

# Irrigated Urban Vegetable Production in Ghana

Characteristics,  
Benefits and  
Risk Mitigation

**Second Edition**



Edited by

**Pay Drechsel**  
and  
**Bernard Keraita**



RESEARCH  
PROGRAM ON  
Water, Land and  
Ecosystems

LED BY:  
**IWMI**  
International  
Water Management  
Institute

**RUAF**  
RESOURCE CENTRES ON URBAN AGRICULTURE & FOOD SECURITY



Irrigated Urban Vegetable  
Production in Ghana:  
Characteristics, Benefits and  
Risk Mitigation

Edited by  
Pay Drechsel and Bernard Keraita

Second Edition

**IWMI**  
**September 2014**

**Editors:** Pay Drechsel (IWMI) and Bernard Keraita (University of Copenhagen)

**Contributing authors:** Adriana Allen and Alexandre Apsan Frediani, University College London, UK; Andrea Silverman, University of California, Berkeley, USA; Andrew Adam-Bradford, Human Relief Foundation, UK; Bernard Keraita, University of Copenhagen, Denmark; Emmanuel Obuobie, Water Research Institute, CSIR, Ghana; George Danso, University of Alberta, Canada; Gerald Forkuor, University of Wuerzburg, Germany; Gordana Kranjac-Berisavljevic, University for Development Studies, Ghana; Hanna Karg, University of Freiburg, Germany; Irene Egyir, University of Ghana, Ghana; Lesley Hope, University of Bochum, Germany; Liqa Raschid-Sally, Sri Lanka; Manuel Henseler, Switzerland; Marielle Dubbeling, RUA Foundation, The Netherlands; Matthew Wood-Hill, University College London, UK; Olufunke O. Cofie, IWMI, Ghana; Pay Drechsel, IWMI, Sri Lanka; Philip Amoah, IWMI, Ghana; Razak Seidu, Norwegian University of Life Sciences, Norway; René van Veenhuizen, RUA Foundation, The Netherlands; Robert C. Abaidoo, Kwame Nkrumah University of Science & Technology, Ghana; Sampson K. Agodzo, Kwame Nkrumah University of Science & Technology, Ghana; Senorpe Asem-Hiablle, The Pennsylvania State University, USA; and Theophilus O. Larbi, IFAD, Accra, Ghana

**Publication editor:** Robin N. Leslie

**Suggested citation:**

Drechsel, P.; Keraita, B. (Eds.). 2014. Irrigated urban vegetable production in Ghana: characteristics, benefits and risk mitigation. 2nd ed. Colombo, Sri Lanka: International Water Management Institute (IWMI). 247 p. doi: 10.5337/2014.219.

/ irrigated farming / urban agriculture / suburban agriculture / vegetable growing / risk management / wastewater irrigation / cropping systems / food security / food supply / sanitation / water quality / irrigation water / water use / water policy / economic aspects / financing / households / income / marketing / gender / women farmers / land tenure / soil fertility / biological contamination / pesticide residues / helminths / heavy metals / faecal coliforms / environmental health / sustainability / public health / health hazards / malaria / stakeholders / Ghana /

**Cover photos:** International Water Management Institute (IWMI)

ISBN 978-92-9090-798-5

Copyright © 2014 by IWMI. All rights reserved. Download a free copy of this publication at: [www.iwmi.org](http://www.iwmi.org)

Printed by Printel Private Limited, Sri Lanka.

# CONTENTS

**Foreword to the Second Edition** *by Marielle Dubbeling* **vii**

**Acknowledgements** **viii**

## INTRODUCTION

- 1. Irrigated Vegetable Farming in Urban Ghana: A Farming System between Challenges and Resilience** **1**
- 1.1 The Urbanization Challenge
  - 1.2 Urban and Peri-urban Agriculture and Food Security
  - 1.3 Sanitation, Water Quality and Irrigation
  - 1.4 Dynamics and Sustainability of the Urban Farming Phenomenon
  - 1.5 Book Objectives and Structure
- by P. Drechsel, A. Adam-Bradford and L. Raschid-Sally*

## PRACTICES, ACTORS AND ECONOMIC ASPECTS

- 2. Urban Vegetable Farming Sites, Crops and Cropping Practices** **7**
- 2.1 Key National Features
  - 2.2 Irrigated Urban Agriculture in Ghana's major cities
  - 2.3 Farming Characteristics, Crops and Land Tenure
- by G. Danso, P. Drechsel, E. Obuobie, G. Forkuor and G. Kranjac-Berisavljevic*
- 3. Characteristics of Urban Vegetable Farmers and Gender Issues** **28**
- 3.1 Profile of Urban Vegetable Farmers
  - 3.2 Overview of Gender Issues in Urban Agriculture
  - 3.3 Male Dominance in Urban Open-space Vegetable Farming
  - 3.4 Female Dominance in Marketing of Urban Farm Produce
  - 3.5 Conclusions
- by E. Obuobie and L. Hope*
- 4. Financial and Economic Aspects of Urban Vegetable Farming** **38**
- 4.1 Financial Aspects of Irrigated Vegetable Farming
  - 4.2 Socioeconomic Impact and Urban Food Supply
  - 4.3 Possible Negative Externalities
  - 4.4 Conclusions
- by G. Danso, L. Hope and P. Drechsel*
- 5. Marketing Channels for Irrigated Exotic Vegetables** **51**
- 5.1 Background and Survey Details
  - 5.2 Marketing Channels
  - 5.3 Quantifying Food Flows
  - 5.4 Customers and Consumers
  - 5.5 Conclusions
- by M. Henseler and P. Amoah*

## POSSIBLE HEALTH RISKS

- 6. Quality of Irrigation Water Used for Urban Vegetable Production 62**
- 6.1 Urban Sanitation and Water Quality Linkages
  - 6.2 Bacteriological Quality of Irrigation Water
  - 6.3 Helminth Eggs
  - 6.4 Virus Levels
  - 6.5 Emerging Contaminants
  - 6.6 Heavy Metals
  - 6.7 Conclusions
- by B. Keraita, A. Silverman, P. Amoah and S. Asem-Hiablie*
- 7. Irrigation and Soil Fertility Management Practices 74**
- 7.1 Irrigation Systems in Ghana
  - 7.2 Sources of Irrigation Water in Major Cities
  - 7.3 Irrigation Methods Used in Urban Vegetable Farming
  - 7.4 Productivity of Irrigated Urban Vegetable Systems
  - 7.5 Options and Constraints to Technology Change
  - 7.6 Soil Fertility Management Practices
  - 7.7 Conclusions
- by B. Keraita and O.O. Cofie*
- 8. Quality of Vegetables in Ghanaian Urban Farms and Markets 89**
- 8.1 Bacterial Contamination
  - 8.2 Helminth Eggs
  - 8.3 Heavy Metals
  - 8.4 Pesticide Residues
  - 8.5 Estrogen Concentrations
  - 8.6 Conclusions and Recommendations
- by P. Amoah, I. Lente, S. Asem-Hiablie and R.C. Abaidoo*
- 9. Human Health Risks from Wastewater-irrigated Vegetable Farming 104**
- 9.1 Risks from Wastewater Irrigation
  - 9.2 Risks from Microbiological Contaminants
  - 9.3 Risks from Heavy Metals
  - 9.4 Risks from Pesticides and Emerging Contaminants
  - 9.5 Conclusions
- by P. Drechsel, B. Keraita, R. Seidu and R.C. Abaidoo*
- 10. Health Risk Perceptions of Stakeholders 116**
- 10.1 The Importance of Stakeholder Perceptions
  - 10.2 Perceptions of Vegetable Farmers
  - 10.3 Perceptions of Vegetable Sellers
  - 10.4 Perceptions of Vegetable Consumers
  - 10.5 Perceptions of City Officials
  - 10.6 Perceptions of the Government
  - 10.7 Perceptions and Role of the Media
  - 10.8 Conclusions
- by E. Obuobie, B. Keraita, L. Hope and S.K. Agodzo*

## STRATEGIES TO ENHANCE SAFETY AND PRODUCTIVITY

<b>11. Strengthening Urban Producer Organizations</b>	<b>136</b>
11.1 Farmers Production and Organizational Development	
11.2 Farmers' Indigenous Knowledge and Innovations	
11.3 From Seed to Table (FStT) Program	
11.4 Results and Outcomes	
11.5 Lessons Learned and Conclusions	
<i>by T.O. Larbi, O.O. Cofie, P. Amoah and R. Van Veenhuizen</i>	
<b>12. Options for Local Financing in Urban Agriculture</b>	<b>145</b>
12.1 Financing Urban Agriculture – An Overview	
12.2 The Current Situation of Financial Institutions in Accra	
12.3 Bottlenecks in Financing Urban Producers	
12.4 Opportunities for Financing Urban Agriculture	
12.5 Conclusion	
<i>by I.S. Egyir, O.O. Cofie and M. Dubbeling</i>	
<b>13. Land and Planning for Urban Agriculture in Accra: Sustained Urban Agriculture or Sustainable Urbanization?</b>	<b>161</b>
13.1 Introduction	
13.2 Farming in the Inner City: Contested Claims and Practices	
13.3 Where Customary Agricultural Practices Meet Market-led Urbanization	
13.4 Putting Unsuitable Land to Productive Use	
13.5 Pathways for Change	
13.6 Conclusions	
<i>by A. Allen, A. Apsan Frediani and M. Wood-Hill</i>	
<b>14. Health Risk Management for Safe Vegetable Irrigation</b>	<b>180</b>
14.1 Health Risk Management in Wastewater Irrigation	
14.2 Risk Management Strategies – An Overview	
14.3 Options to Improve Urban Sanitation and Wastewater Treatment	
14.4 Farm-based Risk Management Measures for Pathogens	
14.5 Postharvest Risk Management Measures for Pathogens	
14.6 Chemical Contaminants	
14.7 Options to Support Uptake of Safe Practices	
14.8 Conclusions	
<i>by P. Drechsel, B. Keraita, P. Amoah and H. Karg</i>	
<b>15. Governmental and Regulatory Aspects of Irrigated Urban Vegetable Farming in Ghana and Options for its Institutionalization</b>	<b>199</b>
15.1 Informality of Irrigated Urban Farming	
15.2 Agencies Relevant to Irrigated Urban Farming	
15.3 A Review of Regulatory Bylaws, Policies and Development Plans	
15.4 Institutionalizing Safe Vegetable Farming	
<i>by P. Drechsel, E. Obuobie, A. Adam-Bradford and O.O. Cofie</i>	
<b>15. References</b>	<b>219</b>

**Annex:** CD with films by DPU/UCL (UK) and IWMI on urban farming in Ghana



*Ashanti brass art of the “farm to table” value chain  
(Photos: P. Drechsel)*

## Foreword to the Second Edition

Over the last 10 years, the International Water Management Institute's research in Ghana has had a major thrust in urban agriculture in general and (wastewater) irrigated vegetable farming in particular. The first edition of this book was published in 2006 under the title **Irrigated Urban Vegetable Production in Ghana: Characteristics, Benefits and Risks** – demand was high and it eventually ran out of print but the research resulted in many new studies that have improved our knowledge of the subject.

This second edition has been completely revised and updated, with new chapters and about 90 more pages to give a comprehensive overview of urban and peri-urban vegetable farming in and around Ghana's major cities. The book highlights not only the important contribution of urban vegetable production for farmers and society, but also possible risks and risk perceptions related to the use of polluted water sources. More importantly, the second edition transits from descriptive situational analysis towards definitive action. The book contains health risk assessments and outlines options for risk mitigation which were studied in Ghana in collaboration with the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO). Students and lecturers from more than ten universities contributed to this second edition which also includes a DVD that illustrates challenges to and opportunities for urban farming in Ghana and practical options for health risk reduction where polluted water is used for irrigation.

IWMI is a member of the International Network of Resource Centres on Urban Agriculture and Food Security (RUAF Foundation). The Foundation is proud to be associated with this exciting and excellent work being carried out in Ghana for more than a decade. The book is a valuable resource for students, extension officers, academia and policy makers.

**Marielle Dubbeling**

Director, RUAF Foundation

August 2014

## Acknowledgements

The information presented in this book was gathered from different studies carried out by IWMI in collaboration with many national and international partners. Our thanks go in particular to the Kwame Nkrumah University of Science & Technology in Kumasi, the University of Development Studies in Tamale, the University of Ghana in Accra, and the Development Planning Unit, University College London, UK.

The research was funded or co-funded by various donors between 2001 and 2014. These included – among others – the International Development Research Centre (IDRC), FAO, the RUAF Foundation, the CGIAR Challenge Program on Water & Food (CPWF), the Google Foundation, USAID under the Norman Borlaug Leadership Enhancement in Agriculture Program (LEAP) fellowship, WHO, the CGIAR Research Program on Water, Land and Ecosystems (WLE), and the GlobE – UrbanFoodPlus project, funded jointly by the Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung (BMZ, Federal Ministry for Economic Cooperation and Development), Germany and the Bundesministerium für Bildung und Forschung (BMBF, Federal Ministry of Education and Research), Germany. Similar to the first edition in 2006, data generation was supported by many colleagues and students. We would like to express our appreciation to all of them.

The publication of this second edition was made possible by a grant from the University of Sheffield, UK, and the CGIAR-WLE program led by IWMI.

The Editors

IWMI	<a href="http://www.iwmi.org">www.iwmi.org</a>
RUAF	<a href="http://www.ruaf.org">www.ruaf.org</a>
UrbanFoodPlus	<a href="http://www.urbanfoodplus.org">www.urbanfoodplus.org</a>

## 1. Irrigated Vegetable Farming in Urban Ghana: A Farming System between Challenges and Resilience

Pay Drechsel, Andrew Adam-Bradford and Liqa Raschid-Sally

*This chapter serves as an introduction to the book and provides brief information about urbanization in West Africa, and in Ghana in particular, the general role of urban agriculture and the common use of polluted irrigation water. It describes our focus on irrigated smallholder vegetable production and our understanding of the terms ‘urban’, ‘peri-urban’ and ‘wastewater’. The chapter reflects on some of the key challenges of the farming system, its dynamic and resilience. It also gives an overview on the structure of the book, the origins of the data and the main objective of this publication.*

### 1.1 The Urbanization Challenge

Globally, more people are living today in urban as opposed to rural areas. In West Africa, which hosts the megacity of Lagos, the population living in urban areas has increased from only 4% in 1920 to 45% in 2011. The 50% benchmark has probably been passed in the quickly urbanizing coastal belt of West Africa, while the drier and less populated northern belt remains so far mostly rural. For Ghana, a population split of 51.9% urban to 48.1% rural has been estimated (UN-DESA 2012a). In some of Ghana’s peri-urban areas, urbanization is galloping along with high annual growth rates of 6 to 9% (GSS 2002; 2012a). However, the 51.9% calculation should not imply that more than half of Ghana’s population lives in larger municipalities or cities. Each country has its own definition of ‘urban’ and in Ghana, settlements of 5,000 persons and above are classified as urban. Globally, the lower limit above which a settlement is considered urban varies considerably, ranging between 200 and 50,000 inhabitants (UN-DESA 2012b). Aside from human reproduction within cities, a second cause for the increasing urban population is the influx of economic migrants from rural areas in search of better livelihoods. The migrant influx into urban areas is very common across West Africa and requires urban planning to avoid the development of informal settlements and slums along the urban-rural continuum.

### 1.2 Urban and Peri-urban Agriculture and Food Security

Central to the urbanization phenomena are rapid increases in urban food demand that is coupled with increased demands for a wider range of food types that serve the emerging middle-class markets. These changes challenge food production, rural-urban linkages,

transport and traditional market chains. Specialized urban and peri-urban farming systems appear, like large-scale poultry production or high-input vegetable farming.

Urban and peri-urban agriculture can be broadly defined as the production, processing and distribution of foodstuff from crop and animal production, fish, ornamental plants and flowers within and around urban areas (Mougeot 2000). Although the terms ‘urban agriculture’ and ‘peri-urban agriculture’ are often used synonymously, we will use these terms as appropriately as possible. A major question for quantitative studies is where the urban and peri-urban areas start and end and where the rural ‘hinterland’ begins (Brook and Davila 2000; Simon et al. 2006). In our context we will refer to ‘**urban**’ as the administrative city boundary while ‘**peri-urban**’ is used for lands outside the immediate perimeter of the city but within a radius of up to 40 kilometres (km) of the city center (see chapter 2).

In Ghana, *urban* crop farming comprises two major systems: (i) open-space production for the urban market, and (ii) home gardens cultivated mostly, but not only, for home consumption (Table 1.1).

**TABLE 1.1.** The two major categories of urban and peri-urban crop farming in Ghana.

Farming systems	Urban areas	Peri-urban areas
<b>1. Market production</b> (smallholder farming, usually on undeveloped open land)	Exotic vegetables irrigated year-round or seasonal; flowers and ornamentals; rainfed cereals, especially maize	Dry-season irrigated vegetables (often indigenous species), rainfed cereals; commercial fruit and vegetable plantations
<b>2. Subsistence production</b> (cultivation around the house)	Home gardens (small scale); fruit trees, plantain, maize, cassava, local vegetables	Home gardens; farming around homesteads: cassava, plantain, maize

Source: Drechsel et al. (2006; modified).

In this book, we will focus on the first category, i.e. smallholder farming for city markets with a focus on irrigated vegetable production especially in urban areas. These farming systems are usually found on open lands along streams, which are unsuitable or prohibited for construction purposes, but favorable for seasonal or year-round irrigation. These farming sites can be far away from the place the farmer lives and are also called “off-site” compared to “on-site” home gardens, like backyard cropping.

The United Nations Development Programme (UNDP) estimated in 1996 that about 800 million people are actively engaged in urban agriculture worldwide and 200 million<sup>1</sup> are considered to be market producers (UNDP 1996). Urban market gardening focuses in many regions on easily perishable (exotic) vegetables with short shelf life, which complements rural food production where cold transport to the cities and cold-storage facilities are not available. Today, a significant share of perishable vegetables consumed in Ghana’s cities is also produced in their urban and peri-urban areas (see chapter 4). The same applies to Dakar, Bamako, Dar es Salaam, and many other African cities, where depending on crop and season, between 60 and 100% of the consumed leafy vegetables, like lettuce, are produced within or close to the respective cities<sup>2</sup> on irrigated open spaces (Mbaye and Moustier 2000; Drechsel et al. 2007; Smith 2002). This high percentage indicates a noteworthy contribution of urban vegetable farming to balanced urban diets (Zezza and Tasciotti 2008). Apart from increasing food security through direct supplementation of households’ food, urban agriculture in developing countries can also increase employment and income, which in turn, will enable people to purchase food to improve their diet or increase their general food security. In Ghana, the beneficiaries of urban vegetable production are up to 2000 urban farmers, 5,300 street food sellers, and 800,000 daily consumers within the major cities (Table 1.2; for details please see chapter 9) plus an unknown number of traders.

**TABLE 1.2.** Estimated number of urban farmers, street food (‘check-check’) kitchens, and urban consumers of exotic vegetables (lettuce, cabbage) in Ghana based on survey data and sector data.

<b>Urban farmers producing lettuce and cabbage</b>	<b>Street restaurants offering side dishes with lettuce or cabbage</b>	<b>Daily consumers eating dishes with raw lettuce or cabbage component</b>
Ca. 1700-2000	Ca. 3,600-5,300	Ca. 500,000-800,000

Source: IWMI estimates, 2008; updated 2014 (unpublished)

<sup>1</sup> Although this figure is only a vague estimate and probably outdated, there is so far no better assessment available.

<sup>2</sup> Some data, like “urban agriculture produces 90% of ‘all’ vegetables” consumed in Accra (CENCOSAD 1994), are misleading. High percentages only apply to certain leafy vegetables, while for example tomatoes and onions are produced far away and certainly ‘outweigh’ for example, lettuce or spring onions. Care has thus to be taken to state which vegetables are meant and if any share refers to fresh or dry weight, or volume.

### **1.3 Sanitation, Water Quality and Irrigation**

Other than increase in urban food demands, the upsurge of urban populations has far outpaced sanitation infrastructure and service delivery. This does not only apply to Ghana. About 2.6 billion people in the developing world lack access to basic sanitation. While WHO/UNICEF (2013) estimates that only 18% of Ghana's urban population has access to improved sanitation facilities, they also recognize that 70% of the urban population has access to shared facilities. However, none of these figures reflects what eventually happens to the captured excreta. Basically, 85% of wastewater generated from urban centers worldwide ends up in the environment in its untreated form. Also in Ghana only a minor share of the fecal sludge and wastewater are really treated and less than 5% of the population has sewerage connections.

Most domestic grey water passes through storm water drains into streams and/or the ocean (Chapter 6). Urban and peri-urban smallholders in search of irrigation water find it almost impossible to source unpolluted surface water or end up using water from drains. Thus the discussion of irrigated urban and peri-urban agriculture in Ghana is also a discussion of sanitation challenges, water pollution and food safety. In the context of this book we will use, for reasons of simplicity, the term 'wastewater' for all types of water polluted with fecal matter, from insufficiently treated **raw wastewater** to the **stream water** which it will pollute. All these forms are used in urban vegetable production across Africa, although polluted stream water is the most common type within urban and peri-urban settings (Chapter 7). IWMI (unpublished) estimated for Ghana an area of up to 40,000 hectares (ha) seasonally irrigated with our definition of wastewater around cities and towns. This is several times the equivalent of the total area currently under formal irrigation (schemes) in the country.

Wastewater use in agriculture is not new, and with the general global increase in water scarcity, it is seen as a key component of Integrated Water Resource Management (IWRM) supporting fresh water savings for domestic purposes. However, the use of (raw or diluted) wastewater in its untreated form could have negative impacts on public health and the environment. In Ghana, and the wider subregion, the major health concern is with **fecal-oral diseases** transmitted through pathogens (Amoah et al. 2011; see also chapter 9), while the flow of industrial effluents into urban and peri-urban streams is relatively low as larger industries are found only along the coast. So far water pollution from heavy metals does not exceed common irrigation standards (see chapters 6, 8, 9). Likely exceptions are streams passing gold mining areas, vehicle repair yards or tanneries.

#### **1.4 Dynamics and Sustainability of the Urban Agricultural Phenomenon**

Crop production on urban open spaces appears to be a market-driven, highly productive and profitable phenomenon (Drechsel et al. 2006). However, it is often constrained by tenure insecurity and non-agricultural land demands. While market proximity supports urban farming, urban expansion constrains it. Also the common use of polluted water limits the official support of irrigated urban farming. However, despite these constraints, the phenomenon of urban farming appears to be persistent and resilient to its changing environment, although individual farmers might have to shift to other sites when their plots are taken for construction (Drechsel and Dongus 2010). A comparison of different land-use categories in the same inner zone of Accra, between 2001 and 2008, showed a general decrease in open spaces and urban farm areas by over 50% (Forkuor, unpublished, see also next chapter). However, the analysis did not consider that in less densely populated city areas towards the city boundary vacant plots are often transformed into farmland. Moreover, up to 70% of all urban farmers in Ghana indicated that they had continuously cultivated their plots for more than 10 to 20 years. This is not only remarkable in view of limited tenure security, but also in a tropical context, which normally only supports shifting cultivation, especially on poor soils, and urban soils can be of particularly disturbed, moist or poor nature. Farmers cope with tenure insecurity and poor soils through targeted investment in highly effective manure, simple and movable technologies (watering cans) and the cultivation of short-duration crops for immediate cash returns. If farmers are expelled, they might move to another site in the vicinity or towards the fringe of the growing city. The Dar es Salaam example which was carefully analyzed over years supports this observation, as the same amount of area that disappeared emerged elsewhere during the observation period (Drechsel and Dongus 2010). In general, urban open space farming therefore resembles shifting cultivation in its dynamism, and also in terms of resilience through its ability to recover after disturbances with a spatial shift. Thus, the overall phenomenon of urban open-space farming appears to persist although individual farmers or farmer groups might have to change sites unless they are on land that is flood prone or excluded from construction.

#### **1.5 Book Objectives and Structure**

This book is a state-of-the-art summary of the current information about open-space urban vegetable production in Ghana and the challenge of wastewater irrigation. Topics covered in this book include, *inter alia*, the general importance of urban vegetable farming, common

farm practices, economics and externalities, gender issues, produce quality and possible health risks, safe wastewater use, stakeholder perceptions, land access and land security. The information is mainly based on different studies initiated and supported by IWMI in Ghana over the last 10+ years. Many local and international partners contributed to these studies as the Acknowledgements and affiliations of our chapter authors show. The book complements, as a Ghana country case study, the related overview on informal irrigation in urban West Africa (Drechsel et al. 2006).

Following this Introduction, the book is divided into three larger sections:

- PRACTICES, ACTORS AND ECONOMIC ASPECTS
- POSSIBLE HEALTH RISKS
- STRATEGIES TO ENHANCE SAFETY AND PRODUCTIVITY

The first section (PRACTICES, ACTORS AND ECONOMIC ASPECTS) starts by giving a short description of the main farming sites and cropping systems found in vegetable irrigation in Ghana's major cities (Chapter 2). Characteristics of urban farmers and traders, and related gender roles are described in chapter 3. Chapters 4 and 5 describe financial, economic and marketing aspects, and show who eventually eats exotic vegetables in the city.

The second section (POSSIBLE HEALTH RISKS) emphasizes irrigation and soil fertility management practices as well as health risks for farmers and consumers where irrigation water quality is poor. It shows common contamination levels of water and vegetables found in Ghanaian farms and markets (Chapters 6 to 9), followed by a description of stakeholder risk perceptions (Chapter 10).

The third section (STRATEGIES TO ENHANCE SAFETY AND PRODUCTIVITY) looks at options to strengthen farmer organizations and financing urban agriculture (Chapter 11 and 12), land-use planning (Chapter 13) and options for health risk reduction as studied in Ghana (Chapter 14). Related institutional and policy aspects are discussed in chapter 15.

## 2. Urban Vegetable Farming Sites, Crops and Cropping Practices

George Danso, Pay Drechsel, Emmanuel Obuobie, Gerald Forkuor, and  
Gordana Kranjac-Berisavljevic

*The chapter describes the major sites of open-space vegetable farming in Ghana's main cities. It also presents the principal cropping systems and characteristics of urban farmers involved in irrigated vegetable production.*

### 2.1 Key National Features

Ghana lies on the coastline of the Gulf of Guinea in West Africa and occupies a total area of about 239,460 square kilometres (km<sup>2</sup>). It is bordered by Burkina Faso in the north, Togo in the East, Côte d'Ivoire in the West and the Gulf of Guinea in the south. The country is divided into 10 administrative regions and six ecological zones, dominated by semi-deciduous forest in the south and Guinea savannah in the north (Figure 2.1).

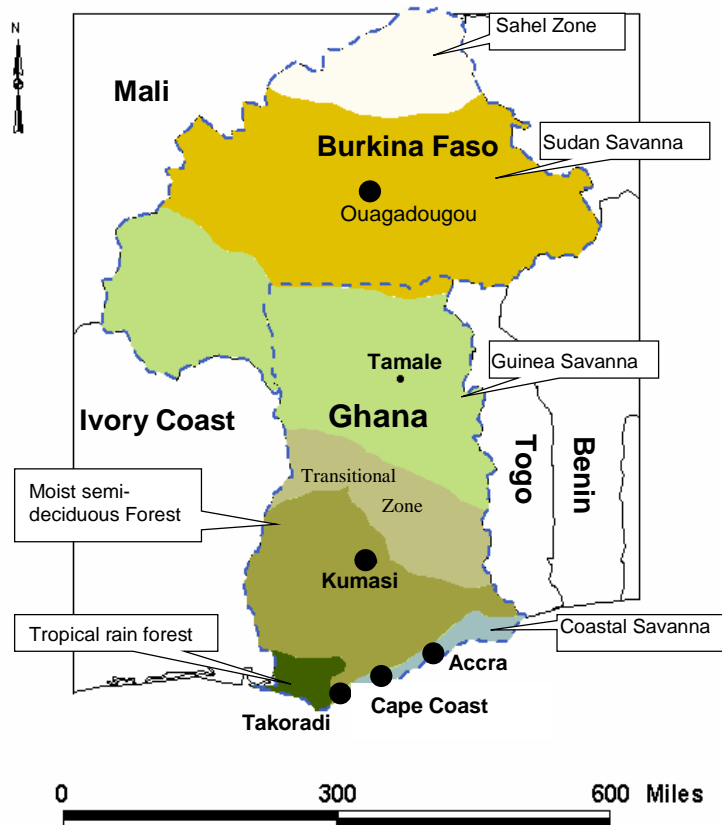


FIGURE 2.1. Ecological zones and major cities in Ghana (Source: IWMI).

The topography is predominately gently undulating with elevations mostly below 500 metres (m). Annual rainfall ranges from about 800 millimetres (mm) in the southeast along the coast in Accra to about 2,200 mm in the extreme southwest. While the southern parts of the country experience bimodal rainfall pattern with peaks in June and October, the north has a monomodal rainfall pattern with a peak in September. The mean annual temperature is about 30°C. For most parts of the country, temperatures are highest in March and lowest in August. The north experiences hot days and cool nights between December and March due to the dry and dusty West African Trade Wind (Harmattan) which blows south from the Sahara into the Gulf of Guinea. In the south, the effects of the Harmattan are felt mostly in January. Humidity is high in the south particularly on the coast where relative humidity can be 95-100% in the morning and about 75% in the afternoon. The north experiences low humidity with relative humidity values of 20-30% during the Harmattan period and 70-80% in the rainfall season (April/May to September). Annual potential open water evaporation has been estimated as ranging from about 1,500 mm in the south to more than 2,500 mm in the north. The conditions in the synoptic stations in Accra, Kumasi and Tamale (Table 2.1) summarize the climate in the southern, middle and northern belts of Ghana, respectively.

**TABLE 2.1.** Climatic data from north, middle and south Ghana (Agodzo et al. 2003).

Long-term yearly averages	Unit	South (Accra)	Middle (Kumasi)	North (Tamale)
Rainfall regime		Bimodal	Bimodal	Monomodal
Rainfall	mm	810	1,420	1,033
Temperature	°C	27.1	26.1	28.1
Relative humidity	%	81	77	61
Wind speed	km/day	251	133	138
Sunshine	Hours/day	6.5	5.4	7.3
Solar radiation	MJ/m <sup>2</sup> /day	18.6	17.0	19.6
Potential evapotranspiration	mm	1,504	1,357	1,720
Aridity index*		0.54	1.05	0.60

\* Aridity index = rainfall/potential evapotranspiration.

