosis is considered of less importance than *E.coli* although of significance in the communities in question, while the contribution of antibiotic residues to the global health burden is probably negligible.

2. **Risk tolerance.** It is hard for decision-makers and the public to accept that “Zero risk does not exist.” There are almost no substances that are always dangerous or always safe. Some exposure to hazards is inevitable, the question being to establish the acceptable or appropriate level of risk. Obviously, this requires taking into account the benefits of UA as well as the harms, and the cost, equity and feasibility of mitigating risks. Setting appropriate levels of protection is a societal decision and should take into account social, economic and other issues of concern, including governments’ obligation to protect their citizens’ Right to Food as mentioned in Chapters 1 and 4 above. Different communities may choose different levels, and levels can change over time (Perry *et al.* 2005).
3. **Risk is multi-source and all sources need to be considered.** For example, halving the cases of salmonellosis from wastewater irrigation will have little impact if 99 percent of cases are transmitted through contaminated food (Bartram *et al.* 2001). Brucellosis is an occupational disease as well as milk borne, *E.coli* O157:H7 may be transmitted via meat, water or even from human carriers while antibiotic residues are present in all animal products. We did not consider the importance of sources other than milk, although without this it is harder for policy makers to decide what should be done about hazards in milk. Literature would suggest that milk is a major route for brucellosis but probably minor for *E.coli* O157:H7.
4. **The risk pathway.** Hazards have an origin and may increase, decrease, and move before entering people. Our study mapped hazard pathways and identified critical control points where action can be taken to reduce hazards. This aids understanding of the many routes to risk reduction goals; it has been found most useful to specify the goal and leave the way of attaining it to stakeholders using various combinations of locally possible risk management options (WHO 2006). Although we mapped pathways, we did not measure changes in hazards along the pathway, a useful subject for further research.
5. **Incrementalism.** Standards, rules and norms developed in rich countries have probably hindered rather than helped poor countries to improve food safety when applied in their contexts. Instead of imposing standards that cannot be complied with, policy makers might look for attainable, cumulative improvements based on the local situation. Every degree of risk reduction saves lives; where the optimal technologies cannot (yet) be adopted it is still useful to make gradual changes that work towards higher standards. Our focus on indigenous mitigation strategies shows the benefits attainable by encouraging good practices already present.

Our case study suggests that risk principles can be usefully applied to food safety problems in developing countries and that cultivating a participatory, evidence-based process will improve understanding and management of both benefits and harms associated with

urban livestock. In the case of Kampala, the study results appear to have achieved this more nuanced objective by figuring among the body of evidence that helped influence the revision of the Kampala municipal by-laws concerning urban agriculture, including livestock activities, as described in Chapter 12 below.

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Managing urban livestock for health

Editors' Commentary

WHAT DO WE KNOW?

While incomplete as a risk assessment, our study indicates risk principles can be applied to food safety problems in poor countries and that participatory, evidence-based processes will improve understanding and management of benefits and harms associated with urban livestock.

We know that around 22 percent of all households in Kampala kept livestock in 2003 and that livestock-keepers operated on a more commercial basis than crop-growers in the city (David *et al.* forthcoming). These data are consistent with findings in another East African town, Nakuru in Kenya, where it was also found that livestock keepers were more likely to be among the better-off. This confirmed earlier observations by Guendel & Richards (2002) and was particularly so for those keeping large livestock, mainly cattle (Foeken 2006; Kang'ethe *et al.* forthcoming). It is clear that urban chicken rearing and dairying provide important economic returns to participating households. Further, section B showed that animal foods consumption has nutritional benefits.

Urban milk consumers and farmers keeping dairy cattle use a range of practices that mitigate risks of zoonotic disease transmission. The commonest mitigation strategy is the practice of boiling milk consumed in the household, particularly for use in tea. While it is not clear that people are aware of this practice as a health risk mitigation strategy, it nevertheless provides considerable protection. Further, greater access to services, belief that urban farming was legal, and a productivity orientation were associated with higher use of mitigation strategies, while those reporting cattle disease were associated with lower use of mitigation strategies. Possibly those with less capability to invest in risk mitigation take a more fatalistic attitude, consistent with related observations that some farmers who perceive risks may be powerless to implement mitigation strategies due to poverty (Chapter 2, above). There were gaps in consumers' and farmers' knowledge about disease risks from consumption of chicken meat and eggs. While many chicken farmers were taking some important mitigation actions such as immunization of chickens, they were not taking others, such as using protective clothes or equipment.

Women and men play different roles in livestock systems. It was predominantly women who were rearing chickens, engaging in their care and distributing their products. In other studies from the region (Ishani *et al.* 2002; Kimani *et al.* 2007; Kang'ethe *et al.* forthcoming) it has been identified that women and men's perceptions of their roles and activities in dairying differ, with men underestimating women's contributions. In these studies in Kampala, women had less knowledge of health risks (with the exception of recognizing brucellosis infection due to their hands-on experience managing the cattle) than men, while women chicken-rearers wanted more information on ways to care for their chickens.

WHAT CAN BE DONE?

General Principles

Providing infrastructure and legitimizing urban agriculture including livestock keeping are important policy principles, given central and local governments' obligations under the Rights to Food and Health and the income and nutritional benefits of urban livestock keeping. Doing so may also be effective strategies for improving practices and decreasing health risks. The approach to risk assessment in resource-constrained cities in poor countries should focus on supporting municipal stakeholders in establishing an evidence-based culture to formulate appropriate policies. The data appropriate to local circumstances is needed rather than high cost and more sophisticated risk assessments (Chapter 3, above). Resource allocation should be based on risk (the probability and severity of adverse consequences):

- a. Some exposure to hazards is inevitable; acceptable risk levels should be established based on a calculus of benefits as well as harms, plus the cost, equity and feasibility of mitigating risks. This is a societal decision that must be taken in context.
- b. Risk is multi-source and all need to be considered.
- c. Every degree of risk reduction saves lives; where the optimal technologies cannot (yet) be adopted it is still useful to make gradual changes that work towards higher standards.
- d. Policies should aim at attainable, cumulative improvements based on the local situation.

Policy Priorities

1. Improved sanitation, as in Section C, plus more hygienic management of animal wastes, will reduce human health risks and allow more healthy feed for animals;
2. Apart from health hazards, environmental and nuisance aspects of urban livestock need neighborhood-level management and reconciliation mechanisms.
3. Specific information, training and education are needed for farmers, especially women. Section B showed the relationship between women's education and greater food security while this section showed women's role in livestock keeping. Better-informed women urban livestock keepers could mean reduction of potential health risks. Policies and programs have to be much more gender-sensitive. Adoption of risk mitigation varied from farm to farm, suggesting a role for farmer-to-farmer extension in improving animal products safety.

- Promote a multi-channel communication strategy, involving health centers, schools, markets and street food vending points. Public information and awareness programs are needed (see key messages below). This work has already begun in promulgation of ordinances around livestock keeping in Kampala (see Chapter 12, below).

Key messages

- Avoid transmitting enteric illness through common pathways of disease transmission from animals to humans;
- 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;
- Follow hygienic practices set out in the KCC Ordinances and Guidelines on UA, Livestock and Milk;
- Develop and use appropriate food storage facilities, such as refrigerators and closed containers, as barriers to pathogenic organisms;
- Boil milk (including as tea) to destroy pathogens and protect health; and
- Raw eggs may carry pathogens and should not be used as medication for specific ailments or as infant food.

Measures for managing specific hazards (Kang'ethe *et al.* forthcoming)

To reduce aflatoxins:

- Do not feed your livestock with damp or stale feed or supplements. Only use feed from trusted sources. Avoid feed being sold off cheaply from unknown sources.

To avoid *cryptosporidiosis*:

- Do not have more cattle than can reasonably be accommodated in the available space;
- Make sure that wells or water sources are not contaminated with surface run-off (as in a shallow well without protection); and
- Avoid contaminating cattle's water and feed with run-off, and especially urine and manure. Use water and feeding troughs and keep them clean.

To reduce microbial contamination, and particularly *E.coli* 0157:H7 which can survive over 12 months in manure and 20 days in soil:

- 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;
- Boil milk before consumption including use in tea; and
- Avoid traditionally fermented milk and cheese produced from non-boiled milk (provide starter kits and training on fermentation using boiled milk).

To protect against bovine *brucellosis* and bovine *tuberculosis*:

1. Keep sufficient distance between residence and cowsheds. (Preferred < 10 m);
2. Use personal protective equipment e.g. gloves when handling aborted fetuses; and
3. Avoid traditionally fermented milk and cheese produced from non-boiled milk (provide starter kits and training on fermentation using boiled milk).

To reduce hazards of veterinary anti-microbials in milk

1. Observe withdrawal period specified for each medication and do not consume or sell milk from a cow treated with antibiotics until after that time.

WHAT COULD WE UNDERSTAND BETTER?