The provisional results of the population and housing census conducted in 2010 showed that the total population of Ghana in 2010 was around 24,233,000 (GSS 2012a). Women represented more than half of the population (51.3%). All the 10 regions of the country experienced increases in population but the highest increases were recorded in Northern (35.6%) and Greater Accra (34.6%). The intercensal growth rate (between 2000 and 2010) was 2.4% per annum, which is a decline from the previous growth rate of 2.7 % (between

1984 and 2000) (GSS 2012a). The population density for the entire country recorded in 2010 was 102 persons per square kilometre. This figure is almost a double the 1984 figure (52 persons per square kilometre). This is an indication that the pressure on land is increasing. The pressure on land is much more in the Greater Accra region where population density is 1,205 persons per square kilometre.

Ghana's economy is largely informal with about 90% of all the economically active people (age: 15-64 years) informally employed, mostly in the private agricultural sector. Agriculture, particularly small scale, is the backbone of the economy accounting for nearly one-third of the Gross Domestic Product (GSS 2012b). Agriculture is mostly rainfed, i.e. heavily dependent on the onset and reliability of precipitation. However, less than 1% of the arable land is currently under formal irrigation (Namara et al., 2011).

The following pages present brief descriptions of the main cities and their urban agricultural activities with particular focus on irrigated open-space farming.

## **2.2 Irrigated Urban Agriculture in Ghana's Major Cities**

In Ghana, urban vegetable farming dates back to the arrival of Europeans. It is likely that the vegetables were grown in the gardens created around the castles and forts along Ghana's Gold Coast from the sixteenth century onwards (Anyane 1963). Also during the Second World War, agriculture was promoted everywhere in order to help feed the allied troops in the Gold Coast (Ghana). In the 1970s, in the economic post-independence crises, the government supported urban agriculture to meet the population's food demands. A national program called 'Operation Feed Yourself' was launched and the population was encouraged to plant anywhere and everywhere in the cities including the use of aquaculture (Asomani-Boateng 2002). In the late 1990s, the decentralization of the Ministry of Food and Agriculture provided urban farming with renewed support, as each district received its own Agricultural Directorate with extension staff (including all cities). However, staff were not necessarily trained in the idiosyncrasies of urban farming. To the present day backyard gardening remains a well-accepted activity socially, especially in the middle income group with sufficient space, such as civil servants.

Open-space farming on the other hand has receives feedback. Livestock roaming in the city center and the use of polluted water for vegetable irrigation in particular have been the subject of considerable debate. The diversity of authorities with a stake in open-space urban farming (e.g. the Ministries of Food and Agriculture; Town and Country Planning; Forestry, Parks and

Gardens; Urban Planning; and the Public Health Department) does not make such a discussion easy. However, in a Vision Statement on urban and peri-urban agriculture in Accra, the Ministry of Food and Agriculture pledged in 2005 its full support and called for ways to overcome any possible challenges (see chapters 10 and 15). The following sections describe the main features of urban vegetable farming across Ghana. Compared with the previous edition of this book (Obuobie et al. 2006), we see at those sites reported then in Accra and Tamale a 36 to 50% decline in urban vegetable farming areas, respectively. However, we also see many new sites, or at least sites we were not aware of at that time. A spatio-temporary analysis is challenged by the question of which city boundary/boundaries should be used as baselines in the different years (see also discussion in chapter 1.4).

### **2.2.1 Accra**

Accra is the capital of Ghana and covers an area of around 200 km<sup>2</sup>. In the current administrative boundary of the Accra Metropolitan Area (AMA), there is an estimated population of 1.85 million (GSS 2012a). Accra's population growth rate in 2000 was about 3.4% annually within the already densely populated AMA boundary. The actual population growth rate reached at that time 6 to 9% outside this boundary. This functional boundary of the Greater Accra Metropolitan Area (GAMA), as the urban dwellers perceive it, has 3.76 million inhabitants which is nearly the same as the 4 million population of the Greater Accra Region (Twum-Baah 2002; GSS, 2012a). About 60% of Accra's population lives in informal settlements in the center of the city while the middle and upper classes prefer its periphery.

Accra lies within the coastal savannah zone (Figure 2.1) with low annual rainfall averaging 810 mm distributed over less than 80 days (Table 2.1). The rainfall pattern of the city is bimodal with the major season falling between March and June, and a minor rainy season around October. Mean temperatures vary from 24°C in August to 28°C in March. Natural drainage systems in Accra include several streams, ponds and lagoons (e.g. Songo, Korle and Kpeshie lagoons). Floodwater drains and gutters are used for gray water, and often drain into the natural system, polluting heavily the lagoons and most beaches. About 60% of the urban area drains into the Odaw River which passes the Korle Lagoon before flowing into the ocean. The wastewater and solid waste that the Odaw receives constitute a major environmental disaster (Figure 2.2).



FIGURE 2.2. Odaw River in central Accra (photo: IWMI).

Irrigated urban vegetable production takes place on more than six larger sites within central Accra (Figure 2.3). Within the AMA boundary, in 2005 about 680 ha were estimated to be under maize, 47 ha under vegetables and with seasonal variation about 251 ha under mixed cereal-vegetable systems. Some of the sites have been in use for more than 50 years (Anyane 1963) and their sizes are still changing under current development (Figure 2.4). Some farm areas, as in La, are shrinking or disappearing, while to date unused space, in the city and in new suburbs, are newly cultivated.

Apart from open-space farming, about 50-70 additional hectares are distributed over 80,000 tiny home gardens (often just a few plantains and chickens) involving nearly 60% of Accra's houses (Obuobie et al. 2006). This figure is much higher than the one of Maxwell and Armar-Klemesu (1999) who surveyed mostly low-income and high-density suburbs. The extent of the peri-urban area of Accra was estimated following the methodological approach described in Adam (2001) for Kumasi. Based on the results, we propose an average radius of 38 km from the city center, with more outreach along the Accra-Kumasi road, and less in-between the major roads. In this peri-urban area, farmland is increasingly converted into settlements but agriculture still plays a significant role. Large-scale pineapple plantations are a major feature of peri-urban Accra which supports, among others, the European market. Also foreign companies started investing in the Accra plains for the cultivation of high value vegetables.

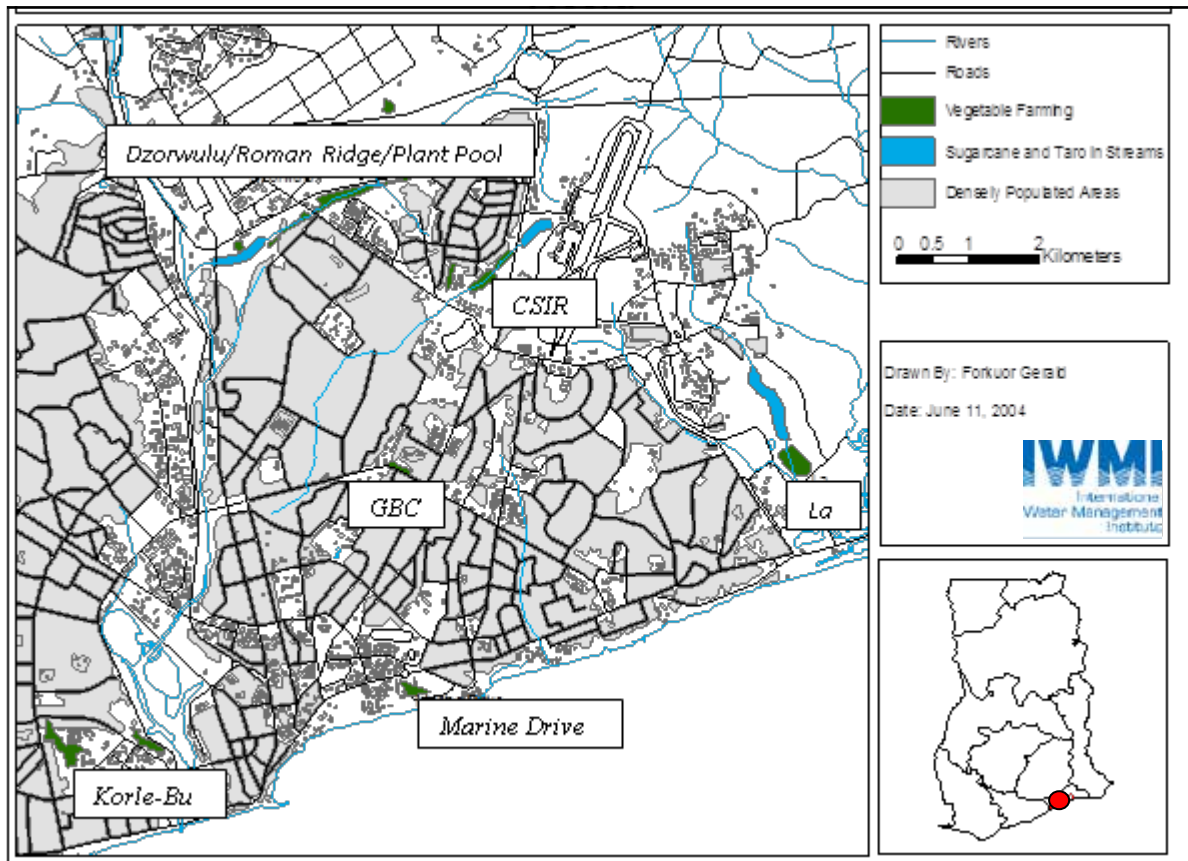


FIGURE 2.3. Vegetable-producing sites in central Accra (Obuobie et al. 2006).

### Major Irrigated Vegetable Farming Sites in Accra

In Accra, including Ashaiman and Tema, there are about 800 to 1,000 vegetable farmers<sup>1</sup> of whom 60% produce exotic and 40% indigenous local or traditional vegetables. Some of the exotic crops cultivated are lettuce, cabbage, spring onions and cauliflower while the more traditional crops are tomatoes, okro (okra), *ayoyo* (*Corchorus sp.*), garden eggs (aubergine) and hot pepper. Plot sizes under cultivation in the city range between 0.01 and 0.02 ha per farmer with a maximum of 2.0 ha in peri-urban areas. The plot sizes of several of these sites, especially behind the Korle-Bu hospital and in the La area, have diminished over time because of land loss to housing development or widening of drains. An additional problem faced by farmers in relation to their farms is tenure insecurity, as formal contracts are rare, and low soil fertility. The locations of some of the irrigated (open-space) vegetable farming sites in the city cited here are shown in Figure 2.4.

<sup>1</sup> See also MoFA ([http://mofa.gov.gh/site/?page\\_id=1561](http://mofa.gov.gh/site/?page_id=1561); accessed 26 August 2014) with selected data on urban farms and farmers in AMA which are cited e.g. in Caradonna et al. (2012) and go back to Obuobie et al. (2006), RUAF surveys, and MoFA surveys on crop and livestock production between 2006 and 2009.

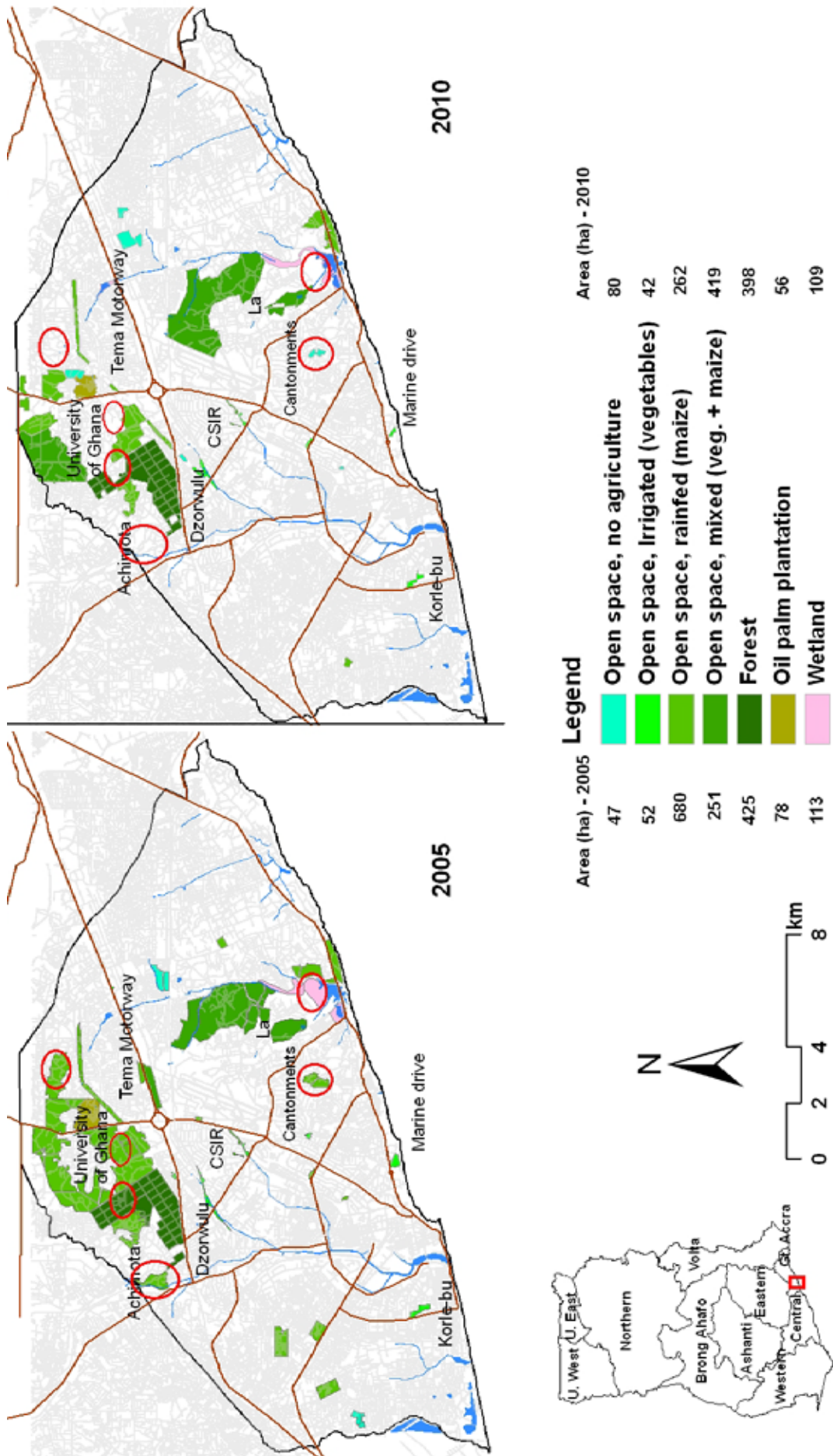


FIGURE 2.4. Map showing open spaces and farming activities in Accra in 2005 and 2010. Red circles indicate areas with significant change (IWMI, unpublished).

Some of the major farming areas are:

- **Dzorwulu/Roman Ridge/Plant Pool:** The three sites are in close proximity covering in total about 10 ha. During the early 1970s the Dzorwulu site served as the first model farm of the Ministry of Food and Agriculture (MoFA). The numbers of farmers vary between years but there are around 100 on all three sites together with only 10% of them being women. Most additional laborers are young migrants from Burkina Faso. A mutual agreement has been formalized with the local authorities for farming in the area as a way of maintaining the land and to prevent any nonagricultural encroachment. The Onyasia stream cuts across the farming sites (Figure 2.5). It is channeled in this part of Accra like a drain and has a similar function. Some farmers use pipe-borne water, most however water from the drain or smaller drains channeled into shallow reservoirs (dug-outs). There are about 130 of such small ponds on this site. Some are interconnected (Figure 2.6). Several are also filled with piped water.
- **Korle-Bu:** This farming site neighbors the largest hospital in Ghana. Many farmers are hospital staff like security guards, cleaners, etc. who farm to supplement their income. In 2008 about 8 ha were cultivated by 70 farmers (with one exception all men). Several attempts have been made at forming a farmers' association. The land belongs to the hospital and farming is done under an informal arrangement to keep the area clean and prevent nonagricultural encroachment. Water is derived from drains, which pass through the hospital compound and staff apartments.



FIGURE 2.5. Parts of the Dzorwulu site (photo: Mary Lydecker).

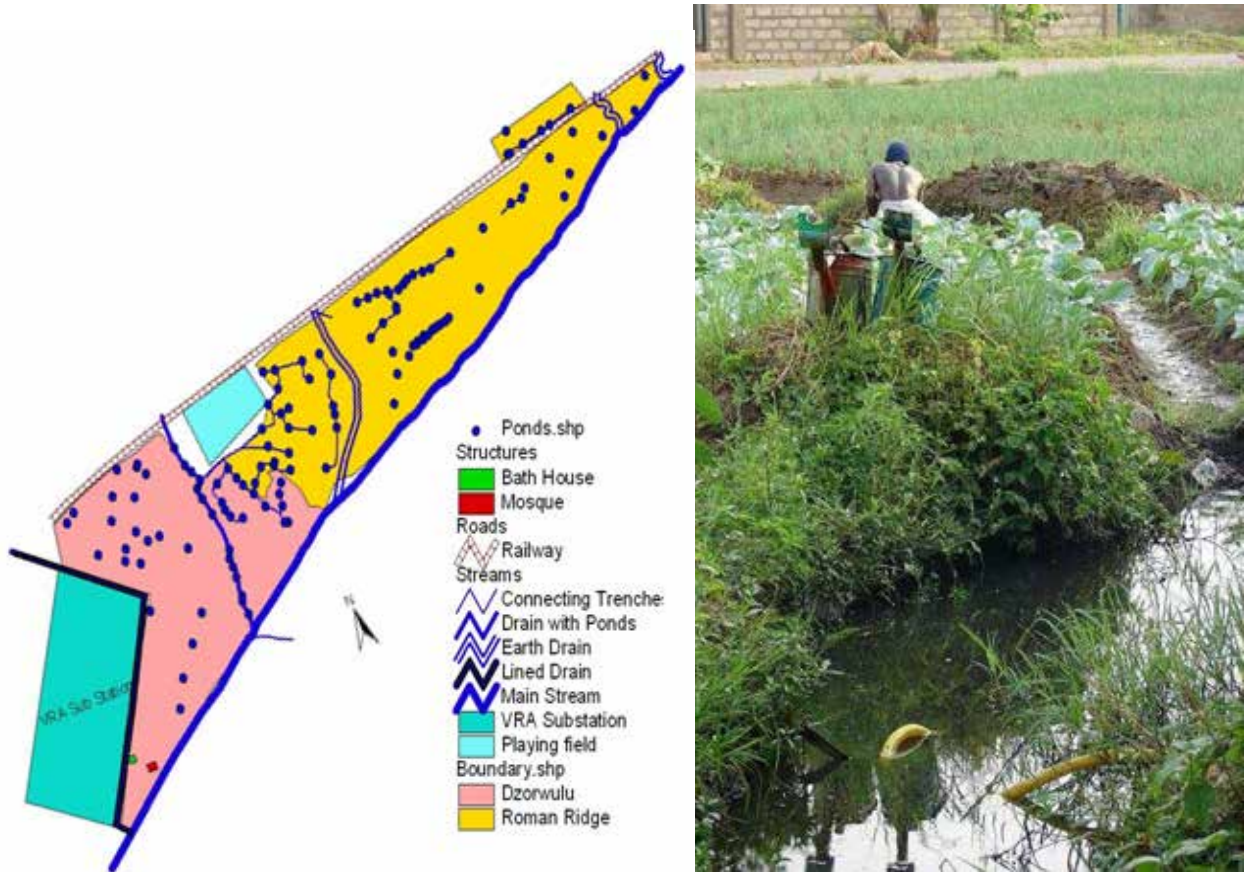


FIGURE 2.6. Distribution of individual and interconnected ponds and dugouts on the Dzorwulu and Roman Ridge sites in Accra, drawing water via pumps from streams and drains (photo: Philippe Reymond).

- **La:** This is probably the largest informally irrigated site in Accra with up to 400 ha under farming before 2000 of which at least 40 ha were under irrigation, rainfed farming or fallow land. However, the site which was once famous for its large-scale okro production, has experienced a development boom since mid-2000 and lost especially between 2009 and 2012 about half of its arable land to housing (Caradonna et al. 2012) forcing farmers to shift plots within and outside the La area.

The most common water source is raw larger or diluted wastewater from the nearby (military) ‘Burma’ camp while other farmers also use pipe-borne water, stream water or water from the final treatment pond of the largely broken down Burma camp wastewater treatment plant. It is in this respect the only site where ‘treated’ as well as raw wastewater are used and also where furrow irrigation is practiced as farmers block the streams to divert the flow through a gravity-based system to their okro, tomato, pepper or maize fields. La is also unique as the gender ratio of farmers is nearly balanced. Since 1988 the

site has had a functional farmer association with a peak of 425 members in 1998. Landownership in La is complex with customary and statutory land rights. The current number of farmers in the south, east and north of the Burma camp is estimated at 200 to 340 cultivating about 140 to 200 ha, mostly rainfed (see also chapter 13).

- **Marine Drive**, near Independence Square: Farming in the area began before 1983 via a church and was aimed at providing employment for local youth and reclaiming the land. The land being cultivated belongs to the Department of Parks and Gardens and was originally zoned by the AMA as an open space in line with the beautification of the metropolis policy. However, lack of funds, time and logistics has motivated the Department of Parks and Gardens to enter into an informal agreement with farmers. The site still had 100 farmers (one woman) aged between 18 and 60 years in 2008. The potential farming area covered at that time was 3.5 ha. Water is provided through a narrow wastewater drain connecting the inner-urban area called 'Ministries' and the ocean. Recent reports indicate that farming activities on the site have been reduced by half or more.
- **Roman Down**: The site of approximately 22 ha is located in the Ashaiman Municipality, part of the GAMA, downstream of the Ashaiman Irrigation Scheme. The site is a natural floodplain receiving water from the reservoir and a stream draining the nearby township. The scheme area including Roman Down was leased by the Ghana Irrigation Development Authority from the traditional councils. Like the other sites, farmers have no formal tenure agreements but are allowed to farm on the site. There are approximately 40-60 farmers on the site of whom about 20 are women (see also chapter 13). Most are members of a local farmers' association which has been fighting increasing housing encroachment since 2006.

Other sites in Accra are, for example in the Airport Residential Area around the Council for Scientific and Industrial Research (CSIR) and IWMI office or close to the Ghana Broadcasting Company (GBC), at the University of Ghana in Legon, as well as east of the airport.

### 2.2.2 Kumasi

Representing the middle belt of Ghana, Kumasi is the capital of the Ashanti Region and the second largest city in Ghana with a 2010 population of 2.04 million (GSS 2012a). Kumasi itself has a total area of about 250 km<sup>2</sup> of which about 40% is open land. Kumasi has a

semihumid tropical climate and lies in the tropical forest zone (Figure 2.1) with an annual average rainfall of 1,420 mm over about 120 days. The rainfall pattern of the town is bimodal with the major season occurring between March and July and a minor rainy season around September and October.

Important streams and rivers include the Owabi River, which flows through the suburb of Anloga; Subin River, which passes through Kaasi and Ahensan; and Wiwi River, which runs through Kwame Nkrumah University of Science and Technology (KNUST) campus. As the rivers have a number of tributaries, the city is rich in waterbodies. The inland valley areas with low groundwater levels surrounding the streams are unsuitable for construction but of high value for urban vegetable production.

Vegetables are also produced in peri-urban Kumasi where more than 10,000 ha were recorded under seasonal vegetable farming (Cornish and Lawrence 2001), which is twice the area under formal irrigation in the whole country.

In the city, at least two out of three households have some kind of backyard farming. A much higher percentage has at least a few plantain crops or poultry (IWMI, unpublished). The peri-urban area of Kumasi has a radius of approximately 40 km from the city center (Blake and Kasanga 1997; Adam 2001). It is characterized – among other features – by a concentration of large poultry farms (the largest farm had depending on the season up to 300,000 birds); however, the poultry industry is today under strong import pressure (Zachary 2004). Lying in the ‘tuber belt’ of West Africa, cassava, plantain, maize and other traditional staple food crops are dominant on upland sites, often accompanied by dry-season vegetable farming especially along streams.

### **Major Irrigated Vegetable Farming Sites in Kumasi**

In urban Kumasi, most land where farming occurs belongs to government institutions, like the university, and private developers. In 2014, IWMI estimated 59 ha (145 acres) of vegetables in the dry season and 48 ha (118 acres) in the rainy season, cultivated by 300 men and 23 women farmers on about 20 farming sites (Table 2.2). This is more than what was estimated in 2005 in the same city boundary<sup>2</sup>. The largest agglomeration of farms remains in the lowlands around the KNUST University (Figure 2.7).

---

<sup>2</sup> The total area used for open space farming in the city (including tubers and cereals) was about 70 ha in 2005 with 41 ha under irrigated vegetable farming (Obuobie et al. 2006).

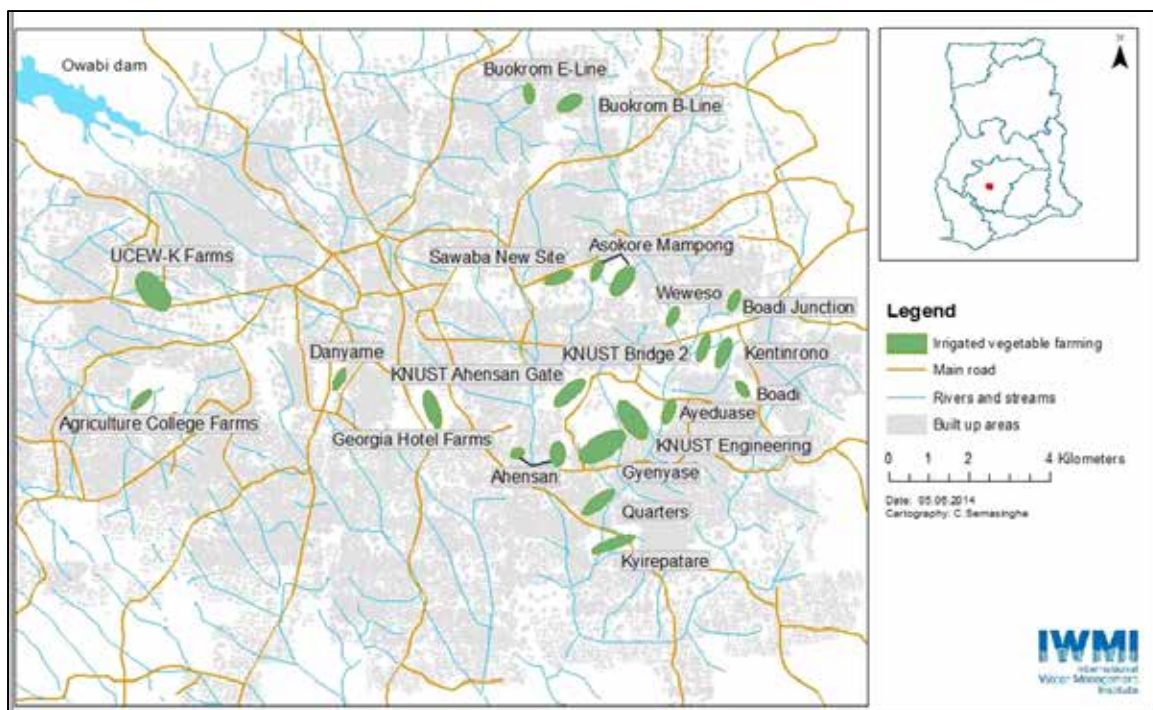


FIGURE 2.7. Vegetable-producing sites in urban Kumasi in 2014.

TABLE 2.2: Features of urban vegetable irrigation sites in Kumasi (IWMI, unpubl., 2014).

Kumasi Sub metro	Farming site names	Acres dry/wet season	No. of farmers (male/female)	Commonly grown vegetables	Common water sources	Irrigation methods
KWADASO	Agric. College Farms and UCEW-K Farms	21/10	20 (19/1)	Cabbage, Green pepper, Carrot, Lettuce	Stream, pipe	Watering can, pumps
NHYIASO	Danyame and Georgia Hotel	3/3	6 (6/0)	Spring onions, Lettuce, Cabbage, Carrot	Shallow well, Stream	Watering can, pumps
MANHYIA	Buokrom B- and E-Line	3/2	7 (5/2)	Spring onions, Lettuce	Shallow well, Stream	Watering can
ASAWASI	Asokore Mampong; Sawaba New site	19/19	41 (41/0)	Cabbage, Spring onions, Cucumber	Stream, shallow well	Watering can, pumps
OFORIKROM	All sites at KNUST north of Gyenase	46/37	152 (134/18)	Spring onions, Cabbage, Lettuce, Pepper, Spinach, Garden eggs	Shallow well, Stream	Pump, watering can
ASOKWA	Kyirepatare, Ahensan, Gyenase, Quarters	53/47	97 (95/2)	Cabbage, Lettuce, Spring onions, Cauliflower	Stream, Shallow well, pipe	Pump, watering can
<b>Total</b>		145/118	323 (300/23)			

### 2.2.3 Tamale

Tamale is the capital of the Northern Region. The Tamale Metropolitan District covers a large area of about 930 km<sup>2</sup> including the city itself and about 30 surrounding villages. Its 2010 population was estimated at about 371,000 of which 274,000 lived in urban Tamale (GSS 2012a). Urban Tamale extends up to 10 km from the city center, while peri-urban Tamale extends about 40 km northwards and 30 km southwards along the busy Accra-Ouagadougou highway. To the west and east, the peri-urban area extends approximately 16 km to Nyankpala and 20 km to Taha (IWMI, unpublished).<sup>3</sup>

Tamale lies in the Guinea-savannah belt (Figure 2.1) with only one rainy season from April/May to September/October, followed by a prolonged dry season. The city is poorly endowed with waterbodies. There are a few seasonal streams, with enough water during the rainy season, but they dry up during the dry season (Giweta 2011). However, the average annual rainfall is higher than in Accra with about 1,033 mm over about 95 days of intense rain. The dry season lasts usually from November to March. Every fourth household has a small backyard with at least a few crops or poultry (IWMI, unpublished). There are also some larger privately owned fields in the urban area (i.e. rural remains) which are used for maize, okro or rice in the rainy season and mostly local vegetables in the dry season.

#### Main Irrigated Vegetable Farming Sites in Tamale

As no permanent streams pass through Tamale, most vegetable farming relies on reservoirs, piped water or is carried out along stormwater drains. About 60% of the farmers grow vegetables only during the dry season, a minority year round, while most switch to maize in the rainy season. More than half of those farmers who irrigate depend on heavily-polluted water sources in the dry season. Nearly all use watering cans and buckets to apply water to their crops (Zibrilla and Salifu 2004; Abubakari et al. 2011). Attempts to explore groundwater for urban farmers have failed because of the high cost of achieving the required depth (about 60 m in many cases).

Figure 2.8 shows some of the major farming sites in and around the city center. The total area under informal irrigation appears to have decreased on the major sites from about 20 to 10 ha between 2006 and 2012, while new sites were reported in recent surveys by the University for Development Studies (UDS). However, there are significant variations over the year making

---

<sup>3</sup> The assessment of the peri-urban area in 2003 was based on the approach outlined by Adam (2001).

it difficult to compare surveys in dry and rainy season, especially in view of the number of hectares under irrigated crops. On most sites maize is grown during the rainy season.

The most common vegetable is cabbage, followed by lettuce, *alefu*, *bra* and sweet pepper, while less than 5% of farmers include spring onion, garden eggs, okro, tomatoes, carrot and *Corchorus* spp. (Abubakari et al. 2011; Giweta 2011; see Table 2.2).

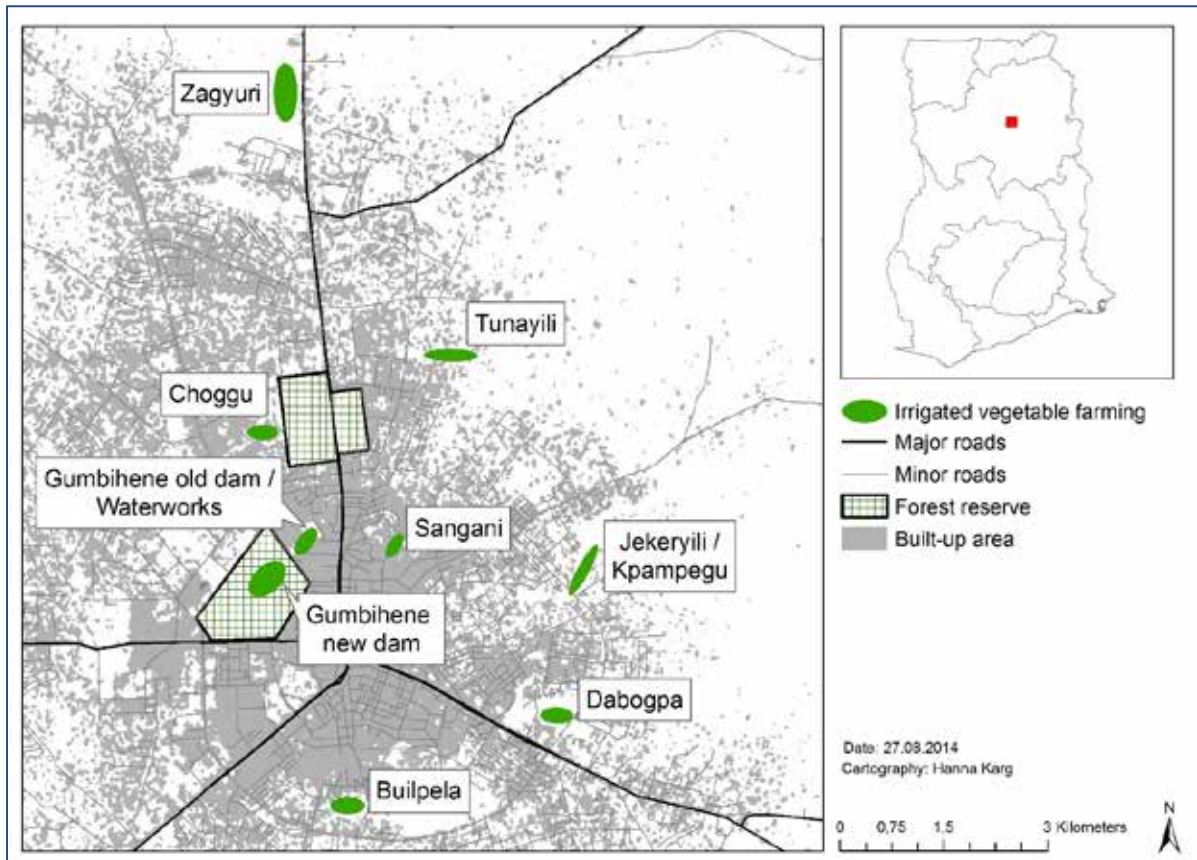


FIGURE 2.8. Main urban vegetable production sites in Tamale in 2014 (Hanna Karg; UrbanFoodPlus project, unpublished).

Examples of some well-known urban vegetable farming sites in and near Tamale are listed below. Most sites suffer from encroachment but some sites like Dobogpa or Tunayili were not reported in the first edition of this book:

§ **Bulpiela (Builpela):** This site is about 2 km south from the center of Tamale. Between 20 to 50 farmers use a dam that was built in 1960 to supply water for domestic use, livestock and vegetable cultivation. The area under vegetable cultivation has decreased from 6 to about 2.5 ha over the last seven years due to house construction (Zibrilla and Salifu 2004; IWMI, unpublished survey 2008, 2012). The numbers of farmers are reported to be still declining and are especially low in the rainy season.

- § **Sangani:** Located 2 km north-east of Tamale town center. Farmers use water from a hand-dug well while a borehole provides drinking water. Reported areas under cultivation and the number of farmers have declined due to competition for water – from about 2 ha in 2006 to 0.5 ha in 2012, and 90 to about 30 farmers. However, another source reports about 5 ha (Giweta 2011).
- § **Water Works/Gumbihene:** Water comes from a reservoir originally built to provide water for Tamale Municipality, but the reservoir is now too polluted for this purpose. Water flowing through the dam is used by vegetable farmers all season round while others use piped water, which is at Gumbihene Old Dam, treated water. Vegetable irrigation areas at Gumbihene Water Works, Gumbihene New Dam and Gumbihene Old Dam vary among different sources (13.5 to 22 ha, with up to 300 farmers). The downstream area declined since 2006 from 10 to about 6 ha.
- § **Zagyuri:** This site is near Kamina Barracks where in peak times up to 120 farmers on 20 ha use untreated sewage from a broken sewer/treatment plant. The site is about 8 km from the city center with currently 2 to 4 ha under dry-season vegetable production while in the rainy season up to 8 ha are under maize farming.
- § **Dabogpa:** Located about 3 km to the south from the town center near the Ghanasco dam. Reports on the number of vegetable farmers vary between sources and seasons from three to 66, while maize is grown in the rainy season. Farmers have to compete with Ghana Senior High School (Ghanasco) for the water.
- § **Choggu (Chufrini, Chefruguni):** Located about 3 km from Tamale central towards the north-west. Around the dam farmers use reservoir water (Figure 2.9ab). Slightly further away (towards the north-west) some farmers have access to piped water, likely from a well. In the beginning of the dry season a drain coming from the dam is still filled with water and farmers who are further away from the dam (towards the east) use that water. Around 60 farmers use the site for irrigation on about 7 ha.

In Tamale, some farmers' associations, NGOs, municipal authorities and research institutions have formed the 'Urban Agriculture Network – Northern Ghana' (UrbaNet) under facilitation by *Action Aid*. The main tasks of the network are farmer group development, capacity building and advocacy for land security (Amarchey 2005; Abubakari et al. 2011). According to UrbaNet, there are seven vegetable grower

associations in and around Tamale Metropolis, all forming part of The Northern Region Vegetable Farmer's Union (NRVFU), with total of 614 members (Giweta 2011).



FIGURE 2.9a: Vegetable beds near the reservoir at Choggu, Tamale (image by Google Earth, 6 January 2014).



FIGURE 2.9b:  
Detailed view of  
Figure 2.9a above  
taken by an UAV  
(Unmanned Aerial  
Vehicle), commonly  
known as “drone”, by  
Johannes Schlesinger,  
UrbanFoodPlus  
Project; 2014  
(unpublished).

### 2.2.4 Other Cities

**Cape Coast:** The Central Region in general and the Cape Coast Metropolitan area in particular are known for their high tourist potential. Many beach resorts, hotels and guest lodges warrant a high and unceasing demand for vegetables within this area. However, the region is also very dry or marshy and irrigated vegetable farming is limited to several small areas, with the exception of 0.5 ha near the Ameen Sangari office, and less than 1 ha on the Cape Coast University where exotic vegetables, okro, garden egg and carrots are cultivated year round using stream or pipe-borne water. In IWMI's 2008 survey only around 10-20 farmers were counted. The bulk (over 90%) of the vegetables consumed in and around the Cape Coast municipality comes from as far as Togo or Kumasi and rural areas surrounding the Cape Coast District.

Based on interviews and observations, reasons for the insignificant level of urban vegetable production include: (1) general scarcity of nonsaline surface or groundwaters including perennial streams; (2) the saline nature of the soils and (3) unsuitable hilly topography with flood-prone flatlands. Particularly during the dry season (October to March) when vegetable prices allow for high returns, the biophysical potential for irrigated urban agriculture is very low. Significantly fewer migrants from the north (compared to Accra for example) and a local preference for fishing are further factors limiting the in-situ development of irrigated vegetable production.

**Sekondi Takoradi:** There are smaller urban and peri-urban irrigated vegetable production sites in the Sekondi Takoradi metropolis where a considerable amount of vegetables is produced. These are located in areas commonly known as the Air Force Strip, Polytechnic, Airport Ridge, Pioneer Tobacco Company and Kwesimintsim (near the 'Obiri' lotteries building). Except for the larger site at Airport Ridge (4.6 ha in 2008), the total area of the other sites covers about 1 ha. Farm sites at both the Air Force Strip and Airport Ridge are all located on land that belongs to the Ghanaian air force. Here farmers by a small annual fee for land cultivation. Almost every farmer cultivates year round. Most farmers in Takoradi use streams as water sources. Streams crossing the town are highly polluted as they function as natural drains for urban wastewater. The total number of farmers in the city was estimated as 80 in 2008 (IWMI, unpublished).

**Techiman:** Within Techiman, which is a leading market town in Central Ghana, staple crops are significantly more often cultivated than irrigated vegetables (Turner, 2013). Vegetables follow in importance to maize, plantain, fruit trees and yam, and are mostly grown in backyards, but so far not on any noteworthy open space in the town (Mackay Niittylä, 2013). However, in the vicinity of Techiman, larger (formal) irrigation schemes, like in Tanoso and Akumadan, are specialized for example in tomato, okro and garden egg cultivation.

### 2.3 Farming Characteristics, Crops and Land Tenure

Open-space vegetable farming is conducted mainly for commercial purposes. Only farmers specialized in traditional (indigenous) vegetables consume a part of such produce. In Kumasi, vegetable farming is done year round, whereas in Accra and especially in Tamale many of the vegetable sites are (also) used for maize and sorghum in the rainy season. Also in peri-urban areas, in particular around Kumasi, vegetables are mostly produced in the dry season when prices are high. Farm sizes are increasing in urban and peri-urban areas with usually 0.02 to 0.1 ha in the cities and up to 1.0 ha in the peri-urban area. As rainfall is high, vegetable farming is done on raised beds, which can vary in size (mostly length) – between 3 to 14 m<sup>2</sup>. Farmers might own 12 to 80 beds (Figure 2.10).



FIGURE 2.10. Vegetable production on long beds in Accra (photo: IWMI)

Due to high labor requirements (land preparation, weeding, watering etc.) farmers with larger land areas have to hire labor or rent a water pump. Family labor is common (cousins, brothers) but also young migrants, especially from Ghana's north, Togo or Burkina Faso are working on urban farms. Poultry manure is generally the preferred and cheapest nutrient source, but commercial fertilizer is also used, e.g. on cabbage.

Most urban farming sites are on lands belonging to governmental institutions and departments or private developers who have not yet started constructing. Preferred farming sites are those in reserved areas along streams or other water sources. Farmers normally do not pay for access to land or water and only have an informal agreement with the landowner or caretaker. As such there is no security of tenure as they are allowed to farm only as long as the owners do not need the land. On other sites, belonging for example to the air force authorities in Takoradi, farmers pay a fee to use the land. Fees vary between USD5/year to USD10/month. In other cases, like in La or Dzorwulu, farmers function as caretakers to avoid any more permanent encroachment of the land. In general, land tenure becomes more secure towards the peri-urban fringe where land is usually owned under customary rights and distributed according to traditional regulations (Flynn-Dapaah 2002). One exception in the urban context is the site of La, where nonindigenous farmers formerly paid to the customary owners of the land or had to agree on sharecropping. The situation changed some years back after a Trust was created to settle nonagricultural land disputes in the area.

More than 15 types of vegetables are cultivated in urban Ghana. Tables 2.3 and 2.4 show that the most commonly-grown urban vegetables are also the most perishable (leafy) ones, which have to be produced in market proximity as long as cold transport is lacking. These are often 'exotic' (nontraditional) vegetables, which reflect 'imported' (urban) diets and are consumed raw in salads, such as lettuce, spring onions and cabbage<sup>4</sup>. In peri-urban areas, on the other hand, more traditional diet vegetables like *ayoyo* (*Corchorus* sp.) and *alefi* (*Amaranthus* sp.) or less perishable (fruity) vegetables like garden eggs and tomatoes are grown. Another noticeable feature is the specialization that sometimes occurs in farming sites. For instance, farmers in D-line in urban Kumasi predominantly plant spring onions while their counterparts at Gyenyasi plant lettuce. Availability of water is one of the factors influencing such a decision next to market demand and soil properties. Specialization is another reason; in some villages around Kumasi, farmers prefer certain vegetables, while in the neighboring villages

---

<sup>4</sup> In Francophone West Africa, the consumption of raw salads is significantly more common than in Ghana.

other vegetables are grown. In Tamale, local vegetables are cultivated in urban areas, a response to a less multicultural demand.

**TABLE 2.3.** Main and secondary vegetables cultivated in and around Tamale in the dry season (UDS field study 2013, unpublished).

Farming community	Main crops	Minor crops (local names*)
Gumbihene new dam	Cabbage/lettuce	<i>Alefu</i> , <i>ayoyo</i> , okro, <i>bra</i> , spring onion
Gumbihene old dam	Cabbage	Onion, <i>bra</i> , <i>alefu</i> , cowpea leaves
Water works	Lettuce	Garden eggs, <i>alefu</i>
Zagyuri	<i>Bra/ayoyo</i>	<i>Alefu</i> , cowpea leaves, okro
Sangani	Lettuce/cabbage	Cowpea leaves, <i>bra</i> , spring onion, <i>ayoyo</i>
Builpela	Cabbage/tomato	Spring onion, cowpea leaves, <i>bra</i> , lettuce
Dabogpa	Cabbage	Spring onion, <i>bra</i> , cowpea leaves, <i>alefu</i>
Choggu	Cabbage/lettuce	<i>Bra</i> , <i>alefu</i> , <i>ayoyo</i> , cowpea leaves

\* *Ayoyo* (*Corchorus olitorius*), *Alefu* (*Amaranthus candatus*), *Bra* or *Roselle* (*Hibiscus sabdariffa*)

**TABLE 2.4.** Common crops and crop combinations in urban Kumasi (IWMI, unpublished).

Main crops		Associated crops	
Crops	Harvest/year	Crop	Harvest/year
Lettuce	9-10	Cabbage	1
Spring onions	6	Cabbage	2
Cabbage/cauliflower	3-4	None	None
Carrots	6	Spring onions	2
Green pepper <sup>b</sup>	6	Lettuce	6
Radish: Red	8	Green pepper	2
Radish: White	5		
<i>Ayoyo</i> , <i>alefu</i>	6	Red onions	3

<sup>a</sup> Rotation and intercropping pattern depends on the season, rotation is the most common.

<sup>b</sup> Mostly intercropping.

Table 2.5 shows the most common peri-urban crop combinations within a given year. Crop rotation is carried out depending on the seasonal demand and likely returns for a particular product and with less priority as a strategy to control pests and diseases. Soil conditions also play a role; in wet areas alternative crops are often sugarcane and cocoyam.

**TABLE 2.5.** Common crop combinations in peri-urban Kumasi.

Main crop	Subsidiary crops in rotation
Cabbage	Lettuce/spring onion, cabbage, green pepper/sweet pepper
Lettuce	Cabbage/spring onion
Maize	Cassava, plantain/cocoyam/cassava
Okro (okra)	Tomato, cocoyam, cassava, garden eggs
Spring onion	Pepper, garden eggs, okro
Pepper	Cabbage, tomato, garden eggs
Tomato	Cabbage, pepper, okro
Plantain	Cocoyam, cassava, maize
Oil palm	Cassava, cocoyam, maize

Source: Gyiele (2002a).

Access to irrigation water is crucial for vegetable farming, especially for leafy salad greens. Due to high evapotranspiration exotic vegetables in Ghana are irrigated twice a day unless it rains. Water fetching and irrigation are usually done with two watering cans; each can holds up to 15 litres. This archaic<sup>5</sup> appearing type of irrigation is hard work, time consuming and in this sense a major cost factor. Since about 2005, the use of small motor pumps is on a steep increase. Pumping water to an intermediate storage place (usually a dugout) reduces walking distance and time while irrigation is still done with the can because irrigating directly from the hose would damage most vegetables. Irrigation costs are lower where the landscape is hilly allowing gravity flow, like at La in Accra, where farmers block narrow drains or streams to create an overflow feeding into furrows for irrigation.

In the rainy season vegetable supply increases as some crops can also be produced without irrigation or farmers can access seasonal streams or reservoirs. With increasing supply the sales price goes down and other crops, like maize, become a viable alternative. Though the production of vegetables continues on some urban farming sites also in the rainy seasons, on other farming sites, farmers shift to maize or yam, not only for market sales but also subsistence needs as mentioned by half of the farmers interviewed. About 40% mentioned the lower price of vegetables in the rainy season as reason for changing crops, and 8% the increased risk of pest attacks under continuous vegetable farming.

<sup>5</sup> As farmers have no land tenure agreements and can be expelled from one day to the next, they rely on mobile equipment and avoid infrastructure investments beyond planting bed construction and dugouts. Dugouts are used for either storing runoff or pumped water or to access shallow groundwater.

### 3. Characteristics of Urban Vegetable Farmers and Gender Issues

Emmanuel Obuobie and Lesley Hope

*This chapter presents a profile of farmers and sellers of irrigated urban produce and related gender issues. It explains why men dominate irrigated vegetable production and women vegetable retail.*

#### 3.1 Profile of Urban Vegetable Farmers

Most urban open-space farmers in Ghana have rural backgrounds and had some experience in farming before coming to urban areas. They come to town mainly to seek good employment opportunities, to trade or to enhance their expertise and education. They take up urban agriculture as an opportunity to earn the money needed for these principal pathways. With low investments and returns possibly after a few weeks, many of these farmers realized that urban vegetable production is a profitable venture. A study conducted by Obosu-Mensah (1999) in Accra revealed that out of 200 urban farmers interviewed, 66% had no intention of stopping farming even if they were offered regular salaried employment. This was because open-space urban agriculture could bring in very good earnings in spite of the risks of crop loss and other issues. Those who indicated that they would stop one day mentioned general sickness or loss of land as major factors that could compel them to do this.

**Educational level:** Though there is a wide variation in literacy levels, many urban open-space farmers are illiterate. Kumasi and Accra show higher levels of literacy among farmers compared to Tamale (Table 3.1) where most farmers are illiterate. However, the illiteracy in Tamale is not restricted to urban farmers because this is a general issue in Northern Ghana.

**TABLE 3.1.** Educational status of farmers.

Educational attainment	Northern Region %		Greater Accra Region %		Ashanti Region %	
	Regional	Tamale	Regional	Accra	Regional	Kumasi
Illiterate	79	79	29	48	43	35
Primary	15	17	45	4	45	51
Secondary	4	3	18	44	8	12
Tertiary	2	1	8	4	4	2

Source: IWMI, unpublished.

These findings should not be extrapolated to urban agriculture in general. Home or backyard gardens, for example, are ubiquitous in the country.

**Religion:** Table 3.2 shows the religious status of farmers interviewed in comparison with the regional data from the population census carried out in 2000. In all three cities the share of Muslims conducting open-space farming was significantly higher than across the region. This may be because many northerners migrate towards the cities in search of job opportunities. Urban agriculture might be their first choice but could also be the second if they do not succeed otherwise because of low levels of education.

**TABLE 3.2.** Religious status (%) of urban farmers compared to the regional average.

Religious affiliation	Northern Region	Farmers in urban Tamale	Greater Accra Region	Farmers in urban Accra	Ashanti Region	Farmers in urban Kumasi
Christians	19	13	83	30	78	61
Muslims	56	86	10	67	13	37
Others	25	1	7	3	9	2

Source: IWMI, unpublished.

A random sample of farmers from the three cities showed that 50 to 80% were between 20 and 40 years of age (Table 3.3). This group represents those in the working class who migrate to cities to look for jobs and end up in farming to either supplement their income or because they failed to get paid jobs. Accra had the highest percentage of farmers over 40 years.

**TABLE 3.3.** Age distribution of farmers in the cities.

Age	Kumasi		Accra		Tamale	
	Frequency	%	Frequency	%	Frequency	%
Below 20	4	4	7	5	1	1
20-30	33	33	45	33	19	25
31-40	35	35	30	21	41	54
Above 40	28	28	56	41	15	20

Source: IWMI, unpublished.

**Gender and household size:** Open-space irrigated urban vegetable farming in Ghana is a predominantly male-oriented activity. On average, less than 10% of all urban open-space farmers were women and many of them cultivated indigenous vegetables, not exotic ones. This concurs with earlier findings in Ghana (e.g. Obosu-Mensah 1999; Gbireh 1999; Armar-Klimesu and Maxwell 1998) but is not representative for all subregional countries (Drechsel et al. 2006). In general, more than a half of the farmers are married and occasionally involve their wives in the marketing of produce. In contrast to farming, women dominate vegetable marketing, especially retail. Table 3.4 shows the household sizes of the farmers in the three cities. While Accra and Tamale showed a wide distribution in household size, Kumasi was exceptional in that farmers were either single migrants or had households of up to five members. Very few farm households exceeded this. In all, the mean household size was 2 for Kumasi and 4 for Accra and Tamale.

**TABLE 3.4.** Household sizes of farmers in the three cities.

Family size	Kumasi		Accra		Tamale	
	Frequency	%	Frequency	%	Frequency	%
Alone	35	35	28	20	11	15
1-5	59	59	67	49	38	50
6-10	6	6	36	26	23	30
Above 10	0	0	7	5	4	5
Total	100	100	138	100	76	100

Source: IWMI, unpublished.

**Economic profile:** Urban farming provides employment and income for a chain of beneficiaries, such as farmers, market sellers, suppliers of agricultural input, etc. and therefore contributes to livelihood support and the economy (Obosu-Mensah 1999; Danso et al. 2002a; Drechsel et al. 2006; see also chapter 4). Out of 138 farmers interviewed in Accra, about 60% rely on irrigated vegetable cultivation as their only source of income, while 33% do it as a supplementary income source. In Tamale, with more seasonal vegetable production, most vegetable producers use it to supplement their incomes from staple crop farming. Only a minority of open-space cultivators uses urban vegetable farming as a one-off means of getting

money for a later investment or as a source of food (Figure 3.1). In general, farmers of exotic vegetables do not consume their own produce.

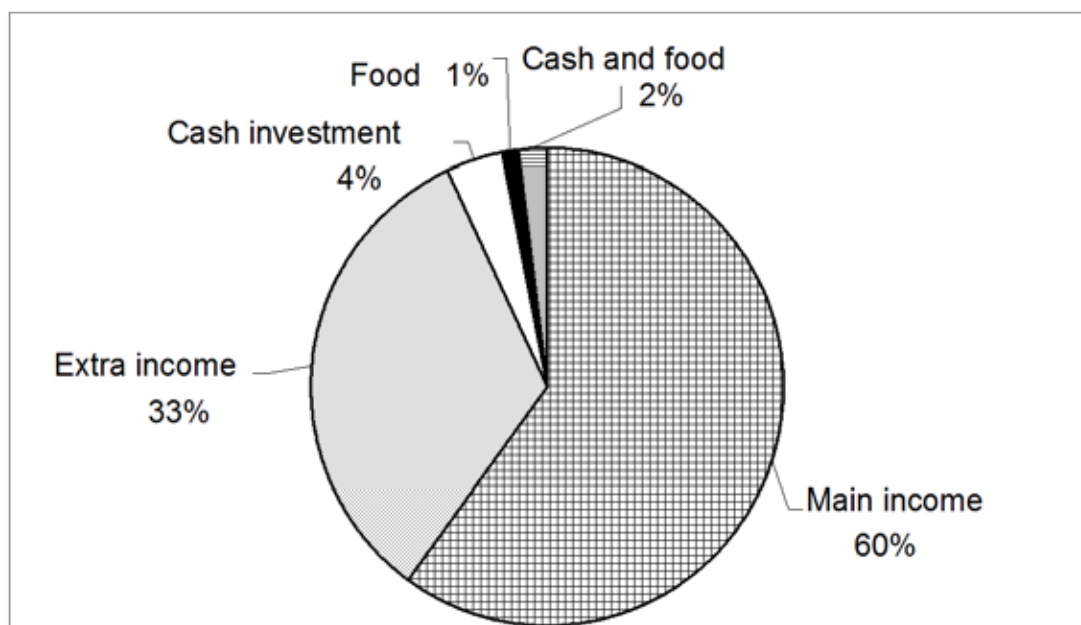


FIGURE 3.1. Main objectives of farmers cultivating vegetables in urban Accra.

Among those for whom farming was a secondary activity in Accra, security guards were predominant (57%) while others were masons, painters, mechanics or cleaners. This also applies to Kumasi. Box 3.1 describes the ‘average’ urban vegetable farmer in Ghana.

### 3.2 Overview of Gender Issues in Urban Agriculture

Studies done in many cities in Africa, particularly in South and East Africa indicate that most urban farmers are women. Examples include Kenya, Mozambique, Tanzania, Uganda, Zambia and Zimbabwe. This is because women continue to bear primary responsibility for household sustenance and well-being (Chancellor 2004), or because of their lower access to education than men, thus, they have fewer opportunities of finding suitable waged employment in the formal sector (Obosu-Mensah 1999). However, there are large differences between countries, cultivated crops (traditional vs. exotic) and between subsistence production and market gardening. In a survey comparing 20 cities in West Africa, men dominated open-space vegetable farming in 16 cities or 10 of 13 countries (Table 3.5).

BOX 3.1. The 'average' vegetable farmer in urban open spaces of Ghana

The typical Ghanaian urban vegetable farmer is a male and within the 31-40-year age group. He cultivates exotic vegetables like cabbage, cucumber, lettuce, onion, cauliflower and green pepper on a land area of between 0.01 and 0.12 ha. Cultivation is done year-round, unless maize pays better in the rainy season. The average farmer could have either primary or secondary school education or be illiterate, often with some education from an Arabic (language) school. The average urban farmer is religious. Muslims account for two out of five farmers in Kumasi, three out of five farmers in Accra and four out of five farmers in Tamale. The average farmer is married and occasionally his wife markets his produce. In many cases however, he would have regular visits from market women who also might provide him with credit. The average vegetable farmer, if he is in Accra or Kumasi, will grow vegetables as his main occupation and primary source of income. His major extra occupation, if in Accra, would be working as a security guard. In Tamale, cultivating vegetables would be his major occupation. He has on average five dependents in Accra and Kumasi and between six and 10 in Tamale. Usually, his dependents are supported by income from his farm. A cousin might assist him; otherwise the farm work is not a family business.

The average urban vegetable farmer is a migrant from a rural area in Ghana and has some experience in farming before coming to the city. Normally, farming is not his main aim for coming to the city. He becomes involved in farming some time after arriving in the city when he finds out that he is not able to favorably compete for a job in other sectors. However, once he is established in producing vegetables, it becomes a serious business and he does not want to quit even when he finds better salaried employment. He knows his extension officer but has stopped expecting any specific advice on his key problems like price fluctuations and marketing of produce, pest control and quality seed supply.

His main source of irrigation water is an open drain if he is in Accra or Tamale, or (polluted) surface water if he is in Kumasi or Takoradi. In all cases, he does not own the land, but he uses it for free. His 'informal' status and low tenure security limit his access to credit and investments in farm infrastructure. Therefore he joins a farmers' association on his site. When asked about his occupational health risks through his exposure to wastewater, he does not consider it an issue, like he does not perceive his normal living conditions (without own toilet and piped water) as peculiar or unhealthy.

Source: IWMI farm survey data (2000-2005).

**TABLE 3.5.** Gender ratio in open-space farming in various cities of West Africa

Country	City	Female (%)	Male (%)
Benin	Cotonou	25	75
Burkina Faso	Ouagadougou	38 (0-72)	62
Cameroon	Yaoundé	16	84
Côte d'Ivoire	Abidjan, Bouaké	5-40	60-95
Gambia	Banjul	90	10
Ghana	Accra, Kumasi, Takoradi, Tamale	10-20	80-90
Guinea	Conakry, Timbi-Madîna	70	30
Mali	Bamako	24	76
Mauritania	Nouakchott	15	85
Nigeria	Lagos, Ibadan	5-25	75-95
Senegal	Dakar	5-30	70-95
Sierra Leone	Freetown	80-90	10-20
Togo	Tsévié, Lomé	20-30	70-80

Source: Drechsel et al. (2006).

To understand the role that gender plays in urban vegetable production in Ghana, an appraisal was conducted among vegetable farmers and traders in Accra, Kumasi, Tamale and Takoradi. The surveys showed that most vegetable sellers are women, while open-space farmers in the cities are often in nine of 10 cases men (Table 3.5). This situation has been verified in many studies on urban farming in Ghana (Hope et al. 2009). In peri-urban areas and urban household backyard gardening, on the other hand, the situation can be different (IWMI, unpublished). The appraisal tried to understand possible reasons for the gender separation and led to some initial conclusions.