1. Assessing benefits as well as harms, and looking at what people are doing right as well as wrong, would capture more of the system under study, be more farmer friendly and help research reach the wider audience of urban agriculture, veterinary and public health stakeholders;
2. Hazards have an origin and may increase, decrease and move before entering people. In addition to mapping pathways and identifying critical control points where action can be taken to reduce hazards, changes in hazards along the pathway need to be measured.
3. Considering strong local preference for free range chicken consumption and its association with better health protection suggested by our data, it is recommended that additional investigation with stronger study designs explore these relationships.
4. Consider further testing (culture, isolation and molecular typing of TB) of farmers and consumers who react on TB testing, to check whether bovine rather than human TB is the cause of reaction. Aflatoxins appear to be widely prevalent; participatory research along the entire feed production, distribution and use chain is needed to identify points for intervention and devise feasible ways of reducing contamination. *Cryptosporidia* needs to be typed and research done to ascertain if *C. parvum* is present because it:
 - a. can be especially harmful to HIV-AIDS sufferers and is difficult to treat;
 - b. is common in sub-Saharan Africa; and
 - c. may require particular pathway analysis and mitigation strategies.
5. Food quality surveillance with selected sampling could provide ongoing information to health and agriculture stakeholders to monitor potential risks from livestock rearing.
6. Continuing epidemiological studies combined with appropriate diagnostic assessments will help assess which chicken and other livestock production practices can reduce health risks, provide important information for analyzing cost-effectiveness, and help incorporate current good practices into guidelines for urban livestock production.

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Urban governance
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Section

Urban governance for health

Overview

This section contains the two concluding chapters that document the contribution of these studies to Kampala's governance and reflect on the entire experience in relation to urban sustainability. First, Chapter 12 picks up the story of the stakeholder research and policy process begun in this Introduction and contextualized in Chapter 2. It includes the setting up of the Urban Agriculture Health Coordinating Committee to guide the project and its transformation into the Kampala Urban Food Security, Agriculture and Livestock Coordinating Committee (KUFSAALCC). Relationships of the research process to Kampala's political and institutional structures and the process of reviewing Kampala City Council legislation affecting urban agriculture are described. The constraints of implementation experienced so far are discussed. Finally, Chapter 13 asks about the wider relevance of this study in one city to efforts to achieve healthier and more sustainable cities in general. Despite its volatile socio-political and institutional environment, Kampala is improving its governance of UA and health as a result of policy-relevant research taking place through institutions that cut across the divide of political action and research and directly involve low-income farmers and civil society actors. The governance model developed in Kampala and presented in this book is now being used by Urban Harvest in scaling out research impact to other urban areas and national policy systems. The historical comparison with North America and Europe is again drawn to show how food is a key area in urban development and how a governance approach can better manage urban food production for poverty and hunger alleviation, as well as taking into account the functioning of the ecosystem. Scientific evidence plays a role in the inherently political process of governance, but human rights and human actions are also at play.



Urban governance for health

**Diana Lee-Smith,
Semwanga Margaret Azuba,
John Muwanga Musisi,
Maria Kaweesa and
George W. Nasinyama**

The story of the health
coordinating committee,
KUFSALCC and the urban
agriculture ordinances

**Gordon Prain,
Diana Lee-Smith
and Donald C. Cole**

Urban governance for
healthy and sustainable
cities: the role of agriculture

CHAPTER 12

The story of the health coordinating committee, KUFSAALCC and the urban agriculture ordinances

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• John Muwanga Musisi • Maria Kaweesa • George W. Nasinyama

HOW URBAN AGRICULTURE IN KAMPALA LED TO INSTITUTIONAL INNOVATION

Despite its recent history of civil war and conflict, Kampala, among its neighbor cities in the region, is fortunate in having a national constitution and decentralization policy that favor a participatory approach to governance. It is also fortunate in having a suitable environment and a rich history of urban development that incorporates agriculture, with the ancient Kingdom of Buganda having its capital located in the city. The traditional pattern of urban settlement, uphill meaning high status and downhill being the place of the poor, with farming on the slopes and in the valleys, still shows in current patterns of both urban and peri-urban farming (David *et al.* forthcoming; Calas 1998, pp. 273 – 289).

Due to the widespread practice of urban agriculture, there was no severe malnutrition observed in Kampala during the 1980s civil war and the structural adjustment policies of the 1990s. Nonetheless, as in other sub-Saharan African states, the urban institutional environment has not been particularly supportive of urban agriculture, with no official policy recognition, the exception being Kampala's Structure Plan of 1994 (Van Nostrand *et al.* 1994). Despite the existence of this document, there has been widespread resistance to its implementation in practice.

This is not to say that there was nothing going on in the policy environment. Just as researchers engaged stakeholders in research and health impact assessment, so others engaged researchers in the process of changing policy and legislation on urban agriculture, all attempting to bring together the sometimes competing and even conflicting interests involved. As explained in the introduction in Chapter 1, and developed further in Chapter 4, this book views urban agriculture from an urban governance perspective, its management being based on interaction between civil society and the state (McCarney 2003, p. 36). A recent study of how the City Ordinances on urban agriculture came about concluded that a number of factors converged to make this innovation possible, namely the farmers themselves, civil society action, influential research and key decentralization policies and actions. The main factor however was seen as the motivation, coordination and collaboration of a set of actors from different institutions (Hooton *et al.* 2007). Here we tell the story of how

Figure 12.1

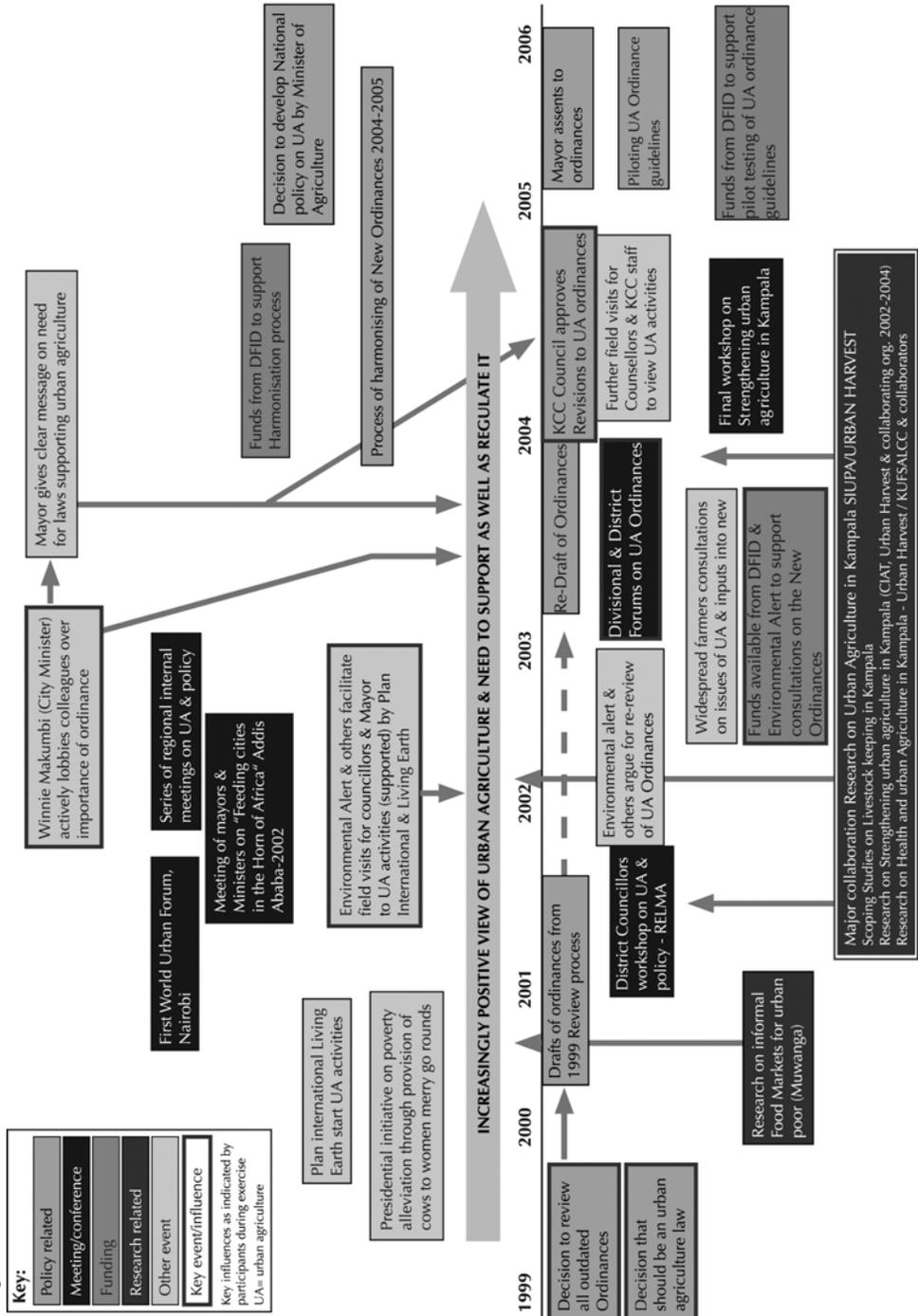
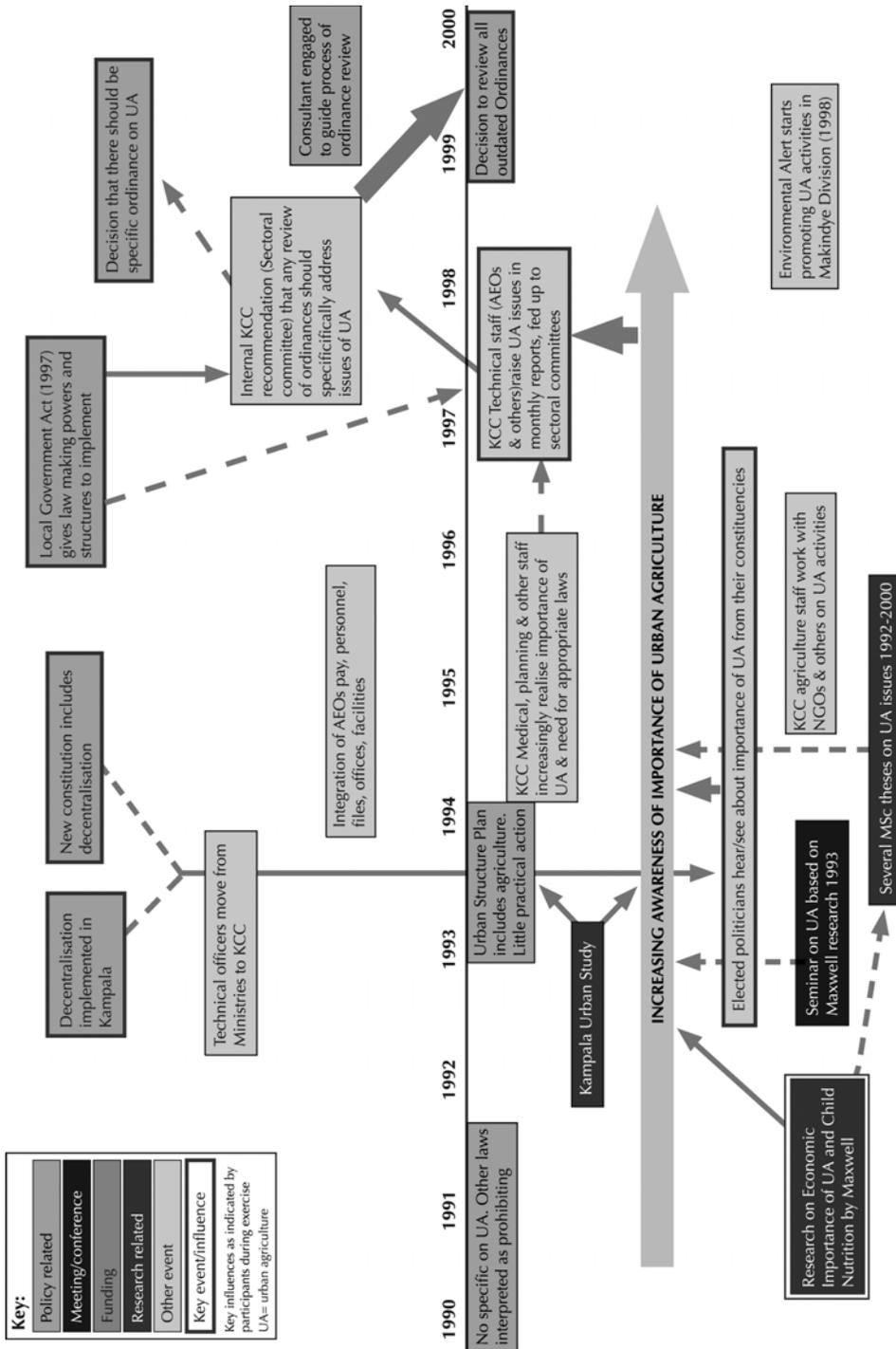