### 3.3 Male Dominance in Urban Open-space Vegetable Farming

**Cultural and economic constraints:** Societal definition of gender roles provides one explanation for why men dominate open-space vegetable farming in urban Ghana. Generally, cash crop farming is considered in most Ghanaian communities as work for men. The reason might however be that women, particularly in northern cities (Tamale), have in many cases less access to land and resources to commence market-oriented farming (Zibrilla and Salifu 2004). In fact, many women who farm usually cultivate crops such as *ayoyo* and other indigenous vegetables, which require low initial capital investment for seeds and less water

than exotic vegetables (reduced labor, see below). In neighboring Ouagadougou, more women than men grew traditional vegetables for subsistence supply and as cash crop, but more men than women grew higher-priced exotic vegetables solely for income generation (Gerstl 2001). While in rural areas, livelihood options are limited, and farming is a family or household affair with family members being the main source of labor, the city offers more alternative options for income generation. Farming is thus much more often an individual activity, only with occasional help from spouses and children. Also this might not favor women farmers who have traditionally more household-related duties than men.

**Access to land:** Land issues were mentioned as a major constraint for women in Tamale (Zibrilla and Salifu 2004). In fact, in some regions, under customary law, women do not have a right to hold land except through male relatives or as widows. However, they can have user rights unless land is in short supply. Sometimes they are pushed towards more marginal plots. In another study of cities both men and women farmers explained that most urban land being cultivated belongs to the government (see Obosu-Mensah 1999) and therefore access does not depend on customary rules and one's gender but rather on the individual's ability to lobby among those who farm already or with the caretaker of the plot.

**Nature of vegetable production:** Exotic vegetables are the main crops grown for commercial purposes in urban areas of Ghana. However, associated productive activities, particularly irrigation and land preparation, which are done manually, are very laborious. Irrigation can take between 40 and 70% of farmers' time and will be carried out in all seasons (Danso et al. 2002a; Tallaki 2005). In addition, farmers use two 15-liter watering cans to repeatedly convey water from the water source to field, an estimated distance of 50 to 100 m. This is in contrast to the general practice of women and children bearing water jars on their heads – watering cans cannot be transported as head loads. Moreover, most land preparation is commonly executed by men. These activities coupled with pesticide application via knapsacks signal female-unfriendly methods of farm operation associated with urban vegetable farming. Table 3.6 shows the farm activities usually performed by men, women and children. In this context it is interesting to see a gender balanced farmer community in La, Accra, where gravity flow and furrow irrigation is common.

**TABLE 3.6.** Division of farm tasks by gender in peri-urban Kumasi.

Tasks (x = usually applicable; - = less applicable)	Men	Women/children
Clearing the bush	x	-
Raising beds	x	-
Nurturing crops	x	-
Planting and transplanting	x	x
Weeding	x	x
Fertilizing	x	-
Spraying	x	-
Manual water fetching and transport as head loads	-	x
Manual watering using buckets	x	x
Manual water catching and watering using two cans	x	-
Mechanical watering (using pumps)	x	-
Harvesting	x	Market women

Source: Cornish et al. (2001); modified.

Another decisive activity in the cultivation of some exotic vegetables is nurturing. The surveys of Cornish et al. (2001) showed that women had less experience in this field and correspondingly less related skills. As seeds are expensive, nurturing skills are crucial for the whole business, which requires a high germination rate and survival of the seedlings (Obuobie et al. 2004).

### 3.4 Female Dominance in Marketing of Urban Farm Produce

In contrast to vegetable farming, women dominate the vegetable marketing sector, in particular retail, as also observed in neighboring countries (Gerstl 2001). Women's general dominance in retail is partly attributed to the Ghanaian tradition that retail in general is a woman's job, though with many exceptions, e.g. between crops and also at different levels of trading (wholesaling, retailing and itinerant trading). There are crops, which are traditionally handled by men, while others are 'women crops'. Among vegetables, cabbage, sweet pepper and cucumber are normally associated in Ghana with men, while lettuce, carrots, spinach, okro, garden eggs and others are associated with women. This differentiation is less binding on urban farms where men grow whatever gives profit, but obvious in wholesale and retail. While there are many male cabbage wholesalers, there are hardly any male lettuce wholesalers. The time needed to access the crops also plays a role. While most lettuce is grown within the urban area, it requires more time to buy cabbage from villages in city

proximity. Long days away from home (duties) have been cited as some of the barriers women traders face.

Both, men and women involved in marketing vegetables see marketing as a quick way to make money on a daily basis, unlike farming which can take months depending on the crop before a farmer receives income from his farm activities. Though some men expressed willingness to sell their own produce on the market, they are held back by the prevailing culture, i.e. men might wholesale certain crops but retail even less. Those who tried to enter this nontraditional domain complained about nontransparent procedures and often gave up unless they had insider support (E. Opare, personal communication). Entering markets is in fact not easy as each commodity has a so-called 'queen mother' who controls and regulates each market slot. Thus it is no surprise that women handle 60 to 90% of domestic farm produce from the point of origin to consumption. Very commonly, women traders enter contracts with the farmers to earmark certain crops for a particular month. They pay in part in advance so farmers can buy seeds etc., and later harvest themselves the best beds. Women pursue marketing activities as their primary means of obtaining cash income for household expenditure. They appreciate the low initial investments compared to farming.

These market vendors are not necessarily members of the household of vegetable farmers. In fact, most are not related to the farmers. Women vendors control the income they generate from the sale of vegetables and use it to support the family. Their income especially that of the wholesalers, can be higher than that of the farmers (Drechsel et al. 2006). Women spend income mainly on food and sometimes on clothing for the children, while the men spend their income on accommodation, children's school fees, utility bills and other major needs or projects of the family. Women also sometimes save part of their income and use it to support their husbands in major projects. Though men and women in a household may not have formally agreed on who spends on what, generally, the Ghanaian culture has already defined who bears what responsibility in the home and this is inherent, at least in the more traditional parts of the society.

### **3.5 Conclusions**

Two clear facts emerged in view of open-space vegetable farming: male dominance in farming and female dominance in retail, while wholesale shows mixed gender. This has in part traditional reasons. Women farmers feel mostly constrained by existing irrigation practices, while men feel significantly oppressed by their dependency on credit and prices

dictated by market women without sharing essential market information. For some commodities, men are making headway, especially in areas of wholesale trading where overland transport is required. Listening to complaints, however, one can deduce that male farmers feel significantly more oppressed than women, in terms of their dependency on market women. These complaints can be substantiated by the observation that wholesalers particularly (but also many retailers) can make significantly higher profits than farmers (chapter 4).

Such issues have to be considered if a full gender mainstreaming is the target as the result might show fewer advantages for women than they have now (Hope et al. 2009; Drechsel et al. 2013). Improved irrigation technology (like access to a motor pump) appears to facilitate a better gender balance on farm. Treadle pumps were rejected by farmers in Accra as the pumps and water hoses require two farmers at the same time and pulling the hose can damage the young vegetables or their beds severely. Moreover, farmers did not know where to store the (relatively heavy) pump overnight as it could easily be stolen.

## 4. Financial and Economic Aspects of Urban Vegetable Farming

George Danso, Lesley Hope and Pay Drechsel

*This chapter explores some of the financial and economic aspects of urban and peri-urban agriculture in Ghana. Cost-benefit analysis comparisons were made of farm finances of common rural, peri-urban and urban farming systems. Substudies also tried to quantify benefits for society and to cost externalities related to soil nutrient depletion, pesticide use and urban malaria.*

While a financial cost-benefit analysis which reflects the perspective of the farmer is as a procedure straightforward, the comparison of vegetable farming systems using freshwater or wastewater can be difficult. There are hardly any locations where both systems are next to each other, which increases the number of confounding factors which have to be controlled. Also comparing the cost and benefits of wastewater-irrigated vegetable farming between locations is difficult as most farmers fetch water from polluted streams, where both, the (value of) beneficial nutrients as well as the detrimental pathogens can vary in large ranges depending on the degree of dilution, although all might be called ‘wastewater irrigation’. The largest challenge concerns the assessment and valuation of possible impacts on farmers’ health where polluted water sources are used as these have to rely on farmers’ perception of risks, knowledge of symptoms and memory (Weldesilassie et al. 2011). Thus, all examples and data reported in this section have to be taken with caution.

### 4.1 Financial Aspects of Irrigated Vegetable Farming

In terms of labor input, Tallaki (2005) analyzed costs and returns of urban vegetable farming, and found that manual irrigation was the most time-intensive activity (38% of total hours), followed by weeding (23%). While irrigation is mostly done by the farmer, land preparation activities, like clearing and bed formation, as well as weeding are larger cost factors as they rely more on hired labor as also observed in peri-urban Kumasi (Cornish et al. 2001; Cornish and Lawrence 2001). Once the land is cleared cultivation can run within cities year-round reducing the initial costs. Use of hired or family labor varies considerably between locations, with more family involvement in peri-urban areas.

Labor input also depends on soil quality, not only for bed preparation but also irrigation. Up to 70% of farmers’ time was spent on irrigation on sandy soils, such as along the beaches of

Lomé (Tallaki 2005). Pump access can reduce time input for watering by more than half, and might be the best argument for hiring a pump if the time can be spent in a better way (Cornish and Lawrence 2001).

Though wastewater-polluted irrigation water carries crop nutrients, the concentrations are usually low due to dilution (Erni et al. 2010) and vegetable farmers rely significantly on other nutrient sources as well as pesticides. In Kumasi and Accra, the use of poultry manure is very common due to its easy availability and relatively low price which varied between USD0.2 and 1.5/50 kg over the last decade. Only a few farmers use mineral fertilizer in addition to this (mostly for cabbage). In peri-urban Kumasi, many more vegetable farmers use mineral fertilizer (USD14/50kg NPK in 2004 and about USD19 in 2010), but combine it with poultry manure when possible (Drechsel et al. 2004). Variations are related to the crops cultivated by the farmers. Table 4.1 shows farm income data based on costs and returns as recorded by farmers in Kumasi, Takoradi and Accra. The data correspond with records from other cities in West Africa (Drechsel et al. 2006). Income varies depending on the type of crop, season, farm size and investments in labor and improved irrigation facilities, like motor pumps.

**TABLE 4.1.** Monthly net income from irrigated mixed vegetable farming in Ghana assessed in 2002 (USD per actual farm size).

City	Monthly income (USD)
Accra	40-57
Kumasi	35-160
Takoradi	10-30

Comparing different farming systems, the data from the Kumasi study showed that urban farmers with access to irrigation water are able to cultivate year-round and can reach annual income levels of USD400 to 800 (see Table 4.2). This is twice the income they would earn in the rural setting. However, being successful this way requires careful observations of market demand (Danso and Drechsel 2003). The greatest factor influencing farmers' profits is not so much the yield obtained but producing at the right time what is in short demand and the ability to sell consistently at above average prices (Cornish and Lawrence 2001).

**TABLE 4.2.** Revenue generated in different farming systems in 2002.

Location	Farming system	Typical farm size (ha)	Net revenue (USD) per actual farm size per year (range)
Rural/peri-urban	Rainfed maize or maize/cassava	0.5-0.9	200-450 <sup>a</sup>
Peri-urban	Dry-season vegetable irrigation <i>only</i> (garden eggs, pepper, okro, cabbage)	0.4-0.6	140-170
Peri-urban	Rainfed maize combined with dry-season, irrigated vegetables	0.7-1.3	300-500 <sup>a</sup>
Urban	Year-round irrigated vegetable farming (lettuce, cabbage, spring onion)	0.05-0.2	400-800

<sup>a</sup> These are typical values; subsistence production has been converted to market values. In case farmers use parts of their maize and cassava harvest for home consumption, the actual net income would be lower.

Source: Danso et al (2002a).

As urban farming is land- and labor constrained, typical farm sizes range between 0.05 and 0.2 ha in Kumasi. Comparing the different farming systems, urban wastewater vegetable production in Ghana generates the highest net revenues per hectare based on a combination of lettuce, cabbage and spring onion. Even with plot sizes that are significantly smaller than in rural areas, urban farmers can earn at least twice as much as rural farmers.

An analysis of the different dry-season vegetable production systems in peri-urban Kumasi showed that the combination of pepper, cabbage, tomato and garden egg yielded the highest profit per hectare among the common peri-urban crop combinations being practiced in the survey area. It was obvious that whenever cabbage was part of the combination, the net profit was high. Cabbage has become a major component of street food and the modern diets of the urban middle and upper class income households (Gyiele 2002a).

Even though cabbage-based crop combinations were the most profitable crop enterprises, only about 10% of the farmers around Kumasi engaged in cabbage production. The reasons for this low figure are not hard to find. There is first of all the harsh competition from urban farms specialized in cabbage production. In contrast to urban sites in Accra, some farms in Kumasi have relatively higher tenure security (university land; less construction pressure) and more fertile soils.

In addition, cabbage production is very input-intensive, especially in view of irrigation and pest control. This entails a correspondingly higher expenditure on labor and plant protection chemicals. This is one instance where, despite high profits arising out of high physical efficiency in production, few farmers are willing to undertake it due to higher investment in cash and time. On the other hand, most vegetables offer a quick cash return. Comparing profit as percentage of production costs, the traditional mixed cultivation with oil palms ranked highest but would require much longer investment periods (Gyiele 2002a).

Abban (2003) compared vegetable production in the informal (urban) production sector (Accra city) and commercial irrigation in the Greater Accra Region. He interviewed 60 farmers in each system, most of them practicing multicropping. The author concluded that the gross revenues were four times higher in *formal* irrigation schemes but also eight times the (variable and fixed) production costs. The resulting net returns still favored formal irrigation with an income twice as high as in informal urban irrigation. The benefit-cost ratio in the production period, however, was two times higher in urban agriculture, making it an interesting venture for migrants trying to establish a livelihood with little start-up capital and in need of quick returns.

#### 4.2 Socioeconomic Impact and Urban Food Supply

Urban agriculture can be market-oriented, subsistence-oriented or serving both purposes. It may be practiced as a sole source of income or to supplement immediate household food requirements and is often carried out alongside other forms of employment (Box 4.1).

Important is to differentiate under the general umbrella of 'urban agriculture' between on- and off-plot farming, or in other words: backyard gardening and open-space market farming (Table 1.1 in chapter 1). Both contribute to different development goals. While backyard gardening usually serves subsistence purposes and improves farmers' food security, market gardening aims at cash generation and contributes first of all to poverty reduction.

**Moving out of poverty:** For peri-urban farmers, dry-season vegetable irrigation adds 40 to 50% income to their rainfed income, especially as significant parts of their rainfed maize and cassava harvest are consumed by the household. Without this additional income, cash availability might actually be less than USD100 per year. Around Kumasi, about 60,000 people in 12,000 households are benefiting from dry-season irrigation (Cornish and Lawrence 2001). However, only a minority of peri-urban farmers shift to year-round vegetable farming.

**BOX 4.1. Wastewater irrigation and livelihoods**

**Accra:** Our farmer is a 51-year-old lady, regularly employed as a teacher, who farms part-time at a site using drain water. She is a Christian and is married with five children; she has secondary school education and lives in Osu, 1 km from the farm. She owns a food-processing machine (corn mill) from which she earns about USD25 per month. She earns the same amount from teaching and her husband, an administrative officer, also contributes USD25 per month. But more substantial is that she can add twice the amount from her vegetable beds per cropping period, and a crop like lettuce requires only one month for growing. She says “This small piece of land keeps my family in a better status and supports the education of our children”.

**Kumasi:** A 32-year-old female farmer who owns about 30 beds, cultivating mainly leafy vegetables explains: “I am a seamstress but I cannot survive without these vegetables. In most cases, I have to prefinance dress sewing with income derived from vegetable production because it can take somebody more than two months to pay for the cost of the dress. I am getting my everyday income from these beds”.

**Tamale:** “We started (cabbage) farming many years ago with our parents here. We depend on it. We had to change from wastewater to piped water due to our inability to access water anymore from the drains. Our colleagues are fortunate to have the wastewater still because it makes crops bigger in size and they look better than ours, while the prices of the crops are the same. We have to pay a monthly water bill while they do not pay anything”.

There are three reasons for this: the importance of maize and cassava for home consumption (mentioned by 52% of the farmers interviewed); the lower price of vegetables in the rainy season (40%); and the increased risk of pest attacks (8%) from monocropping. But those farmers who move to urban areas and take the risk make a remarkable step in overcoming poverty. As shown in Table 4.2, urban vegetable farmers can double the maize-cassava income of their rural colleagues and move over the poverty line of USD1.25 per capita.

**Individual food supply:** As exotic vegetables are most of all a cash crop, the food supply benefits for vegetable farmers are only indirect. The situation is already changing for farmers specialized in traditional vegetables, where any unsold amount is consumed at home, and this is very different for backyard farming. In Accra and Kumasi, household surveys showed that in each city about 600,000 residents from all income categories benefit from their backyard gardens (IWMI, unpublished). These gardens can be very small (e.g. a few plantains, cassava and chickens). The cultivation for subsistence purposes mainly relieves the household of its necessary budget allocation for foodstuff. However due to space limitations, backyard gardening does not play a key role in household livelihood strategies regarding food supply

(see Box 4.2), but is part of it and reduces to a limited extent households' vulnerability to a food crisis.

**BOX 4.2. Home gardens and food security**

An IWMI survey of 120 households engaged in backyard gardening in Accra and Kumasi showed that 3 to 10% of the households take some temporary commercial advantage from the gardening while the large majority uses the gardens only for subsistence supply (Drechsel et al. 2009). The contribution of backyards to household food security has been estimated in terms of the saved cost on food expenditures and direct income from sales. Given the small size of the gardens, the annually saved cost varied between 1 and max. 10% of the overall food expenditures with the higher values in the lower wealth classes. This confirms the magnitude reported a decade ago by Maxwell et al. (2000) in their Accra study that households receive only 7 to 8 percent of their total food in terms of value and calories from their own production. Thus, the contribution of urban backyards to household food security is marginal. However, all households valued the contribution highly. They considered the supplementary food supply, even if the percentage are low, and related reduction in household expenditures as a significant contribution. This might apply in particular to women without any other source of income. Maxwell et al. (2000) also flag potential importance for times of cash-flow crisis.

Another reason for the discrepancy between the quantitative survey and household perception is that every saving counts, even small amounts. Most produced crops are heavy food items (plantain and tubers which constitute the main part of the local diet [*fufu*]). The survey showed that typical backyards in Accra can produce between 44 to 146 kg of cassava and 26 to 104 kg of plantains per year. Although they are in monetary percentages only a small part of the overall annual food expenditures, these households do not have to buy and carry 10 to 25% of their annual needs (Drechsel et al. 2009). For maize even larger degrees of self-sufficiency are possible. Maxwell et al. (2000) estimated that (off-plot) maize farmers might produce enough maize to cover their household maize needs for one to eight months of a year, unless they prefer to sell their produce.

However, those who have more space and larger gardens or chicken coups, might also sell surpluses. In contrast to backyards, open-space cultivation of vegetables is usually for the market. This is especially the case for exotic vegetables while farmers who specialize in traditional vegetables might also consume a part of their produce.

**Urban food supply:** At the macro level, the contribution of urban agriculture to the Gross Domestic Product (GDP) will be small, but the importance for certain commodities, such as lettuce, cabbage, milk and poultry products might be substantial (Table 4.3ab), especially if we consider the whole value chain (Cofie et al. 2003; Drechsel et al. 2007). Nugent (2000) reported that urban agriculture can meet large parts of the urban demand for certain kinds of food such as fresh vegetables, poultry, potatoes, milk, fish and eggs. The proximity of production to consumption reduces traffic, (cold) storage and packaging, and related costs.

**TABLE 4.3a.** Contribution of rural, peri-urban and market-oriented urban agriculture to urban food supply in Kumasi (Drechsel et al. 2007).

Food item (examples)	Kumasi Metropolitan Area (%)	Peri-urban Kumasi (%)*	Rural and import (%) **
Cassava	10	40	50
Maize	< 5	5	90
Plantain	< 5	< 10	85
Yam	0	0	100
Cocoyam	< 2	< 10	90
Rice	0	< 5	95
Lettuce	90	10	0
Tomatoes	0	60	40
Garden eggs	0	60	40
Onions	0	0	100
Spring onions	90	<10	0
Poultry/eggs	15	80	< 5
Livestock	5	10	85
Fresh cow milk***	>95	< 5	0

\* Using a 40-km radius from the city center.

\*\* Mainly rice, onions and part of the livestock are imported.

\*\*\* KNUST farm production.

Emphasizing the contribution of open-space urban agriculture to urban food supply in Kumasi, Table 4.3a shows that the demand for vegetables (like lettuce or spring onions) as well as fresh milk is nearly completely covered by inner-urban production. Food items like tomatoes, garden eggs and cassava as well as eggs and poultry meat are derived from the peri-urban area while staples, such as cocoyam, plantain, maize and rice come from rural areas or via import to the city markets in Kumasi. Another vital part of Kumasi's urban and peri-urban agriculture is poultry production, which is practiced by people from all social sectors. Vegetable farmers in and around Kumasi benefit from this, as it offers them access to cheap but high-quality organic fertilizers (Drechsel et al. 2000). In Tamale, the contribution appears to be smaller, but not all commodities were covered in the survey. There were also significant differences between the lean season (May to August) and the time after harvest.

**TABLE 4.3b.** Contribution of rural, peri-urban and market-oriented urban agriculture to urban food supply in Tamale (IWMI, unpublished).

Crop	Urban %	Peri-urban %	Rural & import %
Yam	0	30	70
Cassava	0	0	100
Plantain	0	0	100
Cocoyam	N/A	N/A	N/A
Rice	15	25	60
Maize	10	25	65
Cabbage	80	20	0
Tomatoes	<5	0	95
Garden eggs	0	15	85
Bananas	0	0	100
Oranges	0	0	100
Okro	10	15	75
Cucumber	0	0	100
Carrot	25	0	75
Onions	0	0	100
Sorghum	<5	30	65

An FAO study based on living standard surveys reported for Accra that urban dwellers engaged in farming show greater dietary diversity and an 18% urban income share from agriculture, with higher percentages in the poorest section of the urban society. However, this does not automatically imply ‘urban’ farming. In the local survey which informed the FAO conclusions households were asked about their activities for income generation. Unfortunately, the questions did not ask in the section on ‘farming’ about where the farm is located and many urban dwellers own plots in rural areas that are used for agriculture (Zezza and Tasciotti 2008).

**Contributions to other urban development objectives:** Urban farming can make substantial contributions to the city beyond the provision of livelihoods and food. These include among others contributions to buffer zone management and flood control, thus supporting climate change adaptation strategies, land reclamation, land protection, resource recovery (from waste), urban greening, biodiversity conservation etc. (see also chapter 15).

These contributions might be more important for some authorities than the food production itself but have not been quantified and assessed so far. An example is that urban open-space farming protects unused land from squatters and uncontrolled waste dumping, thus saving on expenditures on land maintenance and waste collection (Anku et al. 1998).

### **4.3 Possible Negative Externalities**

When assessing the benefits of urban open-space vegetable production to society, there are also a number of possible negative externalities, which should not be ignored. A related checklist of environmental criteria applicable to urban agriculture was compiled by Anku et al. (1998). Examples of possible trade-offs are:

- The potential impact of polluted irrigation water on farmers' and consumers' health;
- The potential impact of pesticide use on farmers' and consumers' health;
- Increased urban malaria through the creation of mosquito breeding grounds;
- Soil nutrient depletion through frequent harvests and/or water pollution by farmers through the (over)use of manure, fertilizers and pesticides;
- Stream siltation and eutrophication through erosion from cultivated slopes.

In the following sections, available data from Ghana have been compiled to illustrate possible dimensions and implications of the abovementioned negative externalities. Many of these studies are based on geographically-limited thesis work and more extensive studies are recommended.

#### **a) Possible Health Impact Through Pathogens in Irrigation Water**

Analyses of water samples, harvested vegetables along the marketing chain and salad sold in fast food kitchens and restaurants in all major Ghanaian cities confirm a high pathogen threat. The vegetable contamination levels with fecal coliforms are seldom below  $10^4$ - $10^5$  (MPN  $100\text{ml}^{-1}$ ) and no vegetable leaves the farms with fewer than 2-6 helminth eggs per 100 g (Amoah et al. 2005, 2006, 2007a; Mensah et al. 2002; IWMI, unpublished). A microbial risk assessment estimated a possible loss of about 12,000 disability-adjusted life years (DALYs) annually in Ghana's major cities through the consumption of salad prepared from wastewater-irrigated lettuce (Drechsel and Seidu 2011). This figure represents nearly 10% of the World Health Organization (WHO)-reported DALY loss occurring in urban Ghana due to various types of water- and sanitation-related diarrhoea (Prüss-Üstün et al. 2008; GSS 2004).

A major challenge for the economic valuation of this risk is that most farmers and consumers are generally exposed to a variety of similar or even higher pathogen-related risk factors in their normal environment (poor sanitation, lack of potable water, unsafe food, etc.), which makes it difficult to distinguish and value individual risk factors, especially if the concerned persons do not perceive and record any particular work- or consumption-related symptoms.

**b) Possible Health Impact Through Pesticide Misuse**

A pilot assessment of the misuse of pesticides on farmers' health was attempted by KNUST-IWMI in the tomato-producing area of Akumadan, Ghana (Gyiele 2002b). The town of Bechem with dominantly traditional staple crop farming was used as a control. Sources of data were farmers, hospitals/health posts, pharmacy/chemist shops and traditional medicine practitioners (herbalists). Health records from January 2000 to May 2001 were analyzed from about 10,000 persons per study area. In addition, about 170 farmers were interviewed and 200 samples of tomato fruits analyzed for pesticide residues. Both locations do not fall under 'irrigated urban agriculture' where studies by Amoah et al. (2006) showed higher pathogen than pesticide risks. However, the Akumadan site could be considered an example of an irrigation system with a well-known high pesticide use, and a higher share of farmers reporting likely related symptoms. For example, records on burning sensation in the eye, watering eye, nausea and vomiting, were for Akumadan 56, 63 and 51% higher than for Bechem (Obuobie et al. 2006). The methods used for the economic assessment at the farmers' level were:

- Cost of medical treatment;
- Opportunity cost of labor, i.e. absence from farming activities due to pesticide poisoning;
- Cost of drugs for treating minor illnesses.

Considering these three approaches, the annual health costs amounted to USD125 per tomato farmer (Gyiele 2002b). With farm sizes under tomato cultivation ranging mostly from 0.3 to 2.0 ha, it becomes obvious that smallholders in particular have to pay a significant share.

These costs were compared with the gains from pesticide use compared to pesticide-free tomato production based on Integrated Pest Management (IPM) principles and biological pesticides. According to farmers' records it appeared that when there was no or little pest attack, both systems achieved the same yields and returns, while under severe attack the IPM farmers were at higher risk of loss than those using pesticides. These initial data still need reconfirmation. However, urban farmers in Accra also stated that despite lower investment

costs, IPM appeared to them as too cumbersome and risky, compared to spraying 'plant medicine'.

### **c) Possible Health Impact Through Increased Urban Malaria**

In comparison with rural areas, West African cities are relatively malaria-free due to general water pollution. The malaria vector *Anopheles* needs, in general, clean water for breeding. Mutations of the vector to less clean water could however occur (Chinery 1984). In a malaria study on a 10-ha urban farming site in Accra (Dzorwulu) with 77 farmer-built shallow water reservoirs filled with either tap water or polluted water, either water pollution or natural predators (e.g. tadpoles) effectively controlled larval development (Miah 2004). Nevertheless, studies conducted by IWMI in Kumasi and Accra (Afrane et al. 2004; Klinkenberg et al. 2005) showed that in some cases, significantly more mosquitoes were caught and/or more children affected in communities around irrigated farming sites than non-farming sites. However, as urban agriculture is often practiced in urban lowlands or other greener areas, which might generally offer more nesting and breeding grounds for mosquitoes than other city sites, an explicit link with urban *farming* activities could not (yet) be established in these cases. There is a need for urban malaria studies using green areas without farming as a control.

A preliminary economic assessment of the potential health expenditure of community members living near irrigated urban farming sites was based on a comparative study of urban areas with and without open-space farming considering treatment costs and working days lost. The analysis showed that on average, for all age groups, sites with urban agriculture increase the risk of a malaria attack by 0.22 attacks per person during a period of six months. In other words, every fourth to fifth person in the vicinity of irrigated urban agriculture will have malaria one time more than if he/she were living in a pure urban area. With a typical malaria treatment cost of USD1.0 per case, an urban household in the vicinity of urban agriculture will spend an extra amount of USD0.22 x 6.6 household members for malaria treatment, i.e. USD1.45 over the observation period (Obuobie et al. 2006).

In addition, about 0.5 extra days will be lost per adult person in communities with urban agriculture than in those without. Considering average estimated household income, the number of working household members and the unemployment rate, the loss will cost the household another one dollar. In total, USD2.45 was attributed to each household over the six-month period as extra malaria-related expenditure in urban communities with open spaces used for irrigated urban agriculture (Gyiele 2002b).

**d) Possible Environmental Impacts**

**Water pollution:** In view of water pollution through fertilizers and pesticides, Gyiele (2002b) and Bowyer-Bower and Tengbeh (1995) concluded that the observed or likely contributions from urban smallholder farms are insignificant in view of the general pollution by the city. This could be different in rural areas where agriculture might be the only source of pollutants.

**Erosion:** In Ghana, the creation of the Buffer Zone Policy (see chapter 15) started a debate on whether urban farming along streams has more positive or negative impacts, i.e. does it help to reduce encroachment and illegal waste disposal or contribute to water pollution. The risk of erosion and stream siltation, for example, will depend on the topography, soil type, original vegetation cover along the streams and the cultivation practices of the farmers. It is possible that the year-round vegetable beds actually support soil conservation, increase infiltration and reduce run-off and erosion, thus contributing positively to flood control and urban drainage. On the other hand, studies in Harare, Zimbabwe, concluded that seasonal maize cultivation on slopes increased soil erosion. This led to a discussion on stream siltation and eutrophication through fertilizer use in urban farming (Bowyer-Bower et al. 1996; Mawoneke and King 1999).