Figure 12.2



In 1988 a group of Ugandan citizens started a local non-governmental organization called Environmental Alert (EA) to combat food insecurity and poverty while promoting sustainable development. The country was emerging from civil war, and EA set out to complement the Extension Advisory Services being provided in one area of Kampala to the many people, mainly women, who were farming in an effort to feed themselves and their families, as well as generate income from garden surpluses. Practical action to provide skills and inputs to farmers for food security and income generation were combined with awareness-building for local politicians.

Then from 1993 onwards, when the Local Government Decentralization Program was implemented to fulfill the National Resistance Movement's promise during its guerrilla struggle (1981-86) to democratize Ugandan society, locally elected councils were empowered to make decisions affecting them. This structure of local councils at different levels was also a centerpiece of the Constitution enacted in 1995, which laid out a framework for devolved law making.

Meanwhile things were also moving on the research front. In 1988 Daniel Maxwell, an American researcher, surveyed 150 households practicing urban agriculture, although many government officials still viewed it as an illegal activity. The results showed that far from being marginal, urban agriculture was important in the livelihoods of 36 percent of Kampala households, with women dominating among the producers. The data were consistent with those emerging from neighboring Kenya and Tanzania, where parallel studies were supported by the International Development Research Centre (IDRC). Nevertheless, the official municipal response was still negative, concerns being expressed about public health and the image of the city (Maxwell 1994; Hooton *et al.* 2007).

Maxwell persisted, engaging policymakers at the start of a new round of research in 1991. Some officials now expressed interest in the nutritional and economic benefits of urban farming as well as understanding the public health risks involved. Environmental Alert also continued its activities. The topic came up during the Kampala Urban Study carried out not long after. Despite meeting with some hostility, especially in regard to the use of wetlands for urban farming, the Kampala Urban Structure Plan was passed in 1994. The plan incorporated recommendations that land use and zoning regulations should encourage mixed uses, reinforce life-work relationships and protect and enhance urban agriculture and forestry activities within and adjacent to the city (Van Nostrand 1994; Hooton *et al.* 2007).

The second round of Maxwell's research findings, showing household economic and nutritional benefits, were presented at a 1993 seminar in Kampala attended by local and national politicians, government staff, researchers and international agencies. The unwillingness of officials to act on the findings was challenged by women farmers present, producing some sympathy among those attending and a consensus that the legal status of urban agriculture should be reviewed. Although it took another decade for this to happen, the research had an impact on local institutions and policymakers (Atukunda 1998).

As a result of decentralization in 1993, Kampala City became an independent Local Government District, made up of five Divisions, with a hierarchy of levels of local councils. Kampala City Council (KCC) is also the District Council whose Chairperson is the Mayor.

Urban politicians were now more exposed to issues affecting their voters, including urban agriculture. Also, technical officers were relocated from the Central Government Ministries' main offices to KCC. At first this was difficult, but the agriculture officers concerned used the opportunity creatively, reaching out to Environmental Alert and later other NGOs. Agriculture, planning, public health and other officers also reported upwards on urban agriculture, including the lack of an effective legal framework to manage it appropriately (Hooton *et al.* 2007).

KCC's collaboration with Environmental Alert was particularly effective – mass sensitization involving local leaders leading to formation of zonal urban agriculture groups. The NGO had a strategy of community level development action, including skills training and credit combined with awareness-raising and lobbying. KCC also built Partnerships with different departments of Makerere University and the National Agricultural Research Organization (NARO) to hold higher-level awareness-raising workshops. This approach prepared the ground for subsequent collaborative activities. Other NGOs such as Living Earth, Plan International and Uganda Center for Sustainable Agriculture (UCSA) began work on urban agriculture, providing extension services that linked to the City Council's Agriculture Department. Thus the meager resources of the latter were augmented to achieve much greater capacity for urban agriculture support. In 1999 the Agriculture and Public Health Departments actively collaborated with Makerere University in research on heavy metal contamination in urban farming, in recognition of the need for research evidence regarding chemical contamination of food and clear guidelines to reduce potential risks (Hooton *et al.* 2007; Chapter 7 above).

The national policy environment also became more favourable to low-income groups, with the publication of the Poverty Eradication Action Plan (PEAP) in 1997 and the Plan for Modernization of Agriculture (PMA), although neither included urban agriculture specifically. Also in 1997, the Local Government Act gave legislative powers to local councils, enabling KCC to review and make new laws. By now there were more effective links between politicians and technical officers, who were furthermore able to back up their observations with research findings including in technical committee presentations.

So in 1999, KCC proceeded to review and draft new Ordinances governing all City services and operations including urban agriculture, livestock, meat, milk and fish handling. This review was an internal process, with little community consultation. By 2001 the review had resulted in six new draft Bills for Ordinances dealing with these issues. Although based on model by-laws from elsewhere, they had some prohibitive implications for urban agriculture. Environmental Alert advocated for a participatory re-examination of these ordinances and lobbied KCC to involve the public.

THE URBAN AGRICULTURE HEALTH COORDINATING COMMITTEE

This was the complex institutional environment into which those involved in this book's research project ventured. In May 2002, when the Urban Harvest team of the Consultative Group on International Agricultural Research (CGIAR) called a meeting in Kampala to design an Urban Agriculture Health Project, all the key players turned up. Each of the players in the

arena of health and urban agriculture in Kampala who attended had their own reasons for doing so, but all agreed that the research proposed was needed. They participated in the first task of brainstorming on the benefits and risks of urban agriculture in the city (shared in Chapter 2), which set the research agenda. Some players agreed to lead aspects of the research, and others to contribute towards it, depending on their skills and expertise. Several stakeholders also agreed to take part in a committee to steer the direction of the research, thus institutionalizing the linkages between the separate people and organizations concerned about urban agriculture. The role of this committee in the research was described in Chapter 2 above. This Chapter describes its role in local urban governance.

A second meeting was held a month later when the committee was formalized. The Health Coordinating Committee (HCC) had eight tasks or components in its activity plan, namely: contaminants, nutrition, zoonoses, agriculture, municipal planning, social studies and environmental education. Different members of the committee took on responsibility for specific tasks corresponding to their roles and specializations, and a chair, from Makerere's Department of Veterinary Public Health and Preventive Medicine, was elected. Urban Harvest agreed to act as the secretariat for the committee. It was not easy to manage the budget and administration of multiple complex and inter-related research studies that made up the Urban Agriculture Health Project. Committee members found this work took up a lot of their time. Being unpaid work in addition to their regular commitments, several members dropped out due to overload. Nevertheless, the HCC provided a useful platform for discussion and for moving forward a number of agendas regarding health and urban agriculture.

Institutions represented in the HCC were: Elected representative, Kampala City Council (KCC), Head of the KCC Agriculture Department; Head of the Department of Veterinary Public Health, Makerere University; the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), District Representative; the National Agricultural Research Organization (NARO); Environmental Alert (EA); and Urban Harvest. Two City Councilors were also members of the committee. Working with the KCC and MAAIF representatives, their engagement with the research strengthened it considerably. In the field research with urban farmers, the politicians – one of whom, Winnie Makumbi, was the City Minister in charge of agriculture and the other, Rebecca Mutebi, was a Council Committee Chairman – developed a good understanding of their constituents' concerns. The fact that both were women and had their own farming activities certainly helped as well.

Apart from committee meetings, the Urban Agriculture Health Project research team was able to meet frequently at a campus office provided to the project in Makerere University's Faculty of Veterinary Medicine. With the help of some funds from Urban Harvest, the office was soon turned into an urban agriculture resource center. Canadian as well as Ugandan students working on the various project studies were able to meet up there and access the computers and internet. Hence the urban agriculture health project provided a very important space, both physically and institutionally, in Kampala.

During the participatory research in 2002 and 2003, farmers raised their concerns about the draft City Ordinances on urban agriculture, which they had heard about. Representatives of Environmental Alert, as well as Living Earth and Plan International, took part in the field

research and project workshops, and came to HCC meetings. They reinforced the farmers' concerns when they were discussed by the HCC. A significant result of the HCC's composition and agenda was that municipal staff and political HCC members wanted the results of the research, and they wanted them in a form that they could use directly.

Scientific research is unfortunately done primarily to produce outputs that are read and used by other scientists more than policy makers. Members of the HCC wanted scientific evidence they could use to influence and support urban governance processes, more in keeping with action research and EcoHealth approaches (Sherwood *et al.* 2007). At various project workshops and meetings of the HCC, they pushed for accountability of researchers, including students, to stakeholders. Thus, in addition to scientific papers, the outputs of the Urban Agriculture Health Project were to include public health messages and policy guidelines, such as those in the commentary pieces at the end of Sections B-D in this book. Further they wanted the research results to be directly incorporated into the Ordinances. So the HCC, as an organization, added its voice to the pressure that was building for participatory review of the draft ordinances.

Other activities were facilitating more acceptance and support of UA at the national and international levels. Urban Harvest presented a policy brief on urban and peri-urban agriculture to Uganda's Minister of Agriculture in 2002, suggesting that it could assist the process in relation to HCC work in Kampala. At the international level, inter-institutional collaboration also played a role. Several workshops were organized by United Nations bodies – FAO and UN-HABITAT in particular – on subjects related to urban food and agriculture in 2002. At a 2002 ministerial meeting in Addis Ababa on "Feeding Cities in the Horn of Africa", attended by Kampala's Mayor, a declaration was made on the need for appropriate policy changes to support urban food security, including urban food production. Influenced by City Minister Makumbi, such key political leaders gradually changed their opinions, from being opponents of urban farmers and informal food traders, to being supporters.

REVIEWING THE URBAN AGRICULTURE ORDINANCES

Eventually KCC agreed to engage in a participatory review of the ordinances, although various politicians within the Council and staff in municipal departments were by no means supportive of the idea of regularizing urban food production. While the agriculture officers who had been providing advice and support to urban farmers for many years were primarily supportive, those concerned with health and urban planning had other concerns. Many still thought urban agriculture was a marginal activity and that farming, processing and trading of food were threats to orderly management of the city. The availability of funding for a participatory review became a crucial factor, and here HCC played an important role. HCC members were continuing to raise funds for their research and for implementing research results. In 2003, Makerere University's Department of Veterinary Public Health and Preventative Medicine, on behalf of the HCC, secured a grant from the UK's Department for International Development (DFID) to review the Ordinances. Environmental Alert, Kampala City Council and Urban Harvest also contributed funds and resources. There was enthusiasm among all the players involved to make sure the participatory law-making process worked.

A visiting official from Nairobi City Council who observed the Kampala process was astonished to see that public sector officials from national and local government were turning up to meetings with NGOs and university professors at 8 o'clock in the evening and working until 2.00 am to make sure the District Workshop proceeded smoothly.

A series of six stakeholder consultative workshops were held in Kampala (five at the Division level and one at the District level) in August and September 2003, to raise awareness of the existence and content of the draft Bills for Ordinances and to generate stakeholders' inputs. Workshop participants included researchers, KCC technical and political leaders, MAAIF officials, farmers and processors' representatives, agriculture extension officers, representatives of NGOs and donors. During the workshops, papers were presented on several aspects of urban agriculture, including preliminary research findings from the Urban Agriculture Health Project. Six thematic working groups each addressed one of the Draft Bills for Ordinances, based on participants' interest and specialization. Recommendations and inputs from the group discussions were presented to the plenary for debate and adoption. The outputs from the Divisional workshops formed the main basis for discussion at the District workshop (KUF SALCC and Urban Harvest 2004).

The consultative workshops highlighted numerous areas that had not been properly addressed and made key recommendations both in terms of technical changes and in the structure of the draft Bills for Ordinances (KUF SALCC and Urban Harvest 2004). Preliminary research results shared by Urban Agriculture Health Project members also influenced the draft Bills, such as in the introduction of measures to reduce toxic contamination of sites used for urban agriculture. It was also recommended that a series of simple guidelines to the new Ordinances be produced, with a process of pilot-testing and sensitization prior to full implementation. Finally it was recommended that a national policy process on urban agriculture be formulated, either as a stand-alone policy or involving integration of urban agriculture into existing agricultural policies.

After the participatory review workshops, members of HCC provided the assistance requested to KCC. Thanks to this technical and editorial input from the research team, the recommendations from the District Workshop were forwarded to the responsible KCC Sector Standing Committee in November 2003, and recommendations made to Council for final approval. Council did in fact approve the recommendations, with minor amendments, working through each Bill in turn, in December 2003. At this stage, the five draft Kampala City Bills for Ordinances included ones on Urban Agriculture in general, Livestock and Companion Animals, Meat, Fish and Milk.

Urban Harvest undertook to help raise funds to implement several recommendations, specifically for the production of guidelines and testing implementation of the proposed revised Ordinances. To this end it was important to have a body that could help KCC monitor such testing, essentially a research task. It was at this time that discussions began about broadening the mandate of the HCC, which was seen to be a competent body for managing applied research. KCC even asked for HCC's help in revising the draft Bills in line with the recommendations.

KAMPALA URBAN FOOD SECURITY, AGRICULTURE AND LIVESTOCK COORDINATING COMMITTEE (KUFSAALCC)

As the Urban Agriculture Health Project was moving into its third year of operation in 2003-2004, the related project on Strengthening Urban Agriculture in Kampala was drawing to a close. The research teams usually held the meetings where they reported back on progress together, and the ideas about turning the research results into useful guidelines were shared in discussion. This was of particular interest to the group working with schools, investigating their potential as a means of urban agriculture extension, which had already collaborated with the health research team on mapping the health risks of urban farming (Miiri *et al.* forthcoming). Further, the various teams working on components of the research on Strengthening Urban Agriculture in Kampala lacked a cohesive leadership to complete and write up their findings.

Given the ongoing work on the Ordinances and these other factors, HCC members decided it was time to broaden their base of concern to urban agriculture research in general, and to take the step of becoming a formally constituted organization. When the idea to form the Kampala Urban Food Security, Agriculture and Livestock Coordinating Committee (KUFSAALCC) was accepted by all at a regular meeting in March 2004 the matter was formally resolved. A draft document, outlining the mandate, roles and responsibilities of KUFSAALCC on behalf of its members was debated there and then, although it took until the end of the year for the body to become formally registered as an NGO under the laws of Uganda

Meanwhile KUFSAALCC's broader scope of work continued. Because of its constituent members and its concern with the application of research to policy-making, KUFSAALCC's mandate was defined as carrying out research and related activities to promote the availability of safe, healthy food for Kampala. Being a registered organization enabled KUFSAALCC to manage funds according to the priorities identified by the team. The UK's Department for International Development (DFID), which had already supported livestock research managed by HCC (Chapter 11, above), continued to support KUFSAALCC's work on producing the Guidelines and monitoring implementation of the Ordinances. Field-testing in late 2004 was able to identify potential challenges faced both by farmers in observing the ordinances, and by regulators in implementing them. As mentioned in a preamble to the Ordinances, contained only in the Guidelines, a specific study was planned to assess their gender impact, particularly on poor women traders.

The City Advocate in collaboration with KCC technical officers handled the final incorporation of all the inputs into the revised Bills for Ordinances and then forwarded them to the Attorney General's Office for further review and alignment with National Legislation. The Ministry for Justice and Constitutional Affairs also approved the Ordinances and the Mayor finally assented in June 2005. In 2006, guidelines to the Ordinances were developed and published by KUFSAALCC. The Guidelines, in the form of glossy pamphlets in straightforward language, accurately set out the key elements and requirements of the Ordinances.

Eventually, the five new Bills for Ordinances were formalized as laws in the Uganda Gazette in December 2006 and were published in April 2007 by the Uganda Printers and Publishing Company (UPPC); this was the first instance of public participation in law making under Uganda's 1995 Constitution.