**Soil nutrient mining:** With up to 10 lettuce harvests per year for example, soil nutrient mining is seriously forcing farmers to provide continuous nutrient input. Especially on sandy soils, urban farmers enter into a vicious cycle of applying high rates of nutrients, which might either be taken up by the crop or be leached in the rainy season. However, the urban vicinity also offers many nutrient sources, like organic waste and wastewater, thus costs related to nutrient inputs can remain low. In and around Kumasi, for example, the poultry industry is very strong and farmers pay mostly for the transportation of poultry manure, and only very little for the manure itself (Drechsel et al. 2000). Thus, the related costs to intensive vegetable farming appear relatively lower than in rural areas where the most economical way to address soil nutrient depletion is still shifting cultivation (Table 4.5).

**TABLE 4.5.** Externalities due to soil nutrient leaching in and around Kumasi

System	Maize-cassava intercrop	Year-round vegetable production
Cost assessment	The two-year rental of a new plot is about USD10-50 ha <sup>-1</sup> depending – among others – on proximity to the city, and accessibility.	Nutrient losses account for only USD10 ha <sup>-1</sup> year <sup>-1</sup> if replaced with cheap poultry manure. Mineral fertilizers would increase the replacement costs tenfold.
Costs per year	USD 5-25	USD 10
Percentage of net income	Up to 10%	Up to 1 %

Source: Drechsel et al. (2005).

#### 4.4 Conclusions

Urban vegetable farmers cultivate year-round, which provides them with an earning capacity that is at least two times higher than that of their rural counterparts. This offers opportunities to move out of poverty. Open-space urban farming also contributes substantially to the perishable food requirements of Ghanaian cities. This is partly because food flow from outside the urban areas is constrained due to lack of cold transport and storage facilities, a common challenge in many less developed countries. Thus urban farming saves energy, transportation, storage and packaging costs. There are also a number of other possible benefits, such as flood control, climate change adaptation and land reclamation, which have not been quantified so far. On the other hand, there are different negative externalities, which can fluctuate widely with changing conditions, spatially and temporarily. Some of them relate, however, more to the general challenges of urbanization, poor sanitation and land and water pollution than to the farming practices *per se*. Examples of externalities for farmers are related to pesticide misuse, nutrient depletion and wastewater exposure. Externalities for society include for example possibly higher malaria risks near irrigated urban farming sites. Field data indicate that medical treatment related to the use of pesticides can be a significant cost factor for farmers. This, however, is not a typical problem of urban and peri-urban agriculture but of any farming system depending on pesticides. A comparative analysis of the risk from pathogens and pesticide uptake showed a much more acute and higher pathogen risk on normal urban vegetable sites (Amoah et al. 2006). These risks have been quantified in a variety of assessments as also presented in chapters 9 and 10 (Barker et al. 2014; Seidu et al. 2008; Drechsel and Seidu 2011).

## 5. Marketing Channels for Irrigated Exotic Vegetables

*Manuel Henseler and Philip Amoah*

*This chapter provides qualitative and quantitative information on the distribution pathways of irrigated vegetables, with a focus on lettuce, produced in Kumasi and Accra from the farm to the consumer. The data from a survey carried out in 2005 show the contribution of irrigated urban farming and the size of the beneficiary group in Accra, which is also the group at risk from crop contamination which has been quantified.*

### 5.1 Background and Survey Details

In the context of wastewater-contaminated vegetables from urban agriculture, the objective of this chapter is to present the different lettuce distribution channels and to categorize the groups of sellers and consumers, in order to identify entry points and target populations for risk reduction programs. To get an impression of the dimensions of the lettuce market and its consumer groups, an attempt was made to estimate the total amount of lettuce produced and the size and type of lettuce-consuming population.

The vegetable marketing channel surveys included farmers, wholesalers and retailers (Box 5.1). For the related risks assessment along the food chain, researchers followed from different farms certain batches of lettuce up to the final consumer (Amoah et al. 2005, 2007a). In Accra, six central markets (CM) and five neighborhood markets (NM) were visited, whereas in Kumasi the three main markets (Central Market, Railway Market and Asafo Market) and 12 neighborhood (or community) markets were included in the survey. At each market, a representative number of lettuce traders was interviewed as well as their customers. The survey was repeated in intervals over the dry and rainy seasons.

Most lettuce buyers in both cities were related to year-round fast food selling points in the street food sector. Eighty-three fast food sellers serving lettuce as a side dish in Accra and 144 in Kumasi were interviewed. Likewise, 161 and 212 fast food customers were interviewed in Accra and Kumasi, respectively. In addition, 34 fast food stands were also visited in five different suburbs of Accra, in order to assess the knowledge about the lettuce bought, to explore vegetable washing habits and to calculate the average weight of lettuce in the common fast food meal of rice and chicken (*check-check*). Twenty salad samples were taken to the laboratory, where the lettuce was sorted, weighed (Henseler et al. 2005) and analyzed (Amoah et al. 2005, 2007a). Based on the statistics of the Accra Municipality, the Food

Research Institute (Ghana) and local fast food seller associations, the number of fast food sellers in Accra selling food known for its lettuce supplement was estimated. About 90 fast food vendors in different parts of Accra were then visited at different times over a day to record the absolute number of people who buy food with lettuce (in contrast to other food or the same but without lettuce).

**Box 5.1: Definitions used for this survey**

*Wholesalers* were defined as dealers who buy large quantities and concentrate on one or very few sorts of vegetables. However, distinction between wholesalers and permanent retailers is often not easy as frequently they show mixed behavior (also crop- and season-dependent).

*Permanent Retailers* have permanent stands in a market to display and sell their produce.

*Independent Vegetable Dealers* have permanent stands but are not located in the official market.

*Mobile Retailers* do not have permanent stands but rather roam around with their produce or temporarily install themselves at certain sites.

*Fast Food Stands* are stationary street food vendors that sell ready made food. This survey concentrated only on stands selling fried rice, plain rice, *jollof* rice, *waakye* rice and fried eggs as these dishes usually have a raw salad component. Traditional ‘*chop bars*’, which serve so-called *kenkey*, *fufu*, *banku* etc. were not included, as these meals do not contain raw salad greens.

## **5.2 Marketing Channels**

### **Traditional Marketing Structures**

Wholesale marketing of exotic vegetables, which are *produced in peri-urban areas*, takes place at certain distribution points on specific days during the week. In Kumasi, for example, traders from the city and distant traders from Accra, Cape Coast, Obuasi and Takoradi-Sekondi come for business. The presence of traders from outside Kumasi can influence market prices as they usually make better offers (Cornish and Aidoo 2000). Urban and growing numbers of peri-urban farmers who are not selling to traders on farm, send their produce to various distribution points relatively early in the morning (normally by 5.30 am), where wholesalers, retailers and hawkers converge to purchase the vegetables. In addition to the main markets there are other small sale points located at strategic places within the city.

Once the local market has been satisfied and the nonlocal traders are gone, the market for exotic vegetables on any other day is small and prices are highly erratic (Cornish et al. 2001). However a significant proportion of the exotic vegetables *produced in the city* is sold at the farm gate, i.e. directly to wholesalers or retailers who harvest the (best) crops themselves.

While many agriculture sectors in Ghana are being financed either by the government or external aid, urban farmers specialized in market production can only rely on self-financing (usually to start the business) or market women who can provide credit for the purchase of inputs (especially seeds and chemicals). These women can be intermediaries, wholesalers or actual market sellers. They visit the urban farms and reserve beds of vegetables in advance, thus financing the venture. The contract is oral. The price per bed depends on the season, crop and the size of the bed (approximately USD1.4 to 3.6 per bed) and farmers are not allowed to sell the vegetable to any other person. The total amount of money eventually received may differ from the agreed figure as demand and supply might have changed during the growing period, but seldom to the advantage of the (male) farmers. Thus farmers usually complain about this dependency on the traders (see chapter 3).

When interviewed, vegetable wholesalers in Kumasi stated categorically that they preferred going to the farms within the city to buy fresh vegetables without having to pay intermediaries or transportation costs. This strategy is supported by the lack of cold transport and storage capacity. If the type and quantity traders need cannot be acquired on urban farms, the rest is bought in wholesale markets or other distribution points (see Figure 4.2).

Common challenges of the marketing system are:

- Limited transparency about price information;
- Farmers' associations not strong enough to lobby with traders;
- Lack of safe water and hygiene in markets for handling of produce.

### **Alternative Marketing Strategies**

There are only a few examples of (male) urban farmers who escaped from their dependency on market women. Danso and Drechsel (2003) reported the case of a small group of about three to five farmers within the La area in Accra who farm around a wastewater treatment pond. In 2003 two senior farmers managed the group: one supervised crop production, while the other tried to market the vegetables. The junior members of the group were a mix of laborers or apprentices in charge of vegetable bed preparation, cultivation, watering of crops, spraying of pesticides and harvesting of produce. The 'marketing manager', who is still today

(2014) at the site, was responsible for input supply and marketing of the produce and all the necessary farming information concerning production techniques and marketing strategies. He had a long history in trading of nonagricultural commodities from Nigeria to Ghana, but had never worked as a farmer before he started cultivation in the La area.

At peak production, each of the junior farmers was supposed to have up to 100 beds under cultivation. According to the marketing manager, their cropping pattern depends entirely on the demand (price) for a particular product at a particular time. He studied the market in order to know when to produce what to meet demand peaks and used the following commodity chart at the time of interview:

<b>Main crop</b>	<b>Cropping period</b>
Lettuce	March to April
Cabbage	April to June
Sweet pepper	August to November
Spring onions	September to December

Source: Emmanuel Opare, personal communication.

As many vegetables are grown in short rotation (e.g. lettuce can be cultivated nine to 11 times a year) flexibility is crucial, and the main crop is accompanied by others.

Marketing of the vegetables was carried-out in two ways: a greater portion of the produce will be sent to certain vegetable markets in Accra while the remainder is sold on the farm. During high demand periods, the marketing manager purchases from other producers at different sites in order to improve his profits but also to provide sufficient produce to meet demand. In this way he is partially taking over the function of a wholesaler.

The leaders paid themselves at the time of the interview a monthly wage of USD57 each and USD29 each to the other five members leaving a quarterly net profit of USD286. This amount was used to buy the necessary input for the next crop. In addition, the farmers managed to have a special budget, which was used only when there was loss in production or a member of the group had a problem (family, health, funeral, etc.) (Danso and Drechsel 2003).

### 5.3 Quantifying Food Flows

The analysis of the interviews with lettuce farmers, dealers and their customers allowed mapping of the information in flow charts (Figures 5.1 and 5.2). The charts visualize the flow from the sources of lettuce (top), through its distribution pathways (center) to the target groups who finally buy the lettuce on the market (bottom).

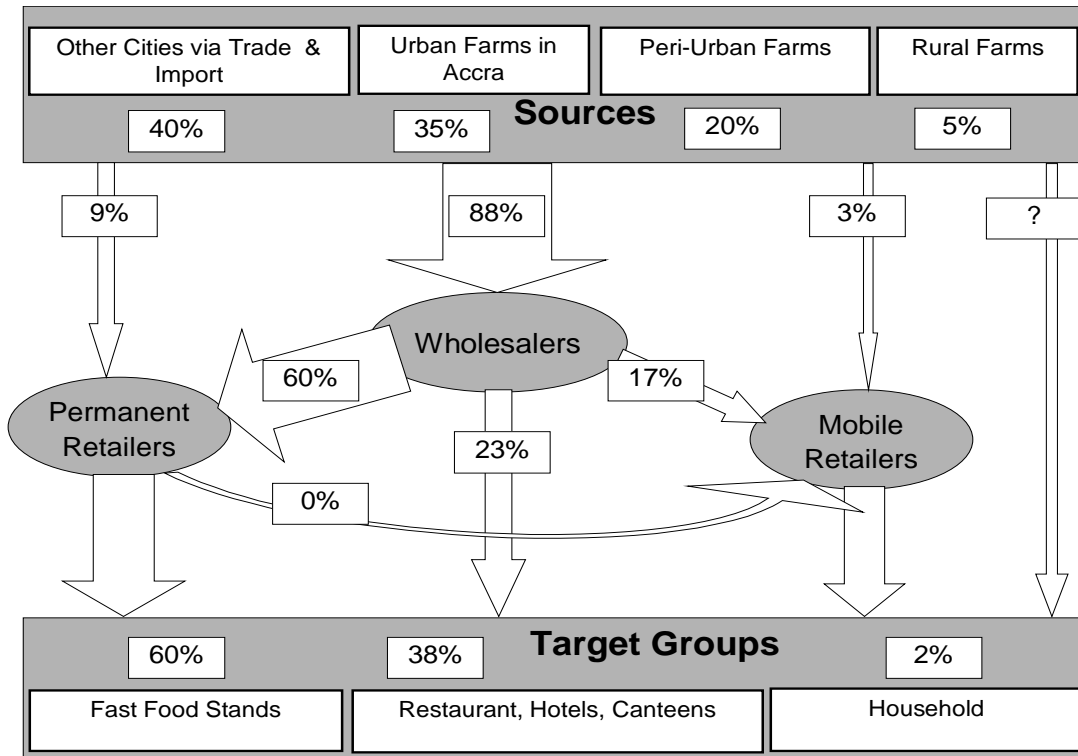


FIGURE 5.1. Flow chart of lettuce distribution in Accra (Henseler et al. 2005).

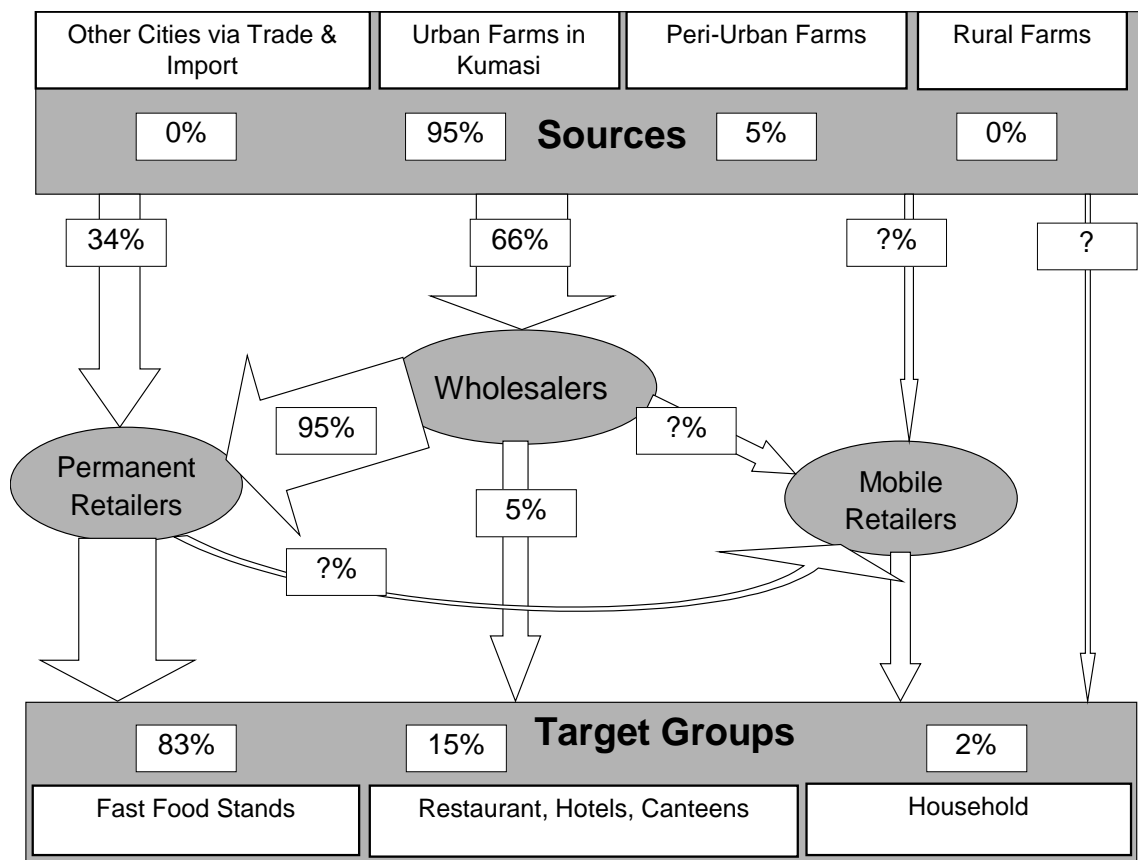


FIGURE 5.2. Flow chart of lettuce distribution in Kumasi (Henseler et al. 2005).

### National Trade and Import of Lettuce

The major sources of lettuce in Accra are urban farms in Accra and other cities (Figures 5.1 and 5.2). *Trade and Import* means in most cases lettuce harvested at farms from urban Kumasi. In a few cases Aburi and Koforidua in Ghana, and Lomé in Togo were mentioned as sources. A large fraction of the lettuce coming from these cities is organized by a small group of seven to 10 female wholesalers. They bring their produce (five to 10 sacks each) in public buses (USD1.1 fee per sack in 2005) or lorries to Accra's Agboghloshie market and sell it there for USD16 to 39 (depending on the season) to other wholesalers and retailers. The Agboghloshie market therefore plays a crucial role in lettuce distribution in Accra. One of such sacks weighs on average 50 kg (wet weight). Sacks used for sales within Kumasi are smaller (average of 30 kg lettuce per sack). These sacks are sold in Kumasi for USD3 to 13, depending on the season. Some wholesalers in Kumasi bring their produce to local bus stations where they sell it to other wholesalers who transport the lettuce in lorries or buses to Accra, Takoradi/Tarkwa, Cape Coast and other cities in Ghana (Figure 5.3). Lettuce from Togo is transported with lorries that also carry other vegetables, including carrots and spring onions.

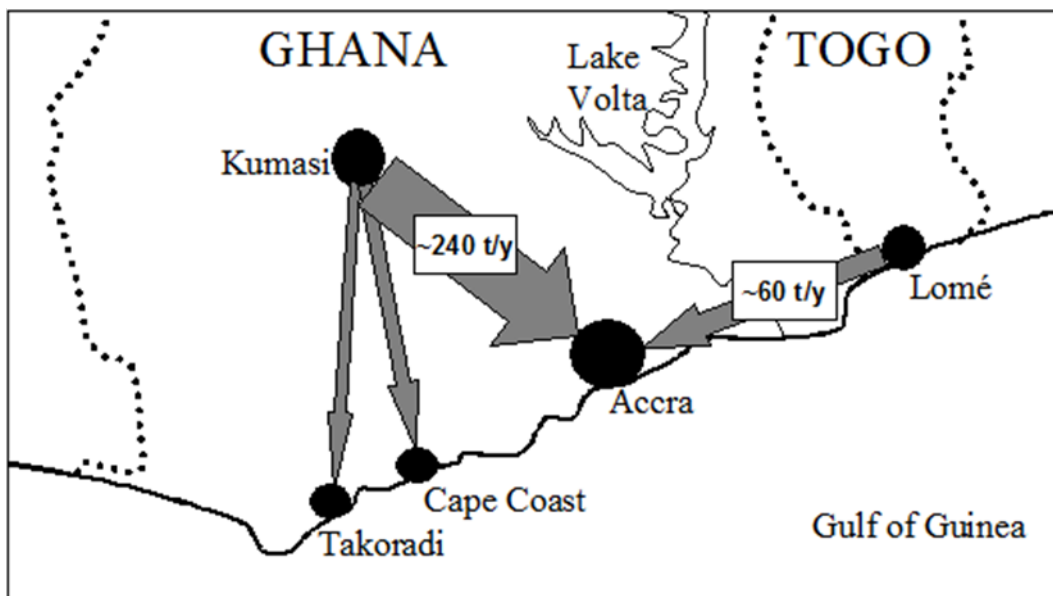


FIGURE 5.3. Import and national trade of lettuce in Ghana.

On market days (Mondays and Thursdays), approx. 50 sacks are brought to Agboghloshie market, mostly from other cities. On Tuesdays, Fridays and Saturdays, less lettuce (approximately five sacks) arrives, whereas on Wednesdays and Sundays, the local supply is

allowed to dominate the market and hardly any lettuce is brought to Agboglobshie from other cities. Based on these numbers, it was estimated that in 2005 a total of over 300 t of lettuce per year is brought to Agboglobshie market from these sources. There are probably other smaller markets in Accra for lettuce wholesale.

#### **Lettuce from Urban and Peri-urban Farms**

In Kumasi, 95% of the lettuce came from urban farms. In Accra 35% came from urban sources within Accra, whereas a reasonable amount (approximately 20% of total lettuce on the market) also came from peri-urban farms. Rural farms obviously contribute very little to lettuce supply in the two cities, probably due to its easily perishable nature. As the lettuce brought from other cities has its origin mostly in urban farms, it is assumed that this source ('irrigated urban agriculture') accounts for about 70% (in Accra) and 95% (in Kumasi) of the total lettuce sold in the cities' markets.

The importance of the different sources of lettuce certainly varies during different seasons. During the major dry season in Accra (November to April), more lettuce is brought from other cities. The shares of the different external sources (i.e. Kumasi and Lomé) again depend on the climatic conditions in those areas. The present survey was conducted when Accra had dry weather, whereas Kumasi was already in its rainy season, which could explain the large share of externally-grown lettuce on Accra's market. The situation during other periods needs to be assessed in a repeat survey in different seasons.

#### **Lettuce Distribution Pathways**

In both investigated cities, the major distribution pathway is from farm gate to wholesalers, from wholesalers to permanent retailers and from retailers to the final target groups (Figures 5.1 and 5.2). Based on the information gathered on the markets, an estimation of the number of lettuce dealers in the two cities was made. Assuming there are seven to eight central and 43 neighborhood markets in Accra (modified from De Lardemelle 1996), a total number of 40 wholesalers and 400 permanent retailers was calculated (excluding *Independent Vegetable Sellers*). Due to the outstanding importance of the Agboglobshie Market in vegetable trade, this market was considered as a separate type of central market. For Kumasi, based on the three larger and 18 neighborhood markets, about 20 wholesalers and 160 permanent retailers were estimated. In Kumasi, hardly any *Independent Vegetable Sellers* were found.

The importance of mobile retailers is uncertain and difficult to determine, as they are hard to spot. In Accra, 21 of them were found during this survey, whereas in Kumasi no mobile retailers were spotted at all.

### **Total Amount of Lettuce Traded in Accra Compared to Kumasi**

The total amount of lettuce handled and purchased in the two cities in 2005 was extrapolated based on amounts, the stratification of traders and number of traders. An alternative assessment was based on areas and production figures.

The total lettuce production during the dry season in urban and peri-urban Accra ranges between 900 and 1,000 t year<sup>-1</sup>. Another 300 t year<sup>-1</sup> are added from other cities totalling approximately 1,250 t of lettuce per year purchased and consumed in Accra.

For Kumasi, this can be calculated on the basis of cultivation area and information on productivity that about 1,000 t of lettuce are produced per year. The market turnover was estimated at 850 t year<sup>-1</sup>. As large quantities of lettuce produced on Kumasi's urban farms are transported to Accra and other cities without ever going to Kumasi markets, this difference seems to be justified. Further, it agrees with the figure calculated by Leitzinger (2000), who estimated total lettuce consumption of 615 t year<sup>-1</sup> in Kumasi. His survey was based on interviews at the household level. It can be confidently expressed that nearly all lettuce actually consumed in Kumasi is also produced there.

### **5.4 Customers and Consumers**

The largest clients of the lettuce marketing chain are the **fast food sellers**, buying 60% of the total lettuce in Accra and 83% of the lettuce in Kumasi. Restaurants, hotels and canteens buy 38% of the total lettuce traded in Accra and 15% in Kumasi. Private households in Accra and Kumasi rarely purchase lettuce, constituting only 2% of the total lettuce sold on the assessed markets. This reflects the fact that lettuce is not part of the traditional Ghanaian diet. It is certainly possible that especially upper class households rather buy lettuce from *independent vegetable dealers* or from *supermarkets*, which were not covered in this present survey. However, there are only very few supermarkets (all in Accra) that sell fresh vegetables. A rapid assessment in two typical (upper class) suburbs showed that the share of households would still remain in the 2 to 4% limit when compared with the quantities bought by fast food sellers, canteens and restaurants.

### Fast Food Stands

Almost all fast food stands purchase their vegetables from markets, i.e. not at the farm gate. In fast food stands, lettuce is normally mixed with other vegetables like cabbage, carrots and onions, with cabbage and carrots also mostly coming from urban farms. The content of lettuce in the offered meals varies. Most fast food stands serve lettuce as a side dish along with fried rice and chicken (check-check), plain rice, *waakye* rice or with fried eggs; in few cases also with *jollof* rice or bread.

Sizes and appearances of the stands vary. Most commonly, they consist of a square-shaped wooden box with a small opening in the front to sell the dishes. Other stands simply have a table and a few pots or thermo-boxes for the food. The (home) ready-made salad is usually stored in plastic plates and sometimes covered with foil.

Dr. P. Johnson of Ghana's Food Research Institute (NRI/DFID/FRI 2000) estimates from field surveys that there are approximately 15,000 street food vendors in Accra. According to unpublished Accra Metropolitan Assembly (AMA) statistics gathered from different suburbs in 2008, about one-third of the registered vendors sell food known for its salad (lettuce and/or cabbage) supplement mostly from urban agriculture. A survey among 90 sellers from this group showed in 2008 that on average 50 units per fast food seller are sold with a salad component per day. This gives a total of about 250,000 units or fast food consumers; but this is certainly a rough estimate. About 60% (or 150,000 meals) of these units contain lettuce, the others only cabbage and other vegetables.

We also estimated the number of fast food consumers by considering the total amount of lettuce traded on Accra's markets (950 t year<sup>-1</sup>), and extracting the fraction that goes to fast food stands (60%) and dividing it by the average weight of the lettuce in one fast food dish (12 g); thus about 130,000 fast food meals with lettuce are sold per day. Combining both assessments, it seems that about 130,000 to 150,000 units of lettuce are served per day. Under additional consideration of cabbage and spring onions, it can be assumed that in Accra every day, probably more than 200,000 people consume uncooked vegetables outside their household. If we consider also canteens and restaurants another 80,000 beneficiaries from urban agriculture are possible. However, this large group also comprises the part of Accra's population at risk of food contamination (see chapter 9).

Although sellers claim to wash their vegetables with tap water, the washing methods and procedures described by them are in most cases insufficient to clean the lettuce properly according to a laboratory test by IWMI (Amoah, unpublished). It is therefore not surprising that salad from street food vendors was found to be contaminated with pathogens (Mensah et

al. 2002). A study conducted in Kumasi (Olsen 2006) showed, however, that street food vendors are convinced that they have eliminated risks via their washing practices. For health campaigns to be effective it is important to target these beliefs of risk-control and correct the misunderstanding about presumed safe practices related to washing of lettuce, safe food temperatures etc.

### **Consumers**

Street food containing lettuce is available in the areas of all income groups, with relatively more frequent lettuce supplement in low-income areas. Customers are mostly men (70%) who buy three to four times a week. Like the typical urban dweller, most live in low-class (50%) and middle-class (approximately 38%) areas, and often work in the small-scale private sector, but they can also be entrepreneurs or students. Some of the fast food with lettuce supplement belongs to the cheapest food available in town attracting the poor and their dependents, as noted by Essamuah and Tonah (2004). Consumers translate their general risk awareness into decisions by selecting food vendors they have personal trust in through the physical appearance of their stand and food.

### **5.5 Conclusions**

The survey has confirmed that most of the lettuce coming to urban markets has its origin in urban farms, many of which only have access to contaminated water for irrigation. While there should be the awareness of the potential health risks to consumers, it is also important to realize the important role of this new and growing economy to the city's food supply. In Accra, at least 200,000 people benefit every day from vegetables produced in urban agriculture. Both benefits and risks should therefore be taken into account when intervention strategies are discussed.

It has been shown that although more direct pathways exist, most lettuce distribution from the farm gate to customers runs through the urban markets. Further, this survey has identified fast food sellers as the major customer group of the lettuce market. Raw salads are a typical modern street food and not common in traditional households where vegetables are eaten cooked in stews. The situation is different in Ghana's neighboring countries which were formerly French colonies and where green salads were introduced into the normal diet of different income groups and green salads are also served at home (Amoah et al. 2007ab).

In order to reduce consumer health risk resulting from eating contaminated lettuce, fast food sellers should be targeted by health campaigns. Also, restaurants and canteens, which sell a reasonable fraction of the total amount of lettuce produced in the two cities, should be included in such programs. Although they often have better infrastructure for hygienic preparation of vegetables eaten raw than dealers in markets or fast food sellers, this also depends on the washing method in order to ensure that the lettuce is thoroughly clean of bacterial load. As most restaurants and canteens are registered, they should be easier to access and control than street vendors.

Vegetable dealers and street food vendors could be approached through the activities of extension agents, including units from the Ministry of Food and Agriculture (MoFA), AMA and other government bodies. MoFA programs directed at vegetable sellers and market infrastructure have already been launched and are ongoing. Different existing programs should be coordinated and focus on the health risk of vegetables eaten raw. MoFA's extension services should also be involved in health implementation activities directed at farmers and street food sellers.

A good entry point for intervention programs could be found in the already existing associations. Various vegetable sellers associations and the so-called Maggi<sup>®</sup> Fast Foods Association of Ghana would be suitable networks to access the described target groups. Their organizational structures should be strengthened so that they can be used for training purposes or as a platform for information exchange with government bodies. Unfortunately, many vegetable dealers and fast food sellers are not yet members of the existing associations.

A legal framework, consisting of a set of municipal by-laws, to regulate hygiene standards in markets and food stands exists (Laryea 2002), although it is not well adapted to reality. By-law enforcement, which should be the task for example of AMA's health department, is unsatisfactory due to common lack of resources and the ignorance of dealers and sellers. As many fast food sellers are not registered and have neither permanent stands nor association membership, it is difficult to physically contact them or control their movement. A health campaign broadcast via radio, TV, and street banners, or transmitted through wholesalers could probably reach this group better as well as consumers and restaurants to increase risk awareness and if needed put pressure on vegetable dealers and fast food sellers to comply with the recommended hygiene standards. On the other hand, education and risk awareness will not be enough to change behaviour, and incentives will be needed for compliance with recommended practices, especially where control is weak (Drechsel and Karg 2013).