The five Bills for Ordinances were the:

- Local Governments (Kampala City) (Urban Agriculture), Ordinance 2006
- Local Governments (Kampala City) (Livestock and Companion Animals), Ordinance 2006
- Local Governments (Kampala City) (Fish), Ordinance 2006
- Local Governments (Kampala City) (Milk), Ordinance 2006
- Local Governments (Kampala City) (Meat), Ordinance 2006

KUF SALCC has continued to carry out research and operate its urban agriculture resource center. Although all its members do not have the same level of involvement, they are working in their own organizations and on different urban agriculture projects funded through various donors and the Kampala City Council. Some of these are briefly described in Chapter 13 below.

THE OUTCOME

As discussed in the DFID supported study on the Kampala Urban Agriculture Ordinances (Hooton *et al.* 2007), only time will tell whether the initiative will have a lasting, or even a beneficial effect. The strong desire of KCC and government officials to contain and restrict urban agriculture because of perceived health threats, meant that there were provisions for licensing, monitoring and control of all urban agriculture activities contained in the Ordinances. The assessment of feasibility carried out by KUF SALCC demonstrated that the resources needed for a comprehensive record of all urban farming activities were enormous, although the awareness created by the process meant that farmers were able to learn about measures to protect their health and showed willingness to comply with the various provisions if they could afford to.

In 2008 Environmental Alert collaborated with Kampala City Council to publish simple versions of the Ordinances as posters to popularize them. The posters clearly indicate farmers' obligations, and the prohibitions and penalties as spelt out in the respective Ordinances. The City Council has allocated Ug Shs 100 million (equivalent USD \$ 62 500) of its Local Government Development Grant (LGDP) for the 2008/2009 planning period to facilitate the popularization of the new Ordinances, including those pertaining to urban agriculture.

The combination of facilitating legal and constitutional provisions for local law-making, decentralized government, relevant research, widespread farming and pressure from civil society organizations combined to make the participatory Ordinance development process possible. The high level of motivation and close collaboration among key individuals in different institutions working with a common purpose actually made things happen so that the supportive urban agriculture Ordinances were passed. They made an historic contribution to participatory law making in Uganda. In this chapter, we have told the story of how a space was created so that this group of people could become an active institution. Whether this

institutional innovation will have a lasting effect in terms of the status of urban agriculture in Kampala, the safety of Kampala's food supply, the wellbeing of its farmers and the food security of its people, will only be known through future assessments.

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CHAPTER 13

Urban governance for healthy and sustainable cities: the role of agriculture

Gordon Prain • Diana Lee-Smith • Donald C. Cole

This book began by situating urban agriculture and health in two contexts, one historical and the other current, namely the urgent need to respond to food and livelihood insecurity among growing urban populations. It went on to consider three perspectives on urban agriculture and health (Section A):

- citizens involved in agricultural production;
- researchers involved in generating evidence on the health benefits and risks of urban agriculture; and
- governments charged with the management of urban natural resources and public health.

Subsequent sections (B through D, Chapters 5-11) have described primarily the second of these perspectives in one case city, Kampala, as a response to the interests and concerns inherent in the first and third perspectives. These substantive chapters thus reflect the collaborative engagement among the different actors aimed at better understanding the broad health benefits and risks of urban agriculture, including the urban management challenges which stakeholders face when trying to maximize benefits and mitigate potential risks associated with farming in and around the city. Chapter 12 described the incorporation of the research results into policy work in Kampala. We begin this final chapter by briefly summarizing the policy implications of the research drawn out in the commentaries.

In the second part of this chapter, we consider the process of sharing and transforming the different stakeholder perspectives during agriculture-related action research and policy development, as an aspect of urban governance. Governance involves the relationship between civil society and the state (see Chapter 4, above). In an urban context, “good governance” involves, among other things, the ability “to tap the knowledge, resources and capacities among the population within each city” so that “the many different goals of its inhabitants and enterprises are met, without passing on costs to other people (including future generations) or to their regions” (UN Centre for Human Settlements in Satterthwaite 1999, pp.59-60). Urban governance therefore involves not only the shared management of natural and physical resources, but also adherence to the sustainable development goals of the city itself, the surrounding region and even the whole biosphere (Satterthwaite 1999, p.

6). In light of this characterization of good governance, this part of the chapter highlights agricultural production as a key component of healthy and sustainable cities because of its actual and potential use of urban natural resources and contribution to household food and nutrition security and household reproductive capacity.

The third part of this chapter reflects on the relationships between researchers and civic policy makers more generally, in support of the kinds of research undertaken in Kampala. The fourth part further examines the role of agriculture and public health research in strengthening urban governance. How far has the case city of Kampala come on the road to harnessing the contributions of research to ensure that safe and sustainable food production from its own ecosystem is part of good urban governance? We conclude with some lessons from our work in Kampala, suggesting an approach to public health that would strengthen the role of safe and healthy urban food production in sustainable cities.

POLICY IMPLICATIONS OF THE SUBSTANTIVE RESEARCH

Ensuring secure and sustainable urban livelihoods is an important policy goal for cities; food and nutrition security is another. Local as well as central governments are obliged to respect the Right to Food, meaning they cannot stop people from providing themselves with food essential to their survival. Municipal governments could review the Brazilian Right to Food model that includes urban areas in its supports to family farming in pursuit of these policy goals. Clear policy direction has to be set to meet these goals while ensuring food safety, consistent with government obligations in promoting the Right to Health.

Municipalities should, like Kampala, have an Agriculture or Food Department, to develop and lead this area of policy. Research on Kampala has made significant gains in developing UA typologies with the four types of farm households: “survival”, “sufficiency”, “food security” and “commercial”, listed in order of their prevalence in the city’s population. The City Council has also classified urban and peri-urban agriculture land use types within its boundaries. As they become aware of the potential food and nutrition security benefits of UA, other municipalities could assist the different kinds of urban farmers in securing land to produce nutrient-rich products for home consumption and city markets. Specific policies and programs, framed in a variety of ways and providing different kinds of resources, are needed to support the various groups with interventions ensuring their capability to produce their own food with dignity as well as for their livelihood and food security.

Municipalities can play a key role in linking the needs of consumers and small-scale urban producers by facilitating a broad-based collaboration among relevant stakeholders. Traders, transporters and market administrators are as important as producers and consumers in securing food supply and distribution that can respond to the food crisis. This might follow the direction set in drafting of KCC Ordinances on UA, a participatory analysis of local constraints and opportunities leading to policy and program design and implementation. Building on existing programs, stakeholders can jointly promote a multi-channel communication strategy, involving health centers, schools, markets and street food vending points. Agricultural extension, nutritionists, food technologists and health workers can all

contribute with advice and training on farming methods, as well as food selection, preparation and consumption practices.

In dealing with urban wastes that may impact on healthy horticulture, chemical contaminants should be treated distinctly from biological contaminants in policy, regulation and management. Discharge of potentially harmful quantities of heavy metals and combustion by-products into air, soil and water must be curtailed, especially by traffic, as a source of polyaromatic hydrocarbons, and large industries, the main source of heavy metals along with leaded fuel. Such reductions would strengthen provisions included in the KCC UA Ordinances (2006). Improved sanitation and public awareness of health risks from contaminated water are both essential. Results from ongoing research and development into ecological sanitation alternatives involving waste re-use in UA should be reviewed for potential policy application. Further, the array of potential strategies to better manage the considerable health hazards associated by biological contaminants should be more fully implemented. Policy makers must be cognizant that, for many poor subsistence urban farmers, stopping farming due to potential biological or chemical hazard exposure is not a viable option. Where UA is a lifeline for the urban poor, information on how to make better health trade-offs is the preferred solution, with site-specific information as available and education of farmers in risk minimization.

Particularly because of the importance of animal source foods and of livestock in generating income, providing infrastructure and legitimizing livestock keeping seems an important policy direction. This may be an effective strategy not only for improving livelihoods and nutrition security but also for improving practices and decreasing health hazards. Poorer farmers and those using less intensive farming methods will need targeted support to improve their practices. Programs need to consider gender-differentiated perceptions of roles, knowledge of risks and ability to make changes in practices. Given that adoption of risk mitigation may vary from farm to farm, collaboration with those farmers that achieve adequate hazard control with minimal resources should be a priority. Apart from health hazards, environmental and nuisance aspects of urban livestock need neighborhood-level management and reconciliation mechanisms.

The municipal approach to risk assessment in resource-constrained cities in poor countries should focus on supporting municipal stakeholders in establishing an evidence-based culture to formulate appropriate policies. Resource allocation should be based on data appropriate to local circumstances that can permit scoping of the risk (the probability and severity of adverse consequences) of particular practices. Recognizing that some exposure to hazards is inevitable, acceptable risk levels should be established based on benefits of, as well as, harms, plus the cost, equity and feasibility of mitigating risks. Every degree of risk reduction saves lives; where the optimal technologies cannot (yet) be adopted it is still useful to make gradual changes that work towards higher standards. Policies should aim at attainable, cumulative improvements based on the local situation. Overall, municipal stakeholders need to enhance the capability, capacity and vigilance of existing agencies that aim to control potential health risks posed by urban agriculture and those that aim to promote the health benefits.

LOCAL FOOD PRODUCTION, URBAN SUSTAINABILITY AND GOVERNANCE

The World Commission on Environment and Development report, *Our Common Future*, is the source of the most widely accepted definition of sustainable development – development that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED 1987). The definition derives from the key underlying idea of the report, that we live on one earth, a biosphere made up of multiple interacting and interdependent ecosystems in which all human activities are irrevocably embedded. It contrasts with the current reality of multiple, fragmented and competing worlds, resulting in unsustainable use and abuse of the earth’s finite resources.

One chapter of the WCED report is devoted to the Urban Challenge, which highlights the well-known infrastructure and environmental challenges facing developing world megacities, but also the interconnectedness of infrastructure, environment and social and institutional arrangements which offer solutions to these challenges. The chapter highlights the importance for sustainability of linkages between smaller cities and their hinterlands, including agricultural production and markets. It also emphasizes the potential role of urban agriculture in sustainable urban development, through tapping urban resources to enhance access to food for the urban poor, provide supplementary income and employment and maintain green spaces. It also emphasizes the potential for productive recycling of urban organic residues (*ibid.* pp.254-255).

Two distinct preoccupations are identifiable as concepts of urban sustainability and urban sustainable development, some writers focusing on human behavior and institutions in urban space and others addressing biophysical constraints and flows of energy and resources (McDonald *et al.* 2007, p. 20). While the first has a sectoral perspective within the city, the second sees the city in regional or even global space. For the first, urban food production is generally seen as a marginal activity associated with poverty (Adell 1999), while in the second it is seen as an essential component of energy and resource flows (Girardet 1992). There may also be a subtle distinction between the two in their concern with sustainable urban development as an ‘end state’, the aim in the first case being to establish a sustainable development agenda and in the second to put in place natural resource, energy and institutional processes needed to work towards urban sustainability (Gore, personal communication).

The second, or eco-system approach to urban sustainability, has addressed the issue of food production in different ways. Spatial views of cities explore their interdependencies – both positive and negative – with the surrounding region. Concepts such as bio-regionalism (Atkinson 1992), rural-urban linkages (Tacoli 1998) and metropolitan regions (McGee 1997) emphasize both the ecological and the developmental dimensions of interdependency, with flows of agricultural inputs and information, finance, people and wastes and contaminants from urban core to the region and beyond, and natural resources, food, people, goods and contaminants from the region and beyond to the core.

At the macro level the “ecological footprint of cities” has been used to understand and calculate the impact of urban food, energy and natural resource consumption and generation of waste on the region and the wider biosphere (Girardet 1999). London is estimated to

need 8.4 million hectares or over 50 times its own area to feed it (*ibid.* p. 52) in keeping with its compact urban form (see discussion on <http://www.citymayors.com/environment/footprint.html>). Putting a price tag on the ecological footprint of food revealed it accounts for 28 percent of goods transported by road and imposes an estimated external cost of \$4.58 billion per year on the British food basket (Pretty *et al.* 2005). The enormous costs to the environment and increasing pressure on farmland to feed cities has led to stronger demands for local food production and consumption: "All in all, urban food growing is an important component of greater urban sustainability (and) should be regarded as an important component of future urban living" (Girardet 1999, p. 56).

At the micro level combining the sustainable urban livelihoods framework with the concept of rural-urban linkages has the potential to address resource and energy flows while also focusing on human behavior and institutions and as means to enhance urban sustainability (Satterthwaite & Tacoli 2002). The importance of agriculture for many urban areas derives from a range of factors, including food and nutrition security (see Chapters 5 and 6, above), which are key elements of urban sustainability. There is also uptake by agriculture of the organic wastes that cities generate, reducing the export of these wastes as contaminants to the wider region (Furedy *et al.* 1999). Local food production also makes use of urban natural resources such as land and water surfaces (Smit & Nasr 1999), creating productive green spaces often where city authorities lack the budget to maintain parks and gardens (Caridad & Sánchez 2003).

Satterthwaite and Tacoli observe how close-by prosperous agricultural areas add value to urban development, through employment, forward and backward market linkages and the demand for urban goods and services by peri-urban and rural households (*ibid.* p. 53). They see that rural-urban linkages themselves are a type of livelihood strategy that includes temporary migration to supplement agricultural incomes and multifocal households to share mixed incomes and resources across different environments. With urban wages being invested in peri-urban agricultural production and food from rural and peri-urban areas feeding the urban household, social security is enhanced for part of the urban population, as is social sustainability (*ibid.* p. 55).

All these conceptual developments and resultant technologies suggest potential solutions to ecological imbalances in the way cities function and improvements in the situation of low-income urban and peri-urban households. Greater focus on food production in and around cities and greater inter-dependence between agricultural and non-agricultural livelihoods is required. Concepts such as "food miles", mentioned earlier, and the "slow food" movement, continue to drive the trend towards urban agriculture being considered, not just as an indicator of third world urban poverty, but as a strategy to increase urban sustainability (Mougeot 2006; Koc *et al.* 1999).

But urban and peri-urban agriculture might contribute negatively as well as positively to urban sustainability if there was reduced demand for urban goods and services as a result. In this scenario growing urban poverty could also mean fewer jobs and market opportunities for those in the peri-urban and rural areas (Satterthwaite & Tacoli 2000, p. 55). And as we have seen in Chapters 7-9, above, the health of producers and consumers is also vulnerable

to practices in urban and peri-urban areas that enable contaminants of various kinds to enter the urban food system. To address these concerns, public health thinking can benefit from the ecosystem and cross-sectoral ideas described here. The ecohealth approach (Lebel 2003), ideas of the social and economic determinants of public health and the sustainable urban livelihoods framework if applied to the interface of agriculture and health in urban and peri-urban areas, can strengthen urban sustainability. In particular, they can be used to develop methods for the safe use of urban wastes in human food production, whether wastewater for irrigation, solid wastes for composting or different types of organic residues for animal feed.

The Kampala case study should be seen in this wider context of evolving concepts and technologies and not only as a case study requiring the application of nineteenth century public health concepts to a marginal activity of the poverty-stricken. In fact, the neglect of food as an aspect of urban planning and its widespread absence in institutions of urban local government appear more and more anomalous as the concepts of urban sustainability develop. In this respect the City Council of Kampala appears to be ahead of the curve in its incorporation of agriculture as a department.

RESEARCH IN SUPPORT OF URBAN GOVERNANCE

Researchers are not natural allies of politicians. And if a week is proverbially a long time in politics, five years is often too brief for researchers to have conclusive evidence for a course of action. In Kampala, when politicians and researchers initially came together in 2002 to discuss priority health and agriculture issues to be addressed, politicians sought rapid solutions to immediate, visible problems such as solid waste management, whilst researchers were concerned with the long-term potential health risks of heavy metal contamination of soils used for urban agriculture. The terms of reference of the research program implemented in 2002 did not permit involvement in solid waste management issues, but this issue, of such clear concern to policy makers, has been incorporated into a more recent research initiative in Kampala involving Urban Harvest and local partners (Nasinyama *et al.* 2008).

Urban research, like other branches of research, is under-resourced in most low-income developing countries. Public expenditures on agricultural R&D in sub-Saharan Africa – a region highly dependent on agriculture – was only 6 percent of global agriculture R&D in 2000, with five of the 48 countries in the region employing 40 percent of all research staff (Beintema *et al.* 2006). Research results and concepts originating in richer industrialized countries are often applied out of context as a result. However, the Global Urban Research Initiative (GURI) of the 1990s observed that, despite the paucity of research, scholars in poor countries were often active in multiple institutional environments including academia and government, policy activism or consultancy, thereby often having a direct impact on policy (McCarney & Stren 2003, p. 13). Although this sometimes results in rapid response to particular urban governance needs, such as the need for decentralization of authority and decision-making and democratization of local government observed in the 1980s and 1990s (*ibid.* p. 6-11), it does not make up for the patchy nature of the knowledge generated and its lack of

incorporation into global or national development discourses. The patchiness of research and its lack of incorporation were the gaps that GURI set out to address (*ibid.* p. 13-20).

The gaps are large in almost every field of knowledge, and particularly striking is the lack of knowledge generated from and relevant to local conditions in developing countries. This has been one of the concerns motivating the research on which this book is based and has resulted in the inclusion of participatory methods in most component studies.

Although participatory and qualitative methods have been in use in anthropology and some other disciplines for many decades, their use in the wider academic community, including in agriculture, was developed to enable scientific enquiry to tap into the knowledge and understanding of individuals and communities making their living in localities which were little understood by outsiders (Whyte 1984; Chambers *et al.* 1989). In like manner, the “new production” of scientific knowledge is gaining ground, particularly in the social sciences, as a response to the needs for applicable research results by tapping into multiple knowledge contexts. This newer type of research is more often “trans-disciplinary, carried out in a non-hierarchical framework, more socially interactive and accountable and has a more practical (as well as formal scientific) purpose in specific contextual circumstances” than previous types of scientific research (McCarney & Stren 2003, p. 12). Its extension to the health and natural sciences has been documented (Stein *et al.* 2001; Stein & Stren 2001, p. 10) as well as those sciences’ engagement with civil society in the process of knowledge production (Stein 2001, pp. 29-50).

The research on which this book is based is very much in line with this approach, enabling its incorporation into local governance processes as described in Chapter 12, above. As part of the process however, public health policy also needs to be able to use decision-support tools based on data and methods that meet the required standards of the separate disciplines of the sciences involved. The component studies reported in preceding chapters have had to meet those requirements, so several are based on peer-reviewed papers. Creating platforms which respect the standards for quality scientific research and also incorporate methods for full stakeholder participation to formulate and debate evidence-based public policy is a challenge, which is why the Health Coordinating Committee and KUFSAALCC in Kampala provide an interesting experience.