## 6. Quality of Irrigation Water Used for Urban Vegetable Production

Bernard Keraita, Andrea Silverman, Philip Amoah and Senorpe Asem-Hiablie

*This chapter presents findings from studies conducted in Accra, Kumasi and Tamale aimed at assessing the quality of irrigation water used by farmers in and around the cities. Samples for laboratory analysis were taken from sources of water used for irrigation. Microbiological, chemical and other emerging contaminants are presented.*

### 6.1 Urban Sanitation and Water Quality Linkages

The quality of water used for irrigation has implications for agricultural productivity and human health. In Ghana, most irrigation water sources are contaminated with untreated domestic wastewater emanating from poor urban sanitation. The latest National Population and Housing Census conducted in Ghana in 2010 shows that most Ghanaians (34.6%) continue to use public toilets, while nearly 20% of the total population practice open defecation<sup>1</sup>. The percentage of houses served by sewers is less than 5% (GSS 2012a). The Joint Monitoring Programme, which does not consider shared public toilets as improved sanitation facilities, reports that only 19% of urban Ghanaians and 8% of rural Ghanaians have access to improved sanitation facilities (WHO/UNICEF 2013).

About 30% of households dispose of their liquid waste (mostly graywater) through street gutters (GSS 2012a). Most houses in low-density areas have on-plot pit latrines or septic tanks, but usually without drain fields. The overflow of septage from septic tanks into soils, stormwater drains and water courses is common and pollutes the urban environment. Subsequently, most street drains, which cover about 60% of Accra and were meant for stormwater (and graywater) conveyance, also show high coliform levels.

Wastewater and fecal sludge that is collected in Ghana is rarely treated before discharge into the environment. There is no official or definitive inventory of wastewater and fecal sludge treatment plants in Ghana. In 2001, Ghana's Environmental Protection Agency (EPA) recorded 44 treatment plants in an unpublished national survey (EPA 2001), while in 2008 IWMI

---

<sup>1</sup> Using the common black plastic bags ('flying toilets'), which are then removed with solid waste or end up outside the compound, often in stormwater drains.

identified 63 wastewater treatment plants and eight fecal sludge treatment plants across the country (Murray and Drechsel 2011). Ghana’s National Environmental Sanitation Strategic Action Plan (NESSAP) quoted this survey in its list of treatment facilities in Accra, Kumasi and Tema, many of which overlapped with the EPA’s survey (MLGRD 2010). In 2013, IWMI conducted a second survey which excluded some decommissioned facilities and counted 66 wastewater treatment plants and 11 fecal sludge treatment plants; however three of these were still under construction at the time of the survey (Figure 6.1). Among the 66 identified wastewater treatment plants, only three could be considered centralized municipal wastewater treatment plants, while the majority served decentralized sewer systems. Informal fecal sludge disposal sites (mostly depressions without concrete infrastructure) were not included in the IWMI 2013 survey.

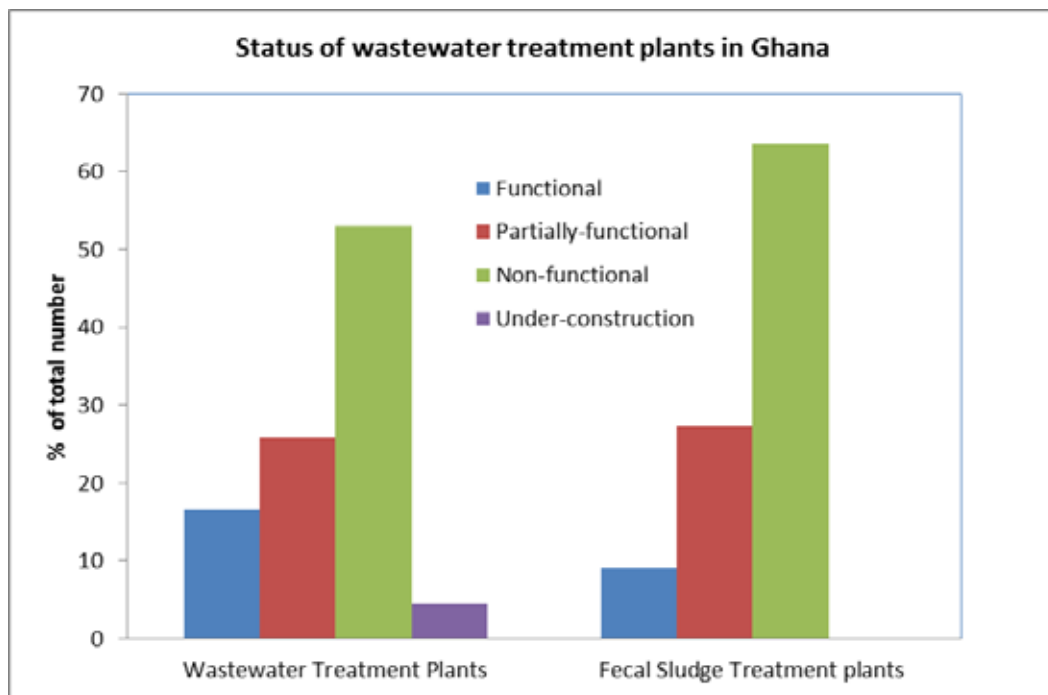


FIGURE 6.1. Status of wastewater and fecal sludge treatment facilities in Ghana in 2013.

Source: IWMI (unpublished, 2013).

Of the 74 wastewater and fecal sludge treatment facilities identified in the 2013 survey (not including the three under construction), only 12 (11 wastewater and one fecal sludge treatment plants), representing about 16% of all treatment plants, were found to be fully functional. About 27% had some capacity to treat influent waste but were unable to treat it to a level that rendered it safe for environmental and public health prior to discharge. Most of these functional and semi-functional plants were small capacity plants owned by hotels and private companies

as also shown by Murray and Drechsel (2011). Most facilities (56.7%) could not be considered functional, although the majority were not officially decommissioned and still received wastewater or sludge. Already in 1998, Akuffo (1998) stated that none of Accra's 18 sewer systems and treatment plants were working or maintained as designed, while Hodgson and Larmie (1999) found the treatment plants in Tamale to be in a deplorable state, the EPA (2001) deemed less than 10 of 44 treatment plants as functional, and MLGRD (2010) categorized only five of the 27 treatment plants in Accra, Tema and Kumasi as rehabilitated or functional.

This general overview illustrates that most of Ghana's wastewater ends up in the environment in its untreated form. Given that the situation is worse in urban areas due to high population density, there is a strong link between a lack of wastewater treatment and the use of polluted water in irrigated urban agriculture; farmers have, in many locations, no option but to collect water from waterways or reservoirs impacted by untreated wastewater, including fecal matter.

## 6.2 Bacteriological Quality of Irrigation Water

A number of fecal indicator microorganisms are used to assess levels of microbiological contamination. Fecal indicator organisms are not necessarily pathogenic but are used to signal the potential presence of waterborne pathogens. However, indicator organisms have varying degrees of specificity in detecting the source of contamination. For example, *E. coli* is a more exact indicator for fecal contamination than fecal coliforms or total coliforms, which could be of animal or environmental origin. However, given that analyzing water samples for specific pathogens can be expensive or difficult to perform, fecal coliforms (also referred to as thermotolerant coliforms) are commonly used as indicators of bacterial contamination.

Thermotolerant coliform concentrations measured in irrigation water sources in Accra, Kumasi and Tamale are presented in Figure 6.2 (Amoah et al. 2005, 2007a). In general, thermotolerant coliform concentrations ranged between 4-10 log units per 100 millilitres (ml), with mean concentrations of about 6 log units per 100 ml of irrigation water. These data indicate that irrigation water sources were highly polluted across all cities, with a few exceptions, such as the shallow well at Weweso farming site in Kumasi. Previous studies carried out in Accra (Armar-Klemesu et al. 1998; Sonou 2001; Zakariah *et al.* 1998) also found that few unpolluted water sources were available for irrigation. The worst case was the highly populated drainage basin of the Odaw River and Korle Lagoon, which covers more than 60% of Accra (Biney 1998). Donkor et al. (2010) found for example very high fecal coliform levels of  $2.3 \times 10^7$  CFU  $100\text{ml}^{-1}$  in well water and  $1.6 \times 10^9$  CFU  $100\text{ml}^{-1}$  in stream water used by urban farmers in Accra.

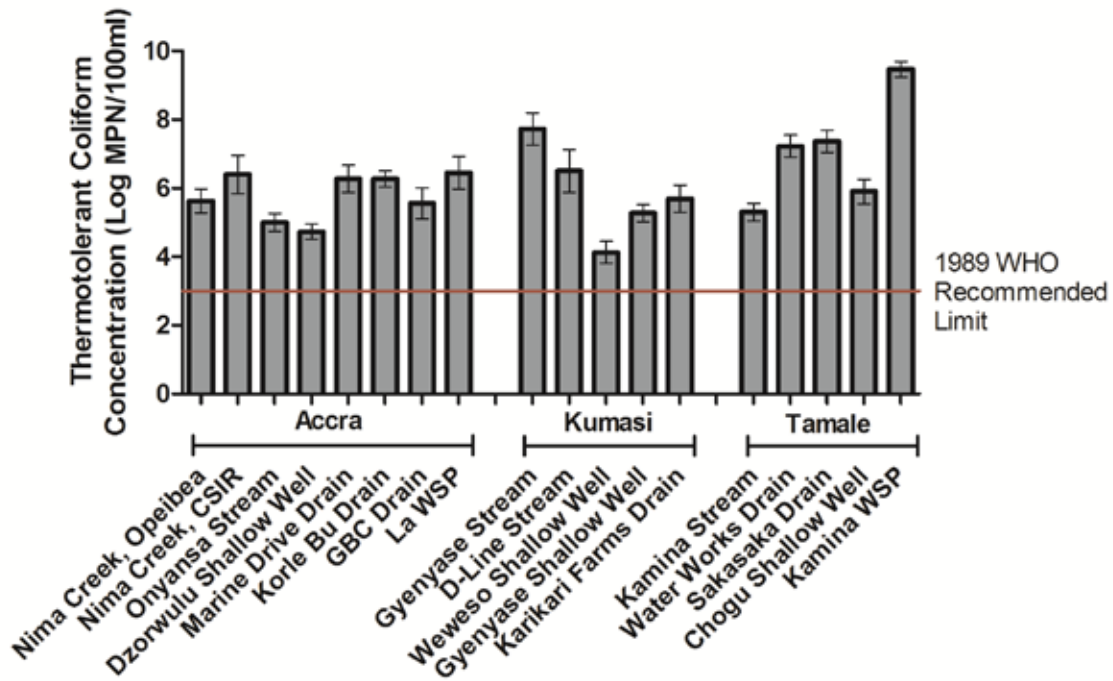


FIGURE 6.2. Average thermotolerant coliform concentrations measured in irrigation water sources in 2003 and 2004 (Amoah et al. 2005, 2007a).

Another recent study conducted in Accra in 2010 used a more specific fecal indicator bacteria, *E. coli*, to assess irrigation water quality (Silverman et al. 2013). The study also found widespread and increasing contamination of irrigation water sources (Figure 6.3).

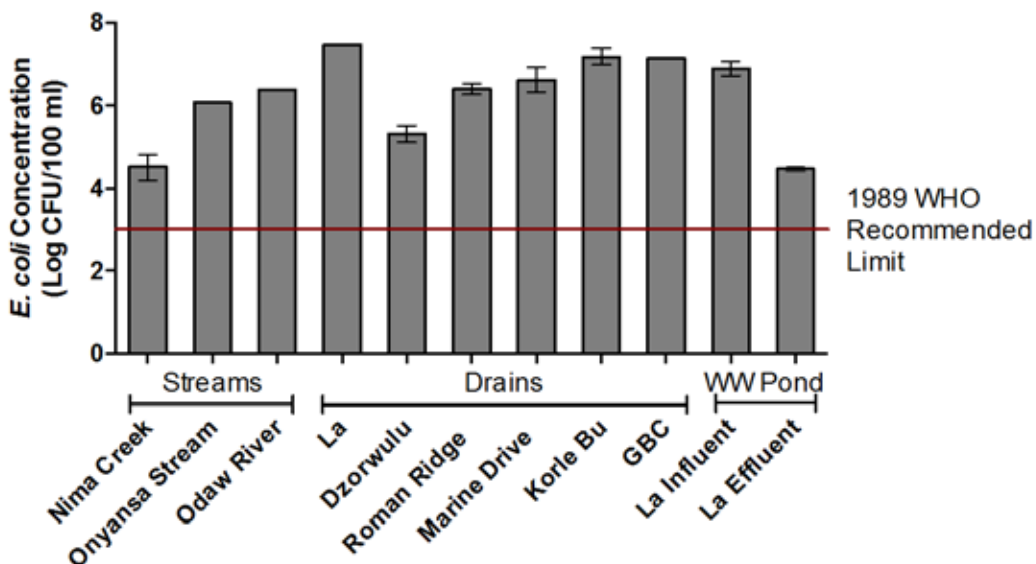


FIGURE 6.3. Average *E. coli* concentrations measured in irrigation water in Accra in July 2010 (Silverman et al. 2013). The denoted 1989 WHO recommended limit is for thermotolerant coliform, a classification of bacteria that includes *E. coli*.

*E. coli* concentrations in all irrigation waters sampled were greater than the maximum thermotolerant coliform concentration recommended by the previous 1989 WHO guidelines for wastewater use in irrigation (Figure 6.3). *E. coli* levels generally ranged between 4.5-7.5 log colony forming units (CFU) per 100 ml. The study also found high contamination regardless of farming site and irrigation water source, other than Nima creek and effluents from stabilization ponds at La, which had comparatively lower levels of *E. coli*.

To assess seasonal variability in irrigation water quality, Amoah *et al.* (2005) monitored thermotolerant coliform concentrations in Accra and Kumasi from May 2003 to April 2004 (Figure 6.4).

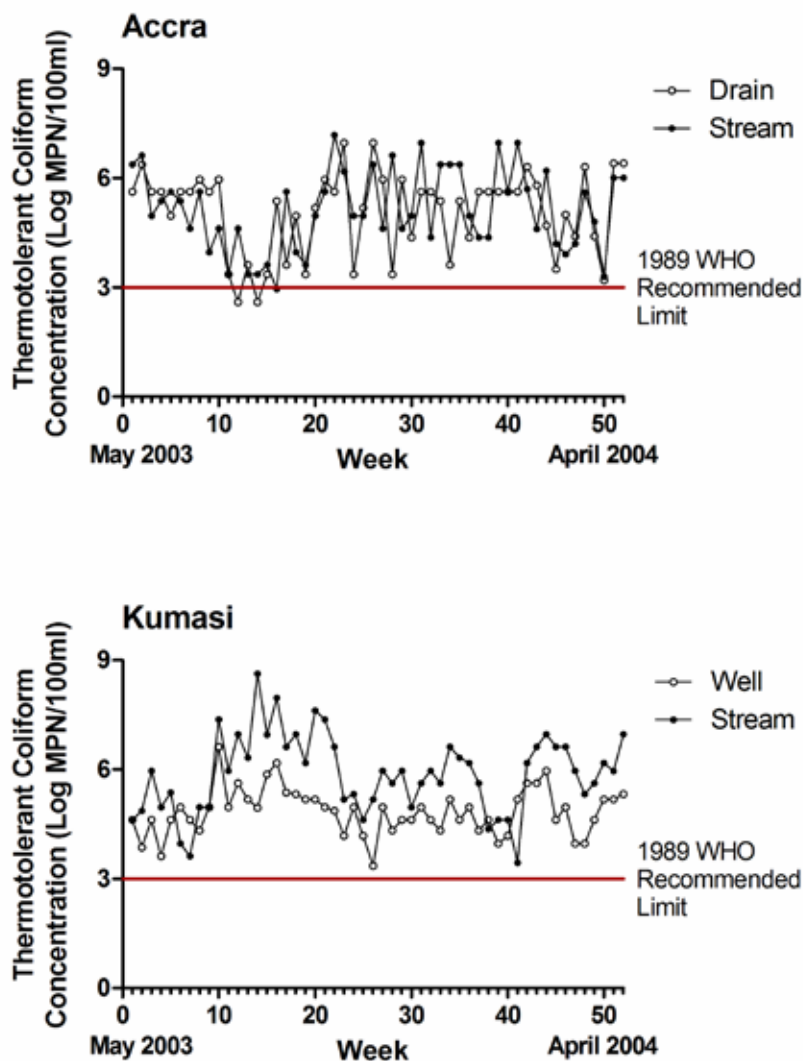


FIGURE 6.4. Temporal variation in thermotolerant coliform concentrations in stream, drain and shallow well water in Accra and Kumasi.

(Source: Amoah *et al.* 2005, 2007a).

Composite samples were collected each week from streams and wells in Kumasi and streams and drains in Accra. Throughout the 12-month sampling period, thermotolerant coliform concentrations in irrigation water in Accra and Kumasi exceeded the WHO (1989) recommended limit for unrestricted irrigation of crops likely to be eaten raw (Figure 6.4). In Kumasi, thermotolerant coliform counts were generally higher in water samples collected from streams than from shallow wells; there was no clearly defined pattern between thermotolerant coliform concentrations in drain and stream water sources in Accra.

Water samples collected in July 2014 in Tamale show a wide range of *E. coli* and fecal coliform contamination level in the irrigation water (Table 6.1) with most levels above the WHO 1989 threshold. The samples were taken from the watering cans after farmers fetched the water. It is important to note that even at Gumbihene Old dam where treated pipe borne water is used fecal coliforms were detected. One reason could be that the watering cans were also used for other water sources. Aside Gumbihene Old dam, other taps mentioned in Table 6.1 probably belonged to mechanized wells (with manual pumps), which could explain possible contamination.

**TABLE 6.1.** Common pathogen levels in irrigation water at different farming sites in Tamale.

Water Source (n=3 each)	E. coli CFU 100ml <sup>-1</sup>		Fecal coliforms CFU/100m <sup>-1</sup>		Helminth eggs l <sup>-1</sup>
	Range	Mean	Range	Mean	
Sangani (dugout)	0 to 4.0 x 10 <sup>3</sup>	1.8 x 10 <sup>3</sup>	6.7 x 10 <sup>4</sup> to 2.2 x 10 <sup>5</sup>	1.3 x 10 <sup>5</sup>	2
Choggu Dam (tap)	0	0	0 to 9.0 x 10 <sup>3</sup>	4.0 x 10 <sup>3</sup>	0
Choggu Dam (reservoir)	0 to 1.0 x 10 <sup>3</sup>	2.0 x 10 <sup>0</sup>	5.1 x 10 <sup>4</sup> to 2.8 x 10 <sup>5</sup>	1.4 x 10 <sup>5</sup>	3
Gumbihene Old Dam (treated tap water)	0	0	0 to 3.0 x 10 <sup>3</sup>	1.2 x 10 <sup>3</sup>	0
Gumbihene New Dam (tap)	0 to 1.0 x 10 <sup>4</sup>	1.8 x 10 <sup>3</sup>	1.2-6.7 x 10 <sup>5</sup>	3.1 x 10 <sup>5</sup>	0
Gumbihene Water- works (canal/drain)	0 to 8.0 x 10 <sup>4</sup>	3.7 x 10 <sup>4</sup>	2.5 x 10 <sup>5</sup> to 9.0 x 10 <sup>6</sup>	2.2 x 10 <sup>6</sup>	4
Jekeryili (stream)	1.2-6.4 x 10 <sup>5</sup>	3.9 x 10 <sup>5</sup>	1.8- 3.6 x 10 <sup>6</sup>	2.7 x 10 <sup>6</sup>	3
Builpela (reservoir)	0	0	8.0 x 10 <sup>4</sup> to 2.0 x 10 <sup>5</sup>	1.5 x 10 <sup>5</sup>	2
Kamina (stabilization pond)	0	0	6.8 x 10 <sup>4</sup> to 1.6 x 10 <sup>5</sup>	9.2 x 10 <sup>4</sup>	5
Nyanshegu (tap)	0 to 1.0 x 10 <sup>3</sup>	7.0 x 10 <sup>0</sup>	2.9 x 10 <sup>4</sup> to 1.4 x 10 <sup>5</sup>	7.1 x 10 <sup>4</sup>	0
Dabogpa (Ghanasco reservoir)	0 to 1.0 x 10 <sup>3</sup>	3.0 x 10 <sup>0</sup>	3.8 x 10 <sup>4</sup> to 1.8 x 10 <sup>5</sup>	8.8 x 10 <sup>4</sup>	2
Tunayili (tap)	0 to 1.0 x 10 <sup>3</sup>	5.0 x 10 <sup>0</sup>	1.1-2.2 x 10 <sup>5</sup>	1.6 x 10 <sup>5</sup>	0
Tunayili (stream)	0 to 1.0 x 10 <sup>4</sup>	4.7 x 10 <sup>3</sup>	1.0 x 10 <sup>4</sup> to 2.2 x 10 <sup>5</sup>	1.1 x 10 <sup>5</sup>	2

Sources: IWMI and Lea Bartels, University of Freiburg (unpublished data; UrbanFoodPlus).

### 6.3 Helminth Eggs

A number of different types of helminth eggs were isolated from irrigation water sources sampled in Accra and Kumasi; these included eggs of *Ascaris lumbricoides*, *Hymenolepis diminuta*, *Trichuris trichiura*, *Fasciola hepatica* and *Strongyloides* larvae (Table 6.2). *Ascaris lumbricoides* eggs were the most predominant species observed, with egg concentrations ranging between 2 to 4 helminth eggs per liter. No helminth eggs were found in piped water sources. The use of pond systems on many farm sites contributed to helminth egg removal through sedimentation, leading to low egg concentrations. Helminth egg concentrations, however, increased in the dry season when farmers must collect water closer to pond sediments due to dropping water levels.

**TABLE 6.2.** Mean helminth egg concentrations measured in irrigation water in Kumasi and Accra (Amoah et al. 2005, 2007a).

Helminth	Mean helminth egg concentration (egg l <sup>-1</sup> )			
	Kumasi		Accra	
	Shallow well /ponds	Stream	Drain	Stream
<i>Ascaris lumbricoides</i>	2	3	3	4
<i>Hymenolepis diminuta</i>	0	4	0	6
<i>Fasciola hepatica</i>	0	2	5	0
<i>Schistosoma</i> sp.	0	3	0	0
<i>Strongyloides</i> sp. larvae	0	15	0	5

A detailed study on helminth eggs in irrigation water derived from the broken down sewer of the Kamina barracks in the Zagyuri community of Tamale showed 13 different types of helminths. The typical fertile *Ascaris lumbricoides* and *Strongyloides stercoralis* as well as *Schistosoma mansoni* were observed to be the most predominant types of helminths. *Ascaris lumbricoides* was the most predominant species recorded with arithmetic mean population of 12 and 17 for wet and dry season, respectively (Abagale et al., 2013). Limited water supply in Tamale as a result of irregularity of flow of domestic pipe water, especially during the dry season, was said to influence greatly the concentration of the helminth eggs in the water samples.

### 6.4 Viruses

To determine whether human viruses were present in irrigation water in Accra, Silverman et al. (2013) analysed irrigation water samples for virus concentrations using quantitative polymerase chain reaction (qPCR) and reverse transcription qPCR (RT-qPCR) (Jothikumar et al. 2005; Da Silva et al. 2007); the results for two human viruses, adenovirus and norovirus genogroup II (GII), are presented. Depending on the serotype, adenovirus can cause respiratory disease or gastroenteritis. Human adenovirus was detected in 11 out of 20 irrigation water samples (55%, Figure 6.5), and found at concentrations above the limit of quantification (LOQ) in seven samples. Of the samples with quantifiable concentrations of adenovirus, concentrations ranged between  $(2.80 \pm 0.92) \times 10^2$  and  $(6.50 \pm 0.60) \times 10^4$  gene copies per 100 ml (LOQ range: 27-240 gene copies per 100 ml). Norovirus is a leading cause of gastroenteritis worldwide, with norovirus GII the most prevalent of five norovirus genogroups in human infection (Atmar and Estes 2006; Da Silva et al. 2007). Norovirus GII was detected in 16 out of 20 irrigation water samples (80%, Figure 6.4) and found at concentrations above the LOQ in 11 samples. Of the samples with quantifiable concentrations of norovirus GII, concentrations ranged between  $(4.75 \pm 2.20) \times 10^2$  and  $(1.58 \pm 0.28) \times 10^4$  gene copies per 100 ml (LOQ range: 330-2,200 gene copies per 100 ml).

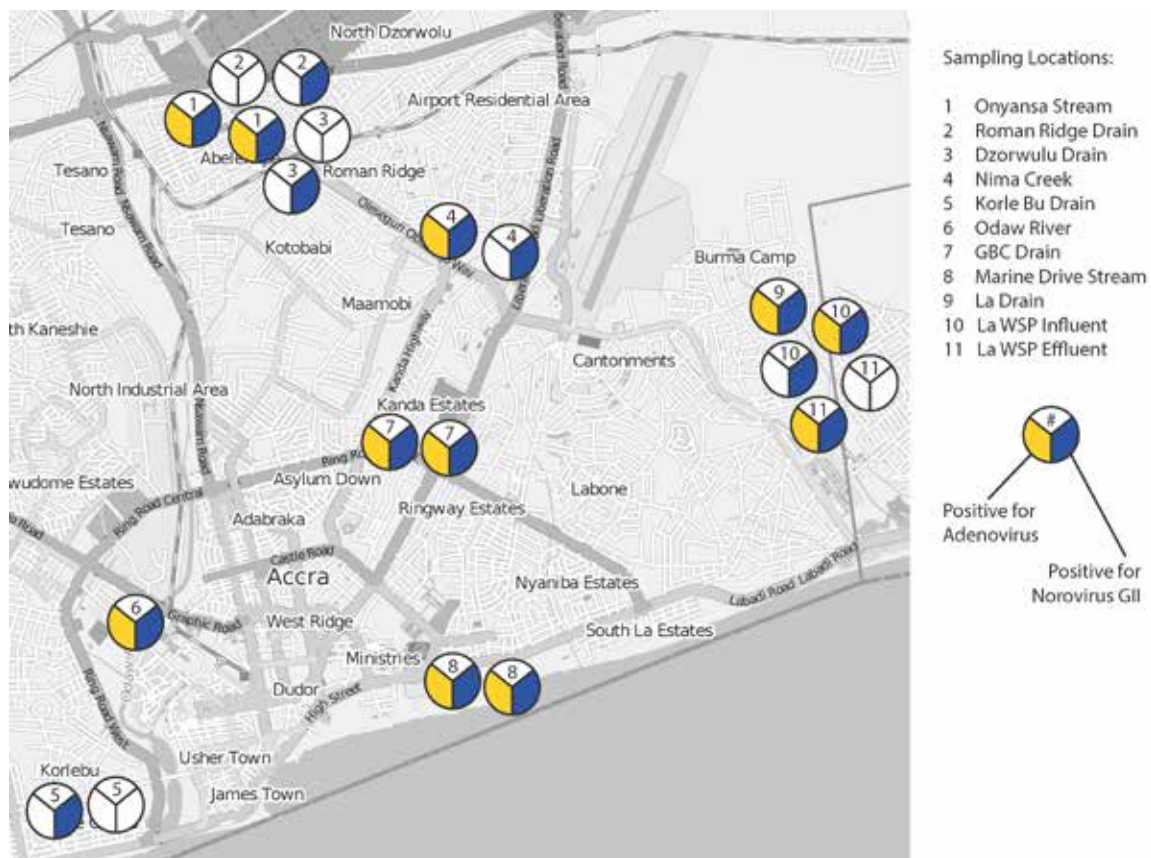


FIGURE 6.5. Occurrence of adenovirus and norovirus GII in irrigation water samples collected in Accra (Silverman et al. 2013). WSP: Wastewater Stabilization Pond

## 6.5 Emerging Contaminants

In addition to pathogens, the domestic sector is a key source of a large number of so called 'emerging' contaminants (ECs), which are receiving increasing global attention. Many of these organic contaminants are endocrine disruptors (meaning that they can interfere with the production, release, transport and metabolism of natural hormones in the body) and derive from pharmaceutical and personal care products. Examples of endocrine disruptors include steroid hormones such as estrogens. While ECs and their treatment standards are the subject of lively debate in developed countries, most Sub-Saharan countries lack information on the actual state and risks of ECs due to low analytical capacity to detect and quantify these organic chemicals in the environment and food chain. Given the huge waste problems faced by many parts of Africa, as well as indiscriminate use of pharmaceuticals and biocide, low risk perception, and seldom enforced environmental standards, there is a significant risk of long-term negative impacts to human and environmental health. Although direct evidence of adverse health effects in humans is lacking, reproductive abnormalities, altered immune function and population disruption potentially linked to exposure to these substances have been observed in amphibians, birds, fish, invertebrates, reptiles and mammals (IPCS 2002).

In a study carried out by S. Asem-Hiablie in Accra, estrogen (E1, E2 and EE2<sup>2</sup>) levels in irrigation water on two farming sites (Korle-Bu and Dzorwulu) were quantified during a six-week study. All three estrogens were present in irrigation water samples (Table 6.3). Estrone was detected in irrigation water samples at Korle-Bu on all sampling days (<LOQ – 11.1 ng/L) however, E2 was recorded once only at a concentration of 1.2 ng/L which was close to the LOQ. As E1 is the primary degradation product of E2, it is likely that microbial breakdown of E2 occurring in the open drains explains the absence of E2 and the dominance of E1 in water samples from the Korle-Bu. The EE2 concentrations were as high as 59.8 ng/L, and being the least biodegradable of the three estrogens, its presence water at Korle-Bu is an indication of its common use among the population. At the Dzorwulu site, where at one end irrigation water was piped from municipal potable water sources and stored in earthen impoundments, estrogens were detected less frequently and E1 and E2 concentrations ranged from below the detection limit to 8.1 and 3.0 ng/L, respectively throughout the sampling period. There was a one-time detection of 3.0 ng/L EE2 in duplicate samples during the 4<sup>th</sup> week of sampling. Natural estrogen was only detected once in irrigation water derived from the inlet to the farming site at

---

<sup>2</sup> Natural estrone (E1), 17  $\beta$ -estradiol (E2), synthetic 17 $\alpha$ -ethynylestradiol (EE2)

Dzorwulu. However, the concentration detected in the faucet water was very low (1.4 ng/L) and close to the method's limit of detection (1.0 ng/L). Sources of the natural estrogens (E1 and E2) may be attributed to the influx of contaminants carried by runoff from manure-applied farm plots and manure stockpiles.