The technical capacities of many urban local governments and the limited availability of relevant applied research present a challenge, the gap sometimes being bridged by partnerships with local academics called in as advisors, contributing to the phenomenon of the multi-tasking, inter-institutional academics discussed earlier. However there is a lack of organizational structures for institutionalizing the process. Sometimes educated members of the public form associations to address specific needs, and the civil society organizations thus created can take on an increasingly assertive role in local governance, sometimes bridging the knowledge gap (Wekwete 1997; McCarney & Stren 2003, p.19-20). The role of Environmental Alert in bringing urban agriculture onto the local governance agenda in Kampala in the 1980s and 1990s, including research on nutrition in particular, is a case in point (Chapter 12, above).

Nevertheless, it is rare that platforms exist specifically to bring together local government and research bodies to address evidence-based policy options. Therefore the role of KUF SALCC in addressing urban agriculture research in one particular municipal government is worthy of attention. For this to happen, the level of sophistication of the local government concerned had to be such that it appreciated the need for scientific evidence in its formulation of policy, and was willing to develop institutions that reach out to civil society, bringing its members into the sphere of public decision-making.

THE KAMPALA RESEARCH EXPERIENCE: A SUCCESSFUL CASE OF GENERATING EVIDENCE TO GUIDE HEALTHY URBAN AGRICULTURE?

The Kampala research on urban agriculture and health aimed to generate evidence on probable impacts of agriculture on human health – positive and negative – for local government officials to make decisions. How successful has that been? “Success” in this case has a number of dimensions. There is the question of whether the research is already, or is likely to be, successful in guiding policy towards establishing healthier local food production in Kampala. But there is also the question of wider applicability. Has this case study generated a research model that is an international public good (IPG) applicable elsewhere in sub-Saharan Africa or even beyond?

In answering these questions, it is important to address the research process itself. The further along the research cycle one moves the more are successful results dependent on other stakeholders. Results over which researchers and their collaborators (including farmers in participatory research) have most control are described as outputs among members of the Consultative Group on International Agricultural Research, of which Urban Harvest is a part. When those outputs are taken up by other stakeholders and used, we talk of outcomes. When outcomes result in significant change in conditions, we talk of impact. For example, the Kampala research on agriculture and human health contributed a number of outputs, related for example to assessment of risk in dairy cattle production and poultry raising. Those outputs – along with other sources of information and influence as described by Hooton *et al.* (2007) – resulted in the outcome of the KCC-led participatory ordinance revision process, guidelines development and passing of the ordinances into law.

To demonstrate outcomes, research on governance itself is needed, examining relations between groups with differing interests, amounts of power and types of engagement with society. At one level this book is itself a case study about the coming together of different groups with a stake in urban food production and public health. But it has also identified some inequalities in access to resources for urban food production, particularly basic services such as water and sanitation, limiting farmers’ ability to mitigate perceived health risks. Likewise, women’s access to resources such as land, education and decision-making power and control of household assets may limit their abilities to mitigate these risks. An investigation of some of these gender aspects is planned as part of monitoring the implementation of the Ordinances (KUF SALCC & Urban Harvest 2004). The innovative approach to policy reform in Kampala linked up to yet another research initiative aimed at better understanding of the impact of research on policy; the International Livestock

Research Institute (ILRI) and the London-based Overseas Development Institute (ODI) documented in detail the long process of engagement between different stakeholders in Kampala and the processes involved in producing outcomes, also discussed in Chapter 12 (Hooton *et al.* 2007).

For the outcomes to result in a successful impact, the Ordinances would need to be applied by KCC officials, followed by Kampala crop and livestock producers and processors, resulting in healthier agriculture in the city. This impact pathway and the documentation of impacts have yet to be realized, and Kampala's politics are currently in turmoil, with the proposed central government takeover of the City being planned in 2008 (see Chapter 4, above). Planned changes, attributed by some to the City being politically controlled by parties in opposition to central government, will combine with numerous other administrative changes in progress, including the Division of Rubaga becoming a separate municipality of Mengo and ceded to the traditional monarchy (Mwanje *et al.* 2008), and the amalgamation of Mpigi (and perhaps one other district) into metropolitan Kampala.

The likely staff and other administrative changes that will accompany these realignments will undoubtedly make it more difficult to implement the Urban Agriculture Ordinances, as well as the proposed policy guidelines – in the short term. The precedent of Kampala City's Structure Plan does not give grounds for hope. Its 1994 recommendations on urban agriculture remained unimplemented. It takes more than a plan or the passing of a set of laws to ensure implementation. Nevertheless, the recommendations in the Structure Plan can be seen as part of a long policy debate surrounding urban agriculture in the city; this debate has been informed by research outputs and has led to the policy guidelines and the new Ordinances. Change of this kind takes time and implementation of the Ordinances to achieve impacts is no different.

Reasons for cautious optimism remain. The creation of metropolitan Kampala could mean expansion of and increased support to agriculture in areas immediately surrounding Kampala. A metropolitan urban, peri-urban and regional agricultural strategy supported by central government in partnership with KCC (Chapter 4, above) is a potential outcome. Furthermore, there is a reservoir of people committed to sustainable urban food production, not least the farmers themselves. It is true that the member organizations and individuals making up KUFSAALCC are now engaged in other urban agriculture-linked projects outside the KUFSAALCC platform. KUFSAALCC as an entity is absent from several ongoing urban environment and urban agriculture projects, including research, being undertaken by KCC. Yet the desire of these individuals and organizations to improve the status, functioning and healthiness of urban agriculture makes it likely that they will use the Ordinances and policy guidelines in various contexts as opportunities arise. Combined with the continuing presence of urban farming in the physical and cultural landscape of Kampala, such commitment offers hope of positive future change. Further, the practice of participatory urban governance, involving the public in re-making urban by-laws as done in Kampala around the issues of urban food production and handling, speaks to the ideals and directions of the 1995 Uganda Constitution. These ideals and directions are clearly contained in other policy documents in the continent, existing or in development, as mentioned above in relation to decentralization and

democratization. In the long run, such participatory processes have a greater chance of bringing about change.

As to the second question, whether the Kampala experience has permitted the development of a “model” for integrating healthy urban agriculture into urban governance in other cities, here too there are grounds for cautious optimism. Despite obvious differences in climate, topography, culture and history affecting urban food production, all towns and cities in Africa are grappling with rapid urban growth accompanied by poverty, food insecurity and low employment levels. Case study statistics on urban food production in the East African countries studied in the companion volume to this book (Prain *et al.* forthcoming) are remarkably similar. The way public health aspects of urban food production have been examined in Kampala as part of a rural to urban continuum, with different patterns of food production and health perceptions along the continuum, might well be widely applicable to other cities (Urban Harvest 2007).

This rural to urban continuum perspective on how farming systems work enables us to see, instead of a sharp rural-urban divide, how farming systems intensify as they get closer to urban centers with their demands for food and their lack of space. Perceptions of health risks associated with agriculture and the elaboration of mitigation strategies also seem to intensify. As for similarities and differences in patterns of crop and livestock production, their intensification, health risk perception and mitigation, more comparative data is needed. Striking similarities observed so far are suggestive rather than conclusive. For example, the large size of urban food producing compared to non-food producing households, the association of livestock production with intensification and commercialization of urban farming by households and the marginalization of poor and women-headed households engaged in urban food production appear consistent across a number of urban locations (Prain *et al.* forthcoming).

The intensification of urban and peri-urban food production presents an opportunity for urban agriculture to move forward the modernization of agriculture which is Uganda’s policy priority, but it is absolutely essential that this is accompanied by informed public health policies because the intensification of production in the context of limited space entails specific health hazards. This book has shown how farmers themselves play the most crucial part in improving and ensuring food safety and how their perceptions and mitigation strategies can inform policy and regulation, so that the public sector makes the appropriate response. This understanding will surely be applicable to other developing country cities.

Perhaps the best evidence that the Kampala case study has generated IPGs of relevance to other locations is the application of this governance model by Urban Harvest and its partners to other urban areas and national policy systems. In Nakuru, Kenya, during research into crop-livestock systems and waste recycling carried out by international and civil society organizations in 2004, it became apparent that the by-laws in Nakuru were unclear in their approach to urban agriculture and needed revision. Led by the Environment Department of the local Council, a series of participatory, multi-stakeholder workshops involving key stakeholders analyzed the by-laws in relation to safe and sustainable urban and peri-urban crop and livestock production and formulated new ones. The Kampala ordinances were

looked at. The new Nakuru by-laws await gazetting by the Council and meanwhile the process seems likely in turn to influence another nearby town (Lee-Smith 2008; Foeken 2006).

Even beyond Africa, the Kampala model has been shown to have relevance, under very different social and geographical conditions. In Lima, Peru, pig raising is an important source of income for tens of thousands of families. In one low-income area of the capital with a population of 125 000 persons, 1600 families raise around 60 000 head of pigs per year in what local government officials recently described as clandestine circumstances (Alegre *et al.* 2007). Again the model of multi-stakeholder collaboration together with research to generate evidence has been applied, along with capacity building for producers and local government officials and GIS mapping to enhance the visibility and distribution of producers. And again, along with structural and institutional changes in the municipality, new by-laws have been formulated and are awaiting approval by the Council.

CONCLUSIONS: FROM URBAN PUBLIC HEALTH TO ECOHEALTH

A major conclusion of this study is that, in the context of a developing world city like Kampala where a significant proportion of the population is involved in food production, urban public health must be seen in the context of several interlocking systems that vary along the rural to urban continuum – employment, natural resource use, food, spatial and social living arrangements and governance. The sustainable livelihoods framework brings many of these together, but the food and health aspects of human capital have to be emphasized and the ways health affects vulnerability elaborated (Harpham & Grant 2002). The framework captures the “bottom-up” perspective of households, as elaborated in Chapter 2, above, and can be a helpful way of programming change towards healthier food production – through capacity building that is relevant to households’ use of different assets in their livelihood strategies.

From a health researcher point of view, as presented in Chapter 3, there is need to look in much more detail at a particular segment of the sustainable livelihoods framework involving agriculture. Agriculture is a particular livelihood strategy that uses natural resources in specific vulnerability conditions (price shifts, seasonal and long-term climate change etc.) and deploys household human, financial and physical capital. What are the probable positive or negative impacts on human health, understood in the broadest terms, of this strategy? From the health researcher perspective there is acute concern with generating quantified evidence on health risks from particular hazards as well as nutritional and other health benefits which can influence policies, institutions and governance structures towards safer, healthier agriculture in urban settings.

The framework can also be used to analyze such policies and institutions in detail to understand how they work for or against low-income food producers and healthy agriculture in developing world cities. This requires the shift in perspective demonstrated in Chapter 4, towards better understanding the working of local government as well as the role of other actors such as private sector or civil society organizations and the relations between them, as captured in the idea of governance. In this type of analysis the municipal perspective is crucial, and particularly so since it is in fact a complex of perspectives that are contested and often contradictory.

Thinking about public health in the ways described in Chapters 2, 3, and 4 suggests that the concept of ecohealth is a more appropriate frame for understanding human health in these complex sets of relations than is a bio-medical approach (Cole *et al.* 1998). This is particularly so because urban food production directly uses natural resources and is intricately intertwined with the ecological processes at work in an urban setting.

Through its examination of the background and thinking of the main stakeholders involved in urban food production and health – farmers, scientists and local government – the study has engaged not only with the generation of evidence to guide policy but also with the political questions of how policy is made and by whom. This has been done not just within the detailed studies, by examination of farmers' strategies for mitigating health risks and their perceptions of risks and benefits, nor just through the translation of scientific evidence into useful guidelines for those who make policy, but also by reflective involvement with larger societal processes of policy and legal change. Though the impact of this activity cannot be fully determined for some time, this book has attempted to set out what is involved in such a participatory process of research that is committed to engage with and strengthen public decision-making.

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Acronyms

- AA DT** – Average Annual Daily Traffic
- AAS** – Atomic Absorption Spectrophotometer
- ANOVA** – Analysis of Variance
- ANT** – Anthracene
- AOAC** – Association of Official Analytical Chemists
- APC** – Aerobic Plate Count
- APHA** – American Public Health Association
- APHRC** – Africa Population and Health Research Center
- ASF** – Animal Source Foods
- ATSDR** – Agency for Toxic Substances and Disease Registry
- BAGACO** – Banda Garbage Collection Organization
- BGA** – Brilliant Green Agar
- CIAT** – Centro Internacional de Agricultura Tropical
- CCFAC** – Codex Committee on Food Additives and Contaminants Cd- Cadmium
- CDC** – Centers for Disease Control
- CFU** – Colony Forming Unit
- CGIAR** – Consultative Group on International Agricultural Research
- CI** – Confidence Interval
- CIAT** – International Center for Tropical Agriculture
- CIDA** – Canadian International Development Agency
- CIH** – Centre for International Health
- CNRIIT** – Center for Natural Resource Information Technology
- COA** – Committee on Agriculture
- CONSORT** – Consolidated Standards of Reporting Trials
- COPC** – Contaminant of Potential Concern

- CRA** – Comparative Risk Assessment
- CRP** – C-Reactive Protein
- Cu** – Copper
- CUCS** – Centre for Urban and Community Studies
- DALY** – Disability Adjusted Life Years
- DDA** – Dairy Development Authority
- DDS** – Dietary Diversity Score
- DEFRA** – Department for Environment, Food and Rural Affairs
- DF** - Degrees of Freedom
- DfID** – Department for International Development
- EA** – Environmental Alert
- EAMJ** – East African Medical Journal
- EC** – Electrical Conductivity
- EDD** – Estimated Daily Dose
- EDI** – Estimated Daily Intake
- EPG** – Eggs per gram
- ELISA** – Enzyme Linked ImmunoSorbent Assay
- FAO** – Food and Agriculture Organization
- FAAS** – Flame Atomic Absorption Spectrophotometer
- FC** – Fecal Coliform
- FLA** - Fluoranthene
- FMD** – Foot and Mouth Disease
- GDP** – Gross Domestic Product
- GIS** – Geographic Information System
- GIT** – Gastro-Intestinal
- GURI** - Global Urban Research Initiative
- HALY** – Health Adjusted Life Years
- HAZ** – Height for Age Z score
- Hb** - Hemoglobin
- HCC** – Health Coordinating Committee
- HFS** – Household Food Security
- HH** – HouseHold
- HI** – Hazard Index
- HIA** – Health Impact Assessment
- HOH** – Head of Household
- HQ** – Hazard Quotient

- IAA** – Indole Acetic Acid
- ICDP** – Indeno[1,2,3-cd] pyrene
- ICRCL** – Interdepartmental Committee for Redevelopment of Contaminated Land
- IDRC** – International Development Research Centre
- IES** – Institute for Environmental Sciences
- IFPRI** – International Food Policy Research Institute
- IFS** – International Foundation for Science
- ILRI** – International Livestock Research Institute
- IPG** – International Public Good
- IWMI** – International Water Management Institute
- K** - potassium
- KCC** – Kampala City Council
- KUFSALCC** – Kampala Urban Food Security, Agriculture and Livestock Coordination Committee
- LGDP** – Local Government Development Grant
- LMS** – Least Mean Squares
- LPP** – Livestock Production Programme
- LSD** – Least Significant Difference
- MAAIF** – Ministry of Agriculture, Animal Industry and Fisheries
- MDC** – Milk Development Council
- MFPEd** – Ministry of Finance, Planning and Economic Development
- MOH** – Ministry of Health
- MRT** – Milk Ring Test
- MUAC** – Mid Upper Arm Circumference
- MUM-FAMrisk** – Multimedia Urban Model, Family Risk
- MUM-Risk** – Multimedia Urban Risk Model
- N** – nitrogen
- N/A** – Not Available
- NACMCF** – National Advisory Committee on Microbiological Criteria for Foods
- NALEP** – National Agriculture and Livestock Extension Programme
- NARO** – National Agricultural Research Organization
- ND** – Not Detected
- NGO** - Non-Governmental Organization
- NHANES** – National Health and Nutrition Examination Survey
- Ni** - Nickel
- NIST** – National Institute of Standards and Technology

NSERC – National Sciences and Engineering Research Council of Canada

ODI – Overseas Development Institute

OFSP – Orange-Fleshed SweetPotato

OHCHR – Office of the High Commissioner on Human Rights

OPCW – Organization for the Prohibition of Chemical Weapons

OR - Odds Ratio

P - phosphorus

p - significance

PAH – Polycyclic Aromatic Hydrocarbon

Pb - Lead

PC – Primary Caregiver

PEAP – Poverty Eradication Action Plan

PHE - Phenanthrene

PLA – Participatory Learning and Action

PMA – Plan for the Modernization of Agriculture

POP – Persistent Organic Pollutant

PPA – Participatory Poverty Assessment

PRSP – Poverty Reduction Strategy Paper

PUA – Participatory Urban Appraisal

PVC – Polyvinyl Chloride

PYR - Pyrene

r - correlation coefficient

R&D – Research and Development

RfD – Reference Dose

RUAF – Resource Centres on Urban Agriculture and Food Security

SAS – Statistical Analysis System

SAT – Serum Agglutination Test

S:B – Sample to Blank ratio

SCN – Standing Committee on Nutrition

SE – Standard Error

SIUPA – Strategic Initiative on Urban and Peri-urban Agriculture (now ‘Urban Harvest’)

SOM – Soil Organic Matter

STROBE – Strengthening the Reporting Of Observational studies in Epidemiology

TB – Tuberculosis

TCBS – Thiosulphate Citrate Bile Sucrose

- TCC** – Total Coliform Count
- TLU** – Tropical Livestock Unit
- TN** – Total Nitrogen
- TPC** – Total Aerobic Plate Count
- TRP** – Total Reactive Phosphate
- TSI** – Triple Sugar Iron
- UA** – Urban Agriculture
- UBOS** – Uganda Bureau of Statistics
- UCSA** – Uganda Center for Sustainable Agriculture
- UDHR** – Universal Declaration of Human Rights
- UDHS** – Uganda Demographic and Health Survey
- UK** – United Kingdom
- UN** – United Nations
- UNACOH** – Uganda National Association for Community and Occupational Health
- UNDP** – United Nations Development Programme
- UN-ESC** – United Nations Committee on Economic, Social and Cultural Rights
- UNICEF** – United Nations Children’s Fund
- UPPC** – Uganda Printers and Publishing Company
- USD** – United States Dollar
- USDH** – United States Department of Health
- USEPA** – United States Environmental Protection Agency
- USFDA CFSAN** – United States Food and Drug Administration Center for Food Safety and Applied Nutrition
- USPHS** – United States Public Health Service
- VRBA** – Violet Red Bile Agar
- WAZ** – Weight for Age Z score
- WCED** – World Commission on Environment and Development
- WFP** – World Food Programme
- WHO** – World Health Organization
- WHZ** – Weight for Height Z score
- WTW** – Wissenschaftlich-Technische Werkstätten
- XLD** – Xylose Lysine Deoxycholate
- ZBMI** – Body Mass Index Z score
- ZMUAC** – Mid Upper Arm Circumference Z score
- Zn** - Zinc

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