**TABLE 6.3.** Concentrations of estrogens 17  $\beta$ -estradiol (E2), estrone (E1), and 17  $\alpha$ -ethynylestradiol (EE2) observed in irrigation water samples from the study sites Dzorwulu and Korle-Bu in the Accra metropolis (Source: S. Asem-Hiablie, unpublished).

	Sample Number	Korle-Bu			Dzorwulu		
		E1 (ng/L)	E2 (ng/L)	EE2 (ng/L)	E1 (ng/L)	E2 (ng/L)	EE2 (ng/L)
<b>Week 1</b>	1	1.4	< LOQ	< LOQ	7.2	1.6	< LOQ
	2	5.5	< LOQ	< LOQ	8.1	2.6	< LOQ
	3	< LOQ	< LOQ	15.9	6.8	2.2	< LOQ
	4	< LOQ	< LOQ	13.7	-	-	-
<b>Week 2</b>	1	5.0	< LOQ	< LOQ	6.6	2.0	< LOQ
	2	4.1	< LOQ	< LOQ	6.7	2.5	< LOQ
	3	4.0	< LOQ	< LOQ	7.4	3.0	< LOQ
	4	3.5	< LOQ	< LOQ	4.9	1.5	< LOQ
<b>Week 3</b>	1	5.8	< LOQ	16.1	< LOQ	< LOQ	< LOQ
	2	9.9	< LOQ	28.2	< LOQ	< LOQ	< LOQ
	3	6.8	< LOQ	12.3	< LOQ	< LOQ	< LOQ
	4	-	-	-	< LOQ	< LOQ	< LOQ
<b>Week 4</b>	1	11.1	1.2	31.9	4.9	< LOQ	3.0
	2	9.1	< LOQ	48.5	5.4	< LOQ	3.0
	3	6.3	< LOQ	46.1	< LOQ	< LOQ	< LOQ
	4	9.9	< LOQ	18.9	< LOQ	< LOQ	< LOQ
<b>Week 5</b>	1	7.7	< LOQ	22.1	< LOQ	< LOQ	< LOQ
	2	< LOQ	< LOQ	< LOQ	< LOQ	< LOQ	< LOQ
	3	2.3	< LOQ	2.2	< LOQ	< LOQ	< LOQ
	4	-	-	-	< LOQ	< LOQ	< LOQ
<b>Week 6</b>	1	11.1	< LOQ	59.8	< LOQ	< LOQ	< LOQ
	2	< LOQ	< LOQ	40.1	< LOQ	< LOQ	< LOQ
	3	6.5	< LOQ	45.7	-	-	-

LOQ: Limit of quantification; < LOQ: Below detection limit

Studies of streams receiving sewage effluent in several parts of the world have shown E1, E2 and EE2 concentrations in part per trillion (ng l<sup>-1</sup>) levels (Jobling et al. 2005; Spengler et al. 2001; Peck et al. 2004). The irrigation waters sampled in Korle-Bu represent typical E1 concentrations observed in sewage effluent; EE2 concentrations measured in this study, however, were higher.

## 6.6 Heavy Metals

Industrial wastewater contamination of surface waters in cities in Ghana is not significant when compared to domestic wastewater volumes and pathogenic contamination. Heavy metal contamination appears mostly to be localized. The metal concentrations analysed in streams in and around Kumasi and Accra did not exceed suggested standards (McGregor et al. 2002; Simon et al. 2001; Cornish et al. 1999; Mensah et al. 2001). Heavy metal concentrations measured in streams and drains in Accra and Kumasi are presented in Table 6.4 (Amoah 2008).

**TABLE 6.4.** Concentration of selected heavy metals in irrigation water sources sampled in Accra and Kumasi (Source: Amoah 2008; thresholds for plant toxicity from Pescod 1992).

City	Irrigation water source	Heavy metal	Mean concentration (mg l <sup>-1</sup> )	Standard deviation (mg l <sup>-1</sup> )	Range (mg l <sup>-1</sup> )	Recommended maximum concentration
Accra	Drain	Fe	1.34	0.92	0.26-3.02	5.0
		Pb	0.03	0.02	0.01-0.06	5.0
		Mn	0.34	0.17	0.09-0.67	0.2
		Cd	0.006	0.005	0-0.01	0.01
		As	0.02	0.03	0.01-0.07	0.1
	Stream	Fe	1.15	0.51	0.51-2.13	5.0
		Pb	0.03	0.02	0.01-0.06	5.0
		Mn	0.64	0.002	0.06-1.21	0.2
		Cd	0.003	0.002	0-0.01	0.01
		As	0.01	0.02	0.01-0.05	0.1
Kumasi	Well	Fe	1.23	0.49	0.59-1.99	5.0
		Pb	0.03	0.02	0-0.06	5.0
		Mn	0.29	0.21	0-0.68	0.2
		Cd	0.02	0.03	0-0.10	0.01
		As	0.002	0.003	0-0.01	0.1
	Stream	Fe	1.15	0.44	0.51-1.90	5.0
		Pb	0.02	0.02	0-0.06	5.0
		Mn	0.43	0.33	0.09-1.0	0.2
		Cd	0.007	0.01	0-0.3	0.01
		As	0.009	0.009	0.01-0.03	0.1

The data show mean metal concentrations mostly below the maximum concentrations recommended by the United Nations' Food and Agriculture Organization (FAO) for crop production (Pescod 1992). Only manganese exceeded FAO's threshold for crops at all sites in both Accra and Kumasi. A recent study (Lente et al. 2012) conducted at major urban vegetable

farming sites in Accra did not find significant differences in heavy metal concentrations from those reported in Table 6.4. Chromium, cadmium and cobalt concentrations were below detectable limits at all farming sites, while Fe, Mn, Cu, Zn, Pb and Ni were below the recommended maximum limits for healthy plant growth (Lente et al. 2012). The situation might be worse in Ghana's rural gold mining areas or if manufacturing and industrial production in Ghana's cities increases without regulation of treatment and disposal of industrial effluent.

## **6.7 Conclusions**

With the exception of piped water and selected small reservoirs, most irrigation water sources sampled at farm sites in Accra, Kumasi and Tamale showed high levels of fecal contamination. High concentrations of fecal indicator bacteria signal the presence of bacterial, viral and protozoan infectious agents, which can present health risks to farmers and vegetable consumers. Of 20 irrigation water samples collected in Accra, 80% contained human adenovirus, norovirus GII or both. After recognizing that available irrigation water sources were contaminated, more recent studies have moved from risk assessments towards developing measures for safe reuse of wastewater (Amoah et al. 2011). Cheaper pathogen detection methods, such as for viruses, are recommended, so that routine monitoring of pathogens can be performed. Overall, chemical contamination (e.g. in the form of heavy metals) is not so pronounced. That being said, the situation can change if there is an expansion of industry and a lack of monitoring and regulation of industrial effluent collection and treatment.

Inadequate sanitation infrastructure and waste management are the main cause of contamination of urban waterbodies that farmers use for irrigation. Inequitable population growth and sanitation infrastructure development will lead to an increase in pollution of water resources. This will not only affect urban agricultural farming sites but many peri-urban farming sites and communities downstream of cities like Kumasi. Stream and rivers passing through Accra flow directly into the ocean, while Tamale does not have any permanent natural waterway (Obiri-Danso et al. 2005; Keraita et al. 2003). In addition to inadequate sanitation infrastructure and waste management, an increase in water scarcity will contribute to the risks from pollution, as limited rainfall will make pollutants increasingly concentrated.

## 7. Irrigation and Soil Fertility Management Practices

Bernard Keraita and Olufunke Cofie

*This chapter describes the different irrigation methods and nutrient application practices used by urban vegetable farmers. Data are based on surveys conducted in Kumasi, Accra and Tamale. Recent relevant publications are also reviewed.*

### 7.1 Irrigation Systems in Ghana

Namara et al. (2010) generally classified irrigation systems in Ghana into two types: conventional (public) systems, which are mainly initiated and developed by the Ghanaian government or various NGOs, and emerging systems, which are initiated and developed by private entrepreneurs and farmers. Irrigation systems in urban and peri-urban areas are generally managed by smallholders and fall under the emerging informal irrigation systems, although there can be exceptions, like the Ashaiman scheme (see 2.2.1 and chapter 13).

A survey done in 2003 shows that Ghana's 22 public irrigation schemes have a developed area of 8,785 hectares (ha), with the area under actual irrigation being about 5,200 ha (Miyoshi and Nagayo 2006) with annual and seasonal variations. However, little is officially known about emerging systems, but they are expanding at a rapid rate, mainly fuelled by access to relatively affordable pumping technologies and to urban or export markets for horticultural crops. It is difficult to establish the extent of area of the emerging systems, but it is believed that the area is much greater than that of the conventional/public irrigation systems (Namara et al. 2010). For instance, two 3.5 HP (horse power) pumps, communally owned by 100 farmers irrigated about 20.1 ha in Ashanti. The corresponding value for two small reservoirs, Tanga and Weega, in the Upper East Region was 7.7 ha serving about 314 farmers. This informal urban and peri-urban irrigation sector is common across Africa and was described in detail for West Africa by Drechsel et al. (2006).

### 7.2 Sources of Irrigation Water in Major Cities

As described in the previous chapter 6, sources and quality of irrigation water vary from using clean piped water to the use of untreated wastewater. Most common is, however, the use of stream and drain water, highly polluted with untreated domestic wastewater. A brief overview of some key features in Accra, Kumasi and Tamale is presented here:

In **Accra**, the main sources of irrigation water are urban storm water drains and polluted streams. The content of these natural or human-induced drains varies from raw wastewater as in Korle-Bu to storm and graywater, often with high fecal contamination (open defecation, flying toilets), though the dilution changes between locations and seasons. In Dzorwulu, a polluted stream (Onyasia) is used, supplemented by pipe-borne water. Other than using a big gray- and stormwater drain that runs through Accra's La area, a few farmers there also use raw wastewater from a punched sewer pipe or partially-treated effluents from ponds of the largely dysfunctional wastewater treatment system belonging to the Burma Military Camp.

In **Kumasi**, larger areas under informal irrigation can be found in the inland valleys passing the city where shallow wells, dugouts and polluted streams are the main sources of irrigation water (Figure 7.1). About 70% of farmers interviewed use polluted streams. None of the farmers interviewed used untreated wastewater or effluents directly from treatment plants. Very few cases ( $n < 5$ ) were reported where farmers, because they have no choice, use wastewater from drains. There is extensive use of shallow dug wells on valley bottoms (27%), especially in the urban area. Of the 70 farmers interviewed, more than 75% said that they use the source of water that is accessible and reliable. Piped water is not only expensive but also often not flowing, if there is an access point close to the fields which is seldom.



FIGURE 7.1. Typical irrigated urban vegetable farming system in Kumasi (photo: IWMI).

In **Tamale**, with no perennial stream and a long dry season, water is scarce, and farmers use water from reservoirs, or have to choose between free water from open drains, water from stand pipes or costly piped water. A common source is graywater or wastewater from urban drains or dysfunctional water and sewage treatment plants, like the Kamina barracks, while for example at 'Waterworks', Choggu, Builpela or Dabogpa farmers use water from dammed reservoirs (Table 7.1).

**TABLE 7.1.** Water sources in different irrigated areas in urban and peri-urban Tamale.

Farm location	Farmers' water sources
Gumbihene Old Dam	Treated tap water
Gumbihene New Dam	Standpipe/well
Gumbihene Waterworks	Canal/drain
Choggu Dam	Reservoir, standpipe/well
Sangani	Dugouts
Nyanshegu	Standpipe/well
Kamina Barracks (Zagyuri)	Wastewater
Builpela Dam	Reservoir
Tunayili	Standpipe; polluted stream; reservoir
Jekeryili	Polluted stream; reservoir
Dabogpa (Ghanasco Dam)	Reservoir

Note: Information from July 2014 (IWMI, Ghana, and Lea Bartels, University of Freiburg; unpublished; UrbanFoodPlus).

### 7.3 Irrigation Methods Used in Urban Vegetable Farming

#### 7.3.1 Watering Cans

This is the most common irrigation method used in all the study areas (Keraita et al. 2007a). It is also the most precise one for fragile leafy vegetables. When using watering cans, water is fetched manually from nearby water sources and applied on the vegetable plant (overhead) using the same watering cans. It is common for farmers to fetch and apply water using two watering cans simultaneously (see Figure 7.2). As men dominate irrigated urban farming, it is rare to see a woman with two watering cans. In peri-urban areas, where more women are involved in irrigating vegetables, the use of buckets, carried as head loads is common. One watering can as used in Ghana has a capacity of 15 l of water.

Almost all farmers in the valley bottom of urban Kumasi use watering cans. Most of them have shallow dug wells on their farms and even for those who have to fetch water from streams, the distance is usually short (15 to 25 m). Previous studies (Keraita 2002; Cornish et al. 2001) showed that in an attempt to make leafy vegetables look fresher, farmers closer to water sources tend to over-irrigate leading to leaching of soil nutrients and increased contamination of crops as sources of irrigation water are polluted (i.e. they use more water than crop water requirements).



FIGURE 7.2. Lettuce irrigation with watering cans in Accra (photo: IWMI).

### 7.3.2 Bucket Method

In this method, bowls and buckets are used to fetch water, usually from various sources of water, but mainly streams, shallow wells and dugouts. The water is then manually carried in the bucket to the fields where it is either applied directly or put in a drum, for example, to be applied later. This practice mostly involves women and children carrying buckets as head loads and is commonly carried out in peri-urban areas. Here male farmers involve family members and take advantage of the traditional role of women and children in carrying water. Farms are comparatively further away from the water source than the ones where watering cans are used, but normally not beyond 200 m.

### 7.3.3 Small Motorized Pumps

Vegetable farmers in Ghana are increasingly using small motorized pumps to lift water from water sources like shallow wells and streams (Figure 7.3). Most motor pumps have an engine capacity ranging from 3.5 to 10 HP (Namara et al. 2010). Based on a survey conducted in 2009, which found 170,000 petrol and diesel pumps and 5,000 electric pumps in use, Namara et al. (2014) estimated that on average 12% of the 1.85 million farming households in Ghana own a pump.



FIGURE 7.3. Farmer using a small motorized pump irrigating from an on-farm pond (photo: B. Keraita).

Pumps are not fixed in the fields but taken home over night. In the field, they are placed near a water source, usually the bank of a stream or near a shallow well and water is pumped through rigid plastic pipes or semi-flexible pipes which are connected to a flexible hosepipe at the end. Farmers use the hose pipe to apply water to their crops either overhead or near the roots on the surface, depending on the crop. In other cases, pumps are only used to lift water from a deep water source and pump it to a water reservoir or pond in the farm, from where irrigation is done using watering cans.

In many cases where motorized pumps are used in Ghana, especially in peri-urban areas, there are often water losses from leaking pipes and the use of pumps of higher capacity and pipes of larger sizes than required is common. Although the use of pumps is reducing the frequency of farmers stepping into the main water source to fill the cans, occupational water contact remains common when farmers try to fix pumps, pipes and direct the water hose to apply water in the field. The fields are usually adjacent to the water sources and the pipes could be as long as 300 m infield. Whenever this method is used to irrigate fragile vegetables and nurseries, a perforated cap (like a shower head) is placed at the end of the pipe to slow water delivery to the crop and prevent physical crop injuries. However caps reduce irrigation speed, so for mature crops and crops that grow tall like garden eggs and green pepper, the caps are removed to hasten watering.

A typical small motorized pump used by farmers in Ghana costs USD250 to 400 while farmers who hire the pumps pay between USD5 to 10 per day. The additional cost of accessories like tubes which can cover one ha are estimated at USD 270. The final cost being influenced by location, HP of the pump, the model/brand of the pump and the size of the cultivated land.

#### **7.3.4 Surface Irrigation**

Gravity irrigation, mainly through furrows is being practiced in La in Accra. The La farming area is a comparatively larger open space with sloping topography that allows for furrow irrigation. The source of water is an open drain from the nearby army camp. Some farmers have constructed an open weir and diversion channel to irrigate their plots downstream by furrows (fruity vegetables like tomatoes), while others divert water into dugouts from where they can fetch water with a watering can (leafy vegetables). During the dry season, farmers raise the water level in the drain with sand bags and divert the water in the main canal, which conveys the water to the plots. In these furrow systems crops are less exposed to contamination as they are grown on ridges. However, low-growing crops are also cultivated and even higher-growing crops like tomatoes, if not staked, can have contact with irrigation water and wet soil if they incline to the ground. Exposure to farmers is also high as they have to block the drain and direct water in the furrows.

#### **7.3.5 Sprinkler and Drip Irrigation**

Both systems are not common methods in urban farming and sprinklers were observed only in locations where farmers have access to pipe-borne water. Cheaper PVC pipes and low cost materials like bamboo were used as sprinkler risers and to make delivery pipes. The systems were not fixed and farmers using sprinklers used watering cans as well. The fields irrigated were larger than those used by other methods but the crops grown were the same. When wastewater is used, sprinkler irrigation though modern, can increase risks both on farm (water applied directly on crops) and off farm (aerosolized particles affecting farmers and the environment).

Drip irrigation systems have been introduced by different institutions, also for vegetables, and are occasionally observed in urban and peri-urban settings, albeit so far at experimental levels introduced for example by the University for Development Studies (UDS) in Tamale. Adoption by farmers has been poor up to now. The systems require a storage reservoir and many farmers are reluctant to install any infrastructure on their plots as long as their land

tenure situation is weak and only of informal nature. Another challenge was the wide spacing of the holes, which did not support the required cropping density of lettuce for instance (see below).

## 7.4 Productivity of Irrigated Urban Vegetable Systems

### Amounts and Frequency of Water Application

Leafy vegetables, which are the most commonly grown crops in irrigated urban agriculture, have higher and more regular crop water requirements compared to more traditional crops. According to Agodzo et al. (2003) irrigation water requirements of most vegetables grown in Ghana vary between 300 and 700 mm depending on the climatic conditions and crop species. As the extension service has limited training to support informal irrigation, farmers have learned over time when and how much water to apply to their crops. When asked a question like “How do you know the amount of water to apply?” most urban farmers indicated ‘hands-on-experience’ mostly using soil, crops and weather as indicators (see Figure 7.4).

Generally, across Ghana, most farmers irrigate in the mornings and evenings, saying that at these times “It is cooler so we can more easily carry the water-load” which corresponds well with periods of low evapotranspiration rates, allowing other farm tasks like weeding to be done during normal working hours (8 am to 5 pm). Irrigation is also done in the rainy season on days without rain as especially the exotic lettuce responds quickly to water shortage. In other countries, like Ethiopia, with a more moderate climate, urban vegetables like lettuce and cabbage are only irrigated about three to four times a week in, for example, Addis Ababa.

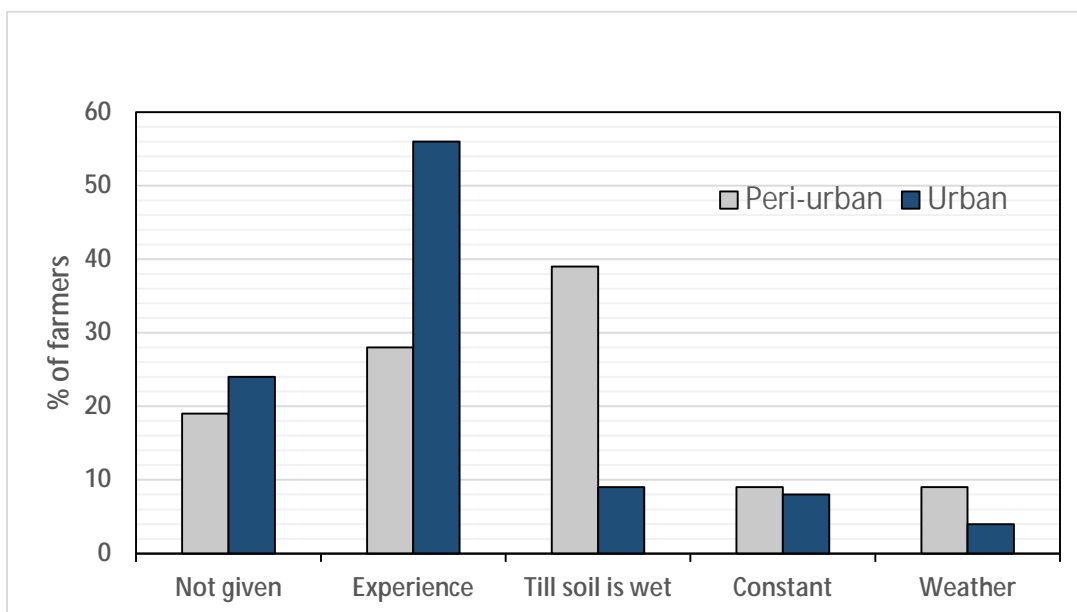


FIGURE 7.4. How farmers know the correct amount of water to apply.

Not all farmers can afford to buy irrigation equipment, like motorized or electrical pumps. However, pumps can be rented for different time periods (Namara et al. 2014) and also neighborhood arrangements can enable farmers to hire pumps on affordable terms. At Dedesua, near Kumasi, for instance, most farmers only pay for the fuel of a local motor pump. Payment can also be made on flexible terms such as paying after selling the crop or by providing labor for the pump owner. Some farming sites have farmers' associations to exchange labor and irrigation equipment. Field observations on irrigation clearly showed a tendency to over-irrigation in urban areas by one-third of the irrigation water requirements and under-irrigation of the same magnitude in peri-urban areas. Urban farms are much smaller (on average one-seventh) than peri-urban farms and farmers predominantly use watering cans for irrigation. Urban farmers achieve a more uniform spatial water distribution, though, because of the watering cans, and their regular irrigation intervals.

Conversely, farmers in peri-urban areas who depend on the availability of pumps, have irregular irrigation intervals and poorer water distribution, especially those using hosepipes. In peri-urban areas, only few peri-urban farmers own a pump, so farmers hiring pumps often wait for long periods before irrigating their farms while queuing to hire a pump. Subsequently it is quite common among these farmers to apply as much water as they can when the pump is available as they do not know when the pump will be available again. In addition, when payment for the pump is done on a daily basis, there is a tendency to over-apply that day assuming that this caters for the other days, so as to maximize the benefit on the money paid for hiring the pumps. In Dedesua (see above), to reduce renting costs, farmers on average irrigated once in three weeks instead of once a week over a 120-day crop growth period of local vegetables like *ayoyo* and *alefu*. These indigenous vegetables have significantly lower water requirements than exotic ones. Farmers felt that this was sufficient for the crops but in reality such long intervals could affect crop productivity.

### **Productivity of Different Irrigation Methods**

Keraita et al. (2007a) compared three irrigation methods – furrow, low-head drip kits and the conventional watering cans under actual field conditions during the dry and wet seasons on irrigated urban vegetable farms in Kumasi. Different farmers volunteered to compare the three methods, each using their expertise on the amount of water needed which is based on a mix of observations (weather/soil/crop). Furrow irrigation resulted in comparatively much lower

fresh weights, both per plant and per area, especially during the dry season, compared to drip irrigation and watering cans methods (Table 7.2). The differences in fresh weights were statistically different in both seasons. The differences were more pronounced in the dry than in the wet season when rainfall supplemented all the methods equally. While drip irrigation plots had higher fresh weights in terms of weight per lettuce plant by 7 to 10%, its production per given area ( $\text{kg m}^{-2}$ ) was slightly lower than under watering cans plots due to a lower cropping density of 13 versus 15 lettuce plants  $\text{m}^{-2}$ .

The common water productivity of lettuce varied between 10 and 15  $\text{kg m}^{-3}$  depending on cropping density, irrigation method, season and soil. Furrow irrigation with a low planting density of 10 lettuce plants  $\text{m}^{-2}$  and a sandy soil had also the lowest water productivity of 3 to 4  $\text{kg m}^{-3}$ .

**TABLE 7.2.** Lettuce yields in the dry and wet seasons.

	Irrigation method	No. of samples	Fresh weights per plant (kg per lettuce plant)			Fresh weights per cropping area ( $\text{kg m}^{-2}$ )	
			Mean	95% CI	% change	Mean	% change
<b>Dry season</b>	WC	24	0.129	0.128-0.130		1.94	
	FI	24	0.056	0.056-0.058	- 56.6	0.56	- 71.1
	DIK	24	0.142	0.141-0.143	+ 10.1	1.85	- 4.6
<b>Wet season</b>	WC	24	0.147	0.146-0.149		2.21	
	FI	24	0.130	0.129-0.131	- 11.6	1.30	- 41.2
	DIK	24	0.158	0.157-0.159	+ 7.5	2.05	- 7.2

WC = watering cans; FI = furrow irrigation; DIK = drip irrigation kits

Source: Keraita et al. (2007a).

### Farmers' Perceptions of Irrigation Methods

In the field trials done by Keraita et al. (2007a), in Kumasi, farmers generally used more water and more labor on furrow irrigation plots due to their sandy texture and were quite negative about the method. Drip kits were more appreciated, in particular because of the physical quality of the lettuce produced. As water reached the root zone directly, foliar injury or soil splash on the leaves were avoided. In general, the drip kits used much less water and saved time and labor costs. Farmers also noticed that the average size of lettuce was much bigger while weeds did not receive water and were suppressed more effectively. The biggest limitation of the kits was some occasional clogging and the wide emitter spacing, especially

with initial drip kits which only supported low cropping densities and thus resulted in very low yields which is not acceptable in space-constrained urban farming.

Though modifications of drip irrigation kits have improved cropping densities, farmers had problems in moving the increased number of drip laterals and microtubes while conducting other farm operations like weeding, land preparation and manure application. In general, farmers appreciated drip irrigation kits but said it was important to modify them to fit their practices. In addition, farmers suggested that drip kits might be better suited for other crops like water melon and green pepper that take a longer cultivation time and need wider spacing. The general perception by farmers was that their watering can method remained the most flexible and thus most suitable method for irrigating vegetables like lettuce. This conclusion appears to hold across the subregion (Drechsel et al. 2006).

### **7.5 Options and Constraints to Technology Change**

Having to spend a significant share of time on manual irrigation (see chapter 4) farmers have a natural interest in less laborious but low-cost irrigation methods that can reduce their workload. However the continued use of arduous methods of irrigation in urban agriculture, even when newer technologies are available, raises the question of the reason why improved methods are not more widely used.

In Accra, farms are often found along streams and drains, and are at best tolerated by the authorities. The conveyance distance when using watering cans is usually short enough to favor labor over capital input. Watering cans allow more flexibility, one-man-usage and are less sensitive to bad water quality and solids. Moreover, they allow ‘soft’ water application, protecting young vegetables on their beds. All these are good reasons to avoid investment in pumps and hoses. In addition, there are differences in the related input markets (also for pumps and hoses). EnterpriseWorks, started promotion of treadle pumps in most Francophone countries of West Africa between 1995 and 1999, while corresponding activities in Ghana only started in 2002 (Adeoti et al. 2007). However, the latest assessment showed that the initiative of treadle pumps in Ghana was not successful compared to the rapid uptake of small motor pumps (Namara et al. 2014).

A comparison with neighboring Lomé, Togo, where farmers cultivate high value crops for export on poor quality beach sands using motorized pumps, shows that there is a combination of factors involved, which goes beyond the higher investment and maintenance costs of such technologies. Farmers in Lomé have access to larger plots, and the city authorities accept

them (Figure 7.5). In many cases, tenure agreements exist. This security favors investments, for example, in tube-wells to access safe water and multiple storage ponds, i.e. conveyance-saving technologies, which are necessary to maximize the profits from larger plots.



FIGURE 7.5. Watering can irrigation with well, pump and storage reservoirs in Togo. Other reservoirs are visible in the background (photo: IWMI).

Thus it appears that technology promotion has to consider a variety of local conditions, both biophysical and socioeconomic. Shallow wells and watering cans may be the most appropriate technology, for example, in Kumasi's inland valleys. The demand for motor pumps might, however, rise on upland sites, and in Accra, especially where farmers can share one pump and the water sources are not too close. Pumps might be tried where groundwater is available between 1 and 7 m or the walking distance between field and water source is more than 50 m. If the pump is not mobile, the farm site needs facilities to secure the pump overnight as farmers might live far from their fields. In general, many farmers prefer using small motorized pumps in combination with watering cans for water lifting and application. Wherever there is better water quality than in drains, low-cost drip irrigation technologies like bucket-kits and drum-kits, could be tested. These might fail without filters where wastewater is used. For drip systems, lateral and emitter spacing has to fit farmers' normal cropping densities or adoption will be low. The authorities should support these changes, which could

reduce the health risk associated with using polluted water, like sedimentation ponds, and changes in irrigation practices. Tenure security could be an incentive for farmers to invest in recommended practices.

## 7.6 Soil Fertility Management Practices

### Nutrient Management Practices

Irrigated urban vegetable farming in Ghana is intensive and continuous, hence significant amounts of nutrients are exported with each harvest (Drechsel and Zimmermann 2005). On such poor soils, corresponding external inputs are needed. In the more humid parts of West Africa, farmers prefer poultry manure due to its high nutrient content coupled with its fast release of nutrients for vegetables, and usually low price (Zickermann et al. 1998; Drechsel et al. 2000). Poultry manure is also favored due to its narrow C/N ratio. The ammonium (NH<sub>4</sub>)-N and uric acid-N content of poultry manures equate to the readily-plant-available-N supply.

Adding manure to the soil has thus agronomic benefits through the addition of plant nutrients (such as nitrogen, phosphorus and potassium [NPK]) but also as a soil ameliorant through its organic matter contents, similar to compost. Manure like compost thus also helps to improve soil structure, water-holding capacity, soil stability and biological activities.

A survey conducted among 108 farmers of different urban cropping systems in Accra showed that there were clear differences in the type of soil fertility management used in the different systems (Hofny-Collins 2006). Farmers specialized in rainfed crops, like maize, relied on traditional low external input measures such as fallowing, crop rotation and crop residues with some limited input of artificial fertilizer and chicken manure. The year-round vegetable growers relied heavily on external inputs for soil fertility maintenance. The survey showed that almost all (93%) used poultry manure and over half (56%) used artificial fertilizers, though not on every crop (Figure 7.6). NPK 15-15-15 is applied for example at rates of 75-180 kg/ha<sup>-1</sup> per year on cabbage, the exact amount depending on the farmer's experience and the soil. Next to manure and chemical fertilizer, vegetable growers used a whole range of other techniques supporting soil fertility and it was common for individuals to use a combination of three to five techniques. Vegetable farmers in this survey said as a fertility input, compost was inferior, particularly in relation to crop establishment and it created a higher water demand (Hofny-Collins 2006). In fact, without adding nutrients to compost (for example co-composting with fecal sludge, or blending with NPK) the wide C/N ratios make it more of a conditioner for soil structure than a fertilizer.

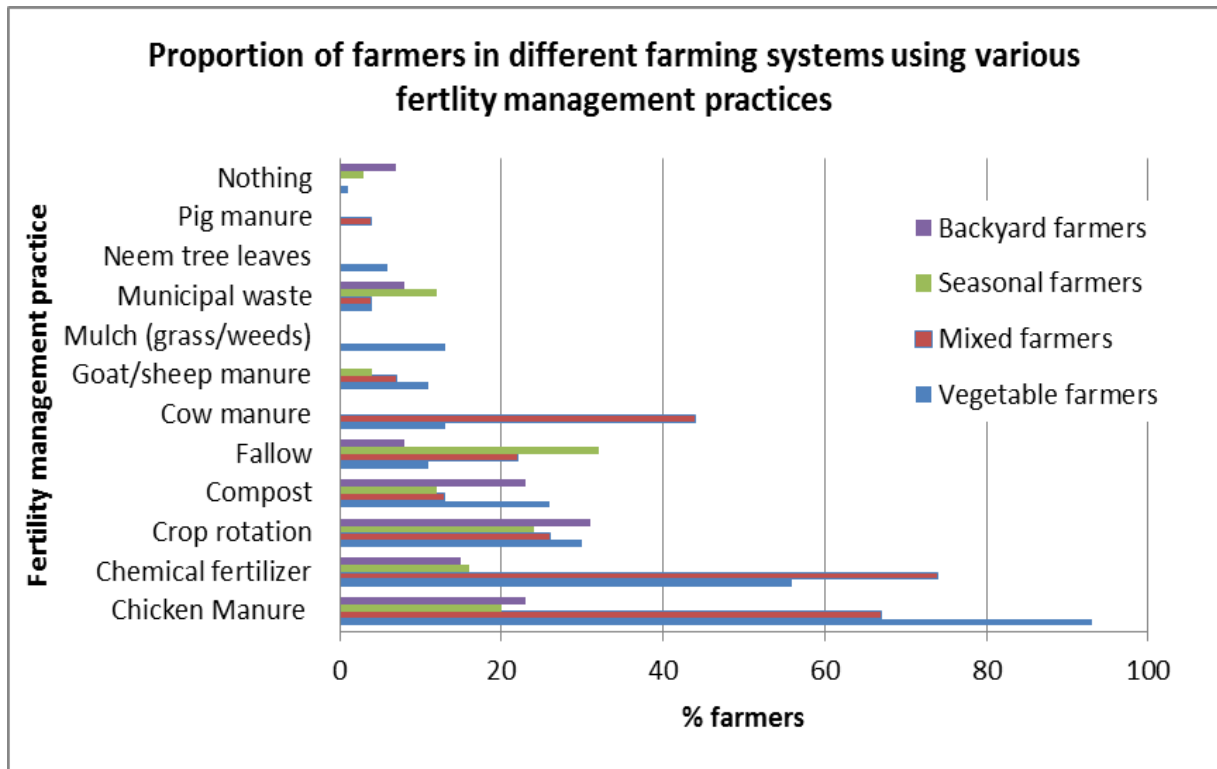


FIGURE 7.6. Fertility management practices in Accra, Ghana (based on 108 farmers). Adapted from Hofny-Collins (2006).

The use of poultry manure is even more common in Kumasi where initially it was considered a waste product of the poultry industry and dumped or burned along roadsides (Quansah et al. 2001). Farmers said that in comparison with chemical fertilizers, poultry manure is cheaper, releases nutrients much slower and is a much better soil conditioner. However, its quality can vary depending on its age and source (broilers vs. layers) (Drechsel et al. 2000). Reported poultry manure application rates vary widely among sources and might range from 7 to more than 20 t ha<sup>-1</sup> for exotic vegetables (Poferl and Keraita 2008; Erni et al. 2010). The application is done manually one week after transplanting. Farmers in Northern Ghana where the lower humidity does not support larger poultry farms, use relatively more kinds of manure from livestock such as cows, goats and sheep, next to chicken droppings.

The use of poultry manure as a fertilizer seems to be quite widespread in West Africa, and its supply is supported by changes in diets making poultry an increasingly common fast food ingredient in the present-day context (see chapter 5). However, poultry manure has to be managed appropriately as it contains a wide range of bacteria, viruses and protozoa, some of which are pathogenic and can have adverse effects on people (Mensah et al. 2001). *Salmonella* spp., *Campylobacter* and *E. coli* are the most common pathogens found in poultry manure (AWWA 1999). Most of these pathogens can survive in soils and manures for more

than a month, but generally the survival rate is lower (one to seven days) in dry conditions. Proper composting can greatly reduce levels of pathogens in poultry manure (a manure pile can be a first step). However, as demand for the manure is increasing it is often not stored/composted long enough before application to allow for pathogen die-off. Studies done in Kumasi show that after collection, about 60% of the farmers apply the poultry manure directly without further composting while 40% heap the manure for some weeks or more depending on the date they need it on their fields (Mensah et al. 2001). Other than direct contact when spreading, manures can contaminate soils and then be transferred to vegetables. Studies done in urban vegetable farms in Ghana have shown higher contamination levels in soils than in irrigation water (Amoah et al. 2005; Keraita et al. 2007ab). Amoah et al. (2005) also associated vegetable contamination with contaminated soil splashing on the leaves of low-growing vegetables and suggested mulching to prevent this, hence reducing levels of contamination on vegetables.

Another input which is highly valued, although more among flower or ornamental farmers is 'black soil' (Cofie et al. 2008). With 'black soil', farmers in Ghana refer to dark, humus-rich topsoil as it can be found in undisturbed forests and decomposed waste dumps, like the community based 'bola' sites. Black soil harvested from local waste dumps, agricultural land and forest for horticulture, gardening and landscaping is very common and the material is highly regarded for its quality. However, the continuous harvesting of black soil makes it increasingly difficult to find it while its removal from natural soils has a strong negative impact on the environment (Danso et al. 2006).

Since 2010, biochar<sup>1</sup> receives increasing attention in Ghana, although so far mostly from research, including the UrbanFoodPlus project ([www.urbanfoodplus.org](http://www.urbanfoodplus.org)). Biochar from rice husks, sugar cane residues or for example wood chips is being tested with indigenous and exotic vegetables in the Volta region and Accra plains on clay soils, on red soils in Kumasi (Yeboah et al. 2013) and on sandy loams near Tamale.

Also the seasonal use of 'human manure' (fecal sludge delivered to the farms through septage carrying trucks) has been reported from peri-urban farming, particularly of maize and other cereals but not vegetables. The practice is most common around Tamale but has also been observed in other parts of Ghana (Cofie et al., 2005; Cofie et al. 2010) including Accra (see the CD attached to this book).

---

<sup>1</sup> Biochar is charcoal that is used for specific purposes, typically soil improvement. It is produced by heating biomass, like rice husks under anoxic conditions (pyrolysis).

### **Wastewater as a Nutrient Source**

Farmers able to tap into raw wastewater and experience its nutrient value, try to consider it in their soil fertility management. Most farmers, however, uses diluted wastewater or polluted stream water which in both cases do not contain enough nutrients for them to build on this input in their decisions to fertilize crops. In fact, the water-borne nutrient concentrations vary with dilution, distance from the wastewater source, over the day and between seasons, making it impossible for farmers (who cannot pay laboratories) to predict the nutrient content. Thus most farmers rely on manure, and use the water first of all to irrigate highly perishable crops; thus irrigation frequency depends on crop water needs and not nutrient needs.

In terms of N and P, the fertilizer input from wastewater was estimated by Erni et al. (2010) to account for only about 10% of what is applied via other fertilizers where diluted wastewater is used along the Oda River which absorbs most of the wastewater generated in Kumasi.

The generally high nutrient input is justified when the number of growing periods over the year is considered, i.e. high frequency of harvests which are significantly contributing to nutrient exports from the farm. The losses are even larger through nutrient leaching, especially where soils are sandy and regularly irrigated. Nutrient balance assessments point at farmers' constant fight against negative N and K balances while probably unknown to them phosphates continuously accumulate in the topsoil. As long as nutrients are supplied at very low costs (especially via poultry manure) farmers do not see the need for more complex nutrient management which is likely to only result in higher direct or indirect costs.

### **7.7 Conclusions**

Streams, drains and shallow wells are the most common sources of irrigation water. Watering cans are predominantly used for good reasons, but make the task arduous. However there is increasing use of small motorized pumps in Ghana, used either to shorten water transport distances, or directly linked to water application. Much could be done to improve irrigation efficiency – not only to save water where water is scarce, like in Tamale, but also where irrigation consumes too much labor and puts extra burden on irrigators. Improving irrigation efficiencies should receive more research attention, ideally combined with health risk reduction for farmers and consumers. Poultry manure continues to be the most used fertilizer among vegetable farmers in Ghana. Initiatives of using other soil ameliorants like compost were received with hesitation due to its limited nutrient content, bulkiness and (too high) water absorption. Municipal solid waste compost is usually poor in nutrients and it might fall short if compared with 'black soil' or manure, unless it gets blended (fortified) for example with NPK, fecal sludge or urine (Adamtey et al. 2009; Nikiema et al. 2012).

## 8. Quality of Vegetables in Ghanaian Urban Farms and Markets

Philip Amoah, Ishmael Lente, Senorpe Asem-Hiablie and Robert C. Abaidoo

*This chapter shows results obtained from analyzing samples of vegetables taken at the farm gate and from selling points in Accra, Kumasi and Tamale. Microbiological data are based on a total of about 1,500 vegetable samples taken from different sampling points along the vegetable distribution chain – farm gates – and from different categories of sellers in Accra, Tamale and Kumasi. Fecal coliforms and helminth eggs were mainly used as the fecal contamination indicator organisms. For chemical contaminants, heavy metals and pesticides in irrigation water and vegetables were analyzed, while estrogens were used as an example for emerging contaminants.*

### 8.1 Bacterial Contamination

While chapter 6 presented findings from studies on the quality of the water used for irrigation by vegetable farmers in and around Accra, Kumasi and Tamale, the following sections present how far the contamination was traced along the food chain.

Table 8.1 shows the fecal coliform contamination levels of lettuce at different entry points starting from farm to the final retail outlet. Irrespective of the irrigation water source, mean fecal coliform levels exceeded the recommended standard. There were no significant differences in the average lettuce contamination levels at different entry points (farm, wholesale market and retail outlet). Also the analysis of individual samples followed from farm to retail on the various sampling dates confirmed that the contamination of lettuce with pathogenic microorganisms does not significantly increase through postharvest handling and marketing (Amoah et al. 2007b). This is however not an ‘all clear’ for the postharvest sector as high on-farm contamination might simply overshadow any additional occurrence as for example any unacceptable log-4 value will hardly be noticed if there is already a log-6 contamination. In fact, the hygienic conditions, including washing habits, clean display and handling of food as well as availability of sanitation infrastructure on market sites is not very supportive. In 1998, a survey showed that only 31% of the markets in Accra have a drainage system, 26% have toilet facilities and 34% are connected to pipe-borne water (Nyanteng 1998); more recent data could not be found. While it thus appears as if the initial contamination on farm is so high that it hides any possible postharvest contamination, the latter however was also reality as seen in those cases where lettuce was irrigated with piped

water, thus making this lettuce generally 1-2 logs safer at final retail, below the ‘unacceptable’  $10^5$  100 gram (g)<sup>-1</sup> (wet weight) but above the ‘undesirable’  $10^3$  100 g<sup>-1</sup> (wet weight) ICSMF (1974) levels. Importantly, crop contamination also takes place on farm under irrigation with piped water. Likely sources of contamination in these cases included the already contaminated soil (FC levels of  $1 \times 10^4$  10 g<sup>-1</sup> in the upper 5 cm) and the frequent application of improperly composted (poultry) manure (Amoah et al. 2005).

**TABLE 8.1.** Mean fecal coliform contamination levels of lettuce from the same farm plots at different entry points along the production and consumption pathway of lettuce.

City	Irrigation water source	Statistics	Log fecal coliform levels (MPN* 100g <sup>-1</sup> )		
			Farm	Wholesale market	Retail
Kumasi	Well (n=216)	Range	3.00 - 8.30	3.10 - 8.50	3.20 - 7.00
		Geometric mean	4.54	4.44	4.30
	Stream (n=216)	Range	3.40 - 7.10	3.60 - 7.20	3.50 - 7.20
		Geometric mean	4.46	4.61	4.46
	Piped water (n=216)	Range	2.30 - 4.80	2.60 - 5.30	2.40 - 5.10
		Geometric mean	3.50	3.69	3.65
Accra	Drain (n=216)	Range	3.40 - 6.00	3.00 - 6.80	3.00 - 6.50
		Geometric mean	4.25	4.24	4.48
	Stream (n=216)	Range	3.20 - 5.70	3.10 - 5.90	3.20 - 5.50
		Geometric mean	4.22	4.29	4.37
	Piped water (n=216)	Range	2.90 - 4.70	2.90 - 4.80	2.80 - 4.50
		Geometric mean	3.44	3.46	3.32

\* MPN, Most Probable Number (adapted from Amoah et al. 2005, 2007b)

**Accra:** In Accra, lettuce, cabbage and spring onion samples were taken from Makola, Agboghloshie, Dome and Kaneshie markets and from some individual sellers. In all markets and selling points, lettuce had the highest levels of fecal coliform population (Figure 8.1). Agboghloshie is the main depot for vegetables from within and outside Accra, where vegetables are not washed as they are mainly sold to other vendors who are expected to wash them before selling (Figure 8.2).

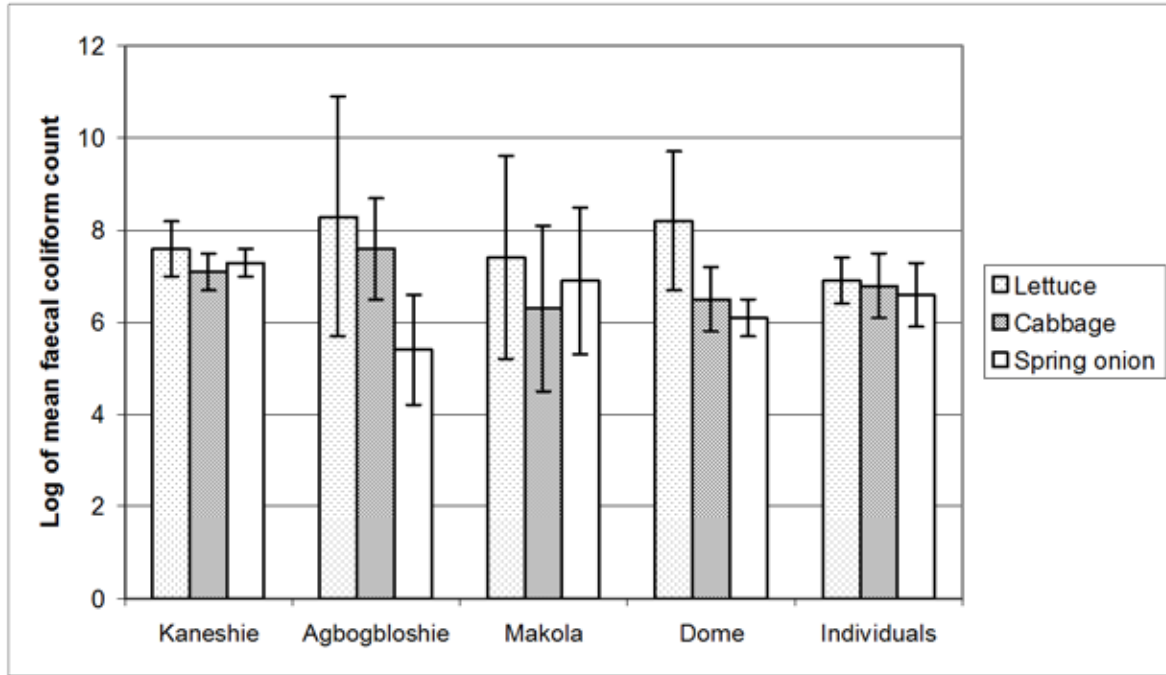


FIGURE 8.1. Faecal coliform populations on selected vegetables from some markets in Accra. (adapted from Amoah et al. 2007b).



FIGURE 8.2. A section of Agboglobshie market showing vegetables displayed on the ground (Photo: IWMI).

For both cabbage and lettuce, there were no significant differences in either fecal or total coliform levels when comparing these vegetables across markets. The same applies to spring onions, except for higher levels in Kaneshie compared to Agbogbloshie.

**Kumasi:** In Kumasi, vegetable samples were collected from three markets ('White' market [opposite the post office], Asafo and Central markets) and from some individual sellers. Samples collected from individual sellers had less contamination compared to the formal markets (Figure 8.3). However, these fecal coliform levels are still higher than the International Commission on Microbiological Specification for Food- (ICMSF 1974) recommended levels of  $1 \times 10^3$   $100 \text{ g}^{-1}$  fresh weight.<sup>1</sup> Mensah et al. (2001) observed that on the smaller 'White' market where (expatriate) consumers asked frequently about produce quality, the sellers changed the water to wash their produce more often than in other markets and indeed reduced the pathogen level.

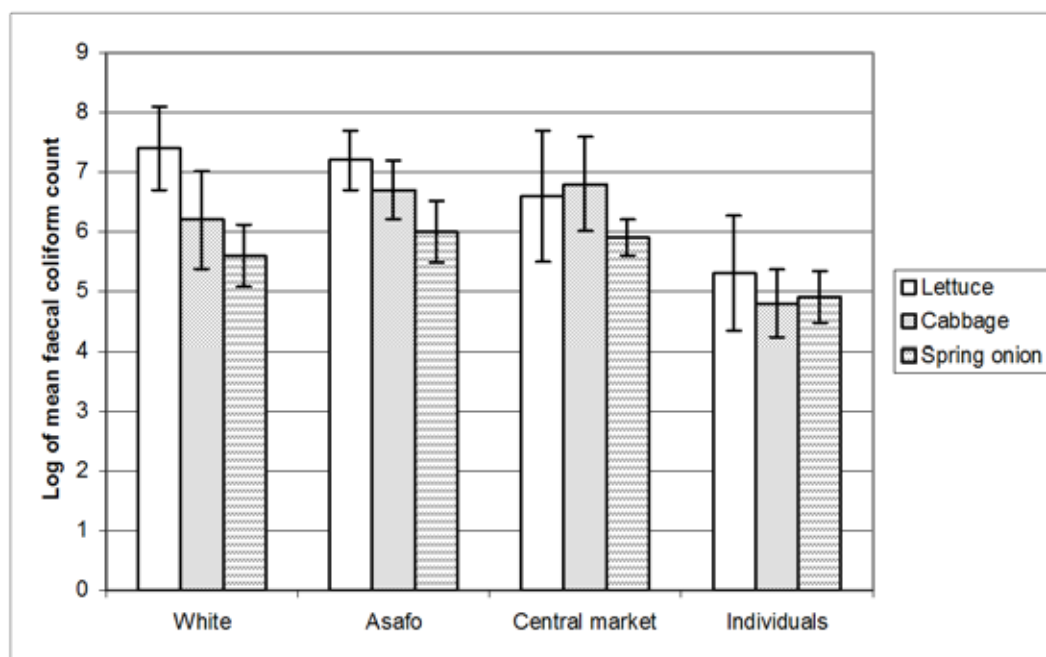


FIGURE 8.3. Fecal coliform populations on selected vegetables from markets in Kumasi (adapted from Amoah et al. 2007b).

<sup>1</sup> Ready-to-eat foods are considered to be still of 'acceptable' quality in England if they contain  $<100$  *E. coli* per gram wet weight (i.e.,  $<10^4$  per 100 g) (Gilbert et al. 2000). This guideline value is used in many other countries, including Australia, Canada and New Zealand. As lettuce is a common component of many ready-to-eat foods, it makes little sense for the wastewater used to irrigate lettuce to be treated to a higher quality than is required for the lettuce itself (WHO 2006).

**Tamale:** Tamale has few vegetable markets and selling points, as it has a smaller population compared with Accra and Kumasi. Sampling was done in two markets (Aboabo and the main market), while some samples were also taken from individual sellers. Fecal coliforms ranged from  $4.0 \times 10^5$  to  $7.5 \times 10^8$  while total coliforms were between  $1.5 \times 10^7$  and  $1.6 \times 10^{10}$  (see Figure 8.4) There was no significant difference in both total and fecal coliform counts for the three vegetables across markets.

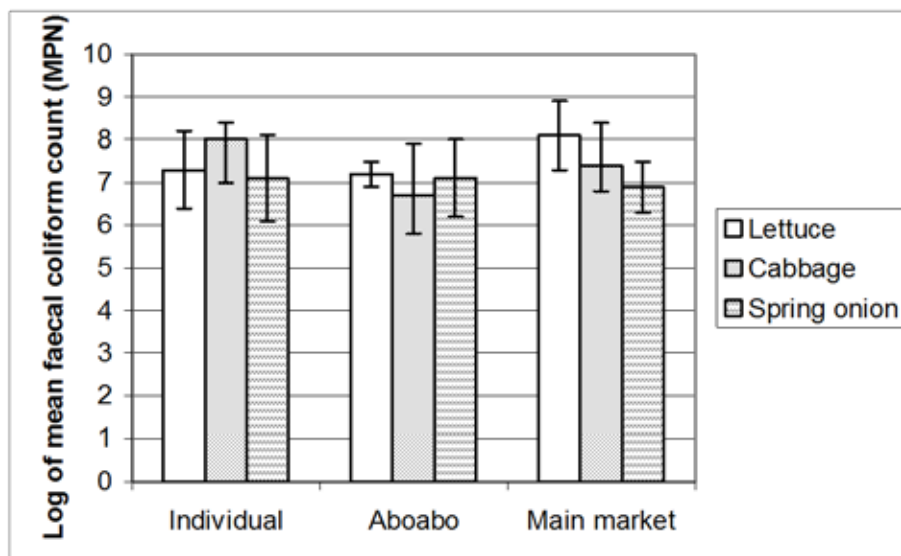


FIGURE 8.4. Fecal coliform populations on selected vegetables from some markets in Tamale (adapted from Amoah et al. 2007b).

Research by Donkor et al. (2010) pointed at the possibility of pathogen internalization in leaves of vegetables, i.e. that microbial contamination of vegetables in Ghana is not limited to the external surface, but internal vegetable parts could harbor microbes which pose risk to consumers.

**Inter-city comparison of bacterial contamination:** Lower levels of both total and fecal coliform populations were recorded for vegetable samples from Kumasi compared to those from Accra and Tamale (Figures 8.5 and 8.6). The reason for this could be both on-farm and postharvest handling of crops. Previous studies done in Kumasi (Cornish et al. 1999; Keraita et al. 2002) show that many farmers use shallow wells along the streams with better water quality for irrigation compared with Accra and Tamale where water from urban drains is mostly used. There is no scarcity of water in Kumasi and vegetables are washed on the farms (though with the same irrigation water), before they are taken to the market.

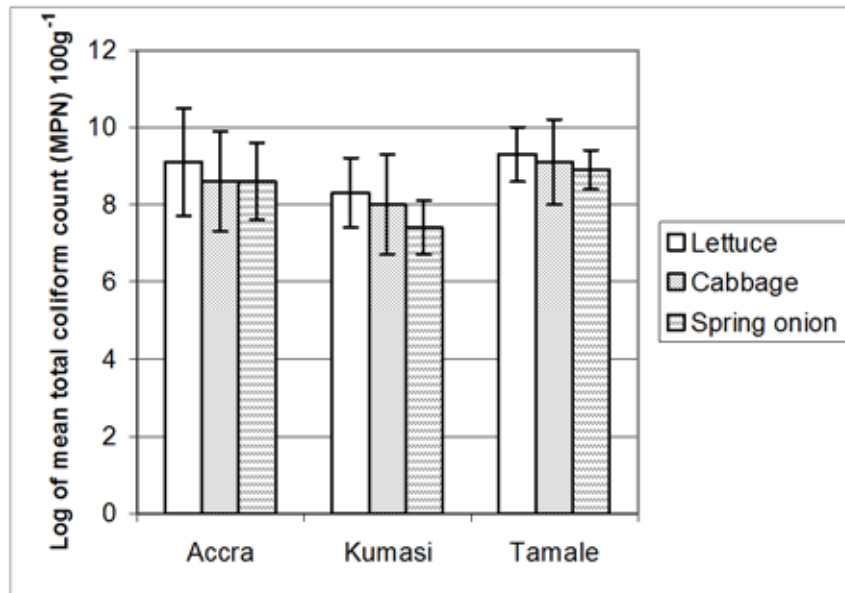


FIGURE 8.5. Total coliform levels in vegetables from Accra, Kumasi and Tamale (adapted from Amoah et al. 2007b).

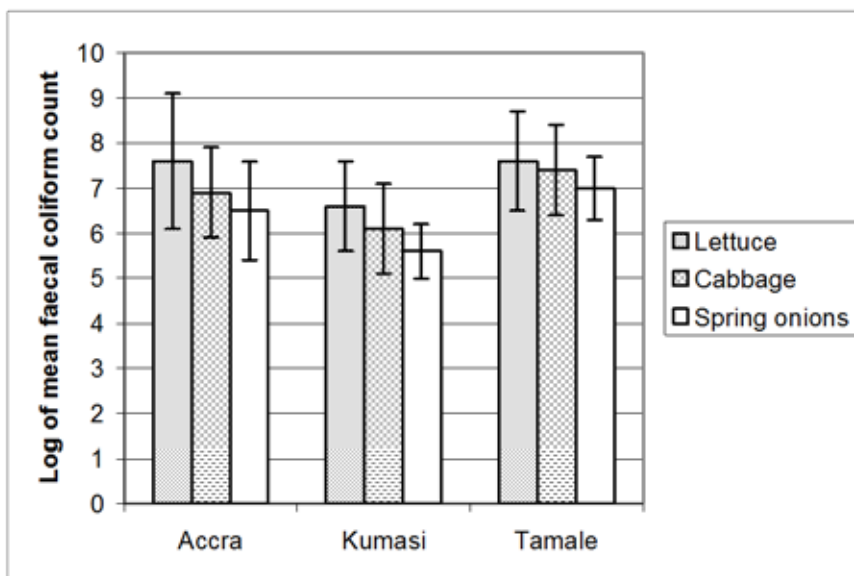


FIGURE 8.6. Faecal coliform levels in vegetables from Accra, Kumasi and Tamale (adapted from Amoah et al. 2007b).

**Inter-vegetable comparison of bacterial contamination:** Among the three vegetables, lettuce showed the highest levels of fecal and total coliform contamination (Figure 8.7) ranging between  $10^6$  and  $10^{11}$  for total coliforms and between  $10^3$  and  $10^9$  for fecal coliforms. These contamination levels are in line with other studies on food contamination conducted in Accra (Akpedonu 1997; Abdul-Raouf et al. 1993; Ameko et al. 2012; Fung et al. 2011; Feglo and Sakyi 2012).

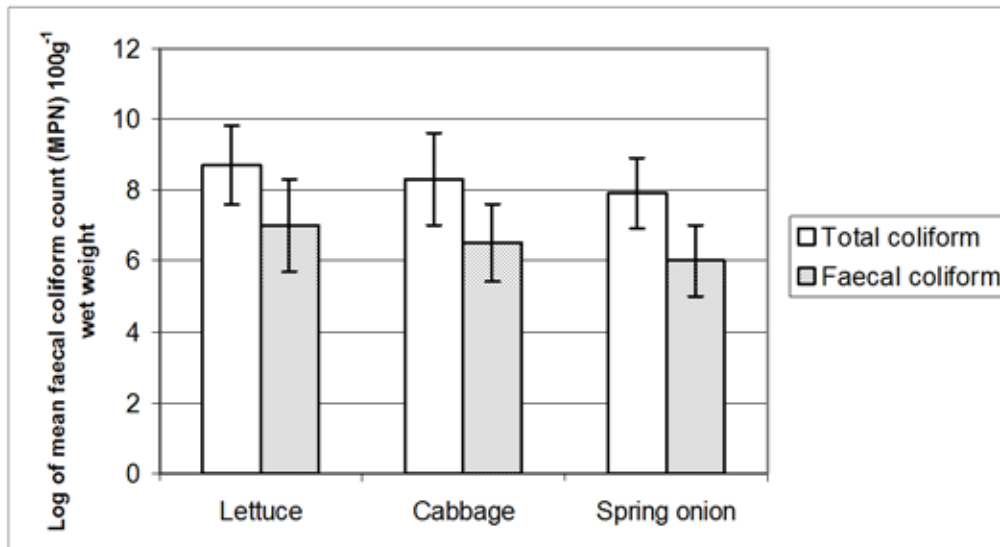


FIGURE 8.7. Fecal and total coliform populations on selected vegetables (adapted from Amoah et al. 2007b).

The differences were significant for faecal coliform counts, which could be attributed to the larger leaf surface of lettuce offering a larger contamination surface. This foliage also protects microorganisms against exposure to environmental factors and prolongs microorganism survival (Shuval et al. 1986; Armon et al. 1994).

**Seasonal Variations of Bacterial Contamination:** Figure 8.8 illustrates faecal coliform populations on lettuce samples collected in Kumasi at the farm gate, wholesale market and retail outlets over a 12-month period and for three irrigation water sources. Similar levels were recorded on samples from Accra (see Amoah 2008). High levels of faecal coliform counts (usually above the common acceptable standard of  $1 \times 10^3$   $100\text{g}^{-1}$  wet weight) were recorded on all irrigated lettuce including that irrigated with piped water.

Apart from stream water-irrigated lettuce from Accra, higher faecal coliform levels were recorded on lettuce from all the other irrigation water sources in the rainy season than in the dry season. However, the differences were significant ( $p < 0.05$ ) only in the cases of well- and stream water-irrigated lettuce from Kumasi. The results further showed that in 80 to 90% of the weeks sampled in Accra and Kumasi, there was no significant difference in the faecal coliform counts of samples analyzed from the farm gate, the market and final retail points.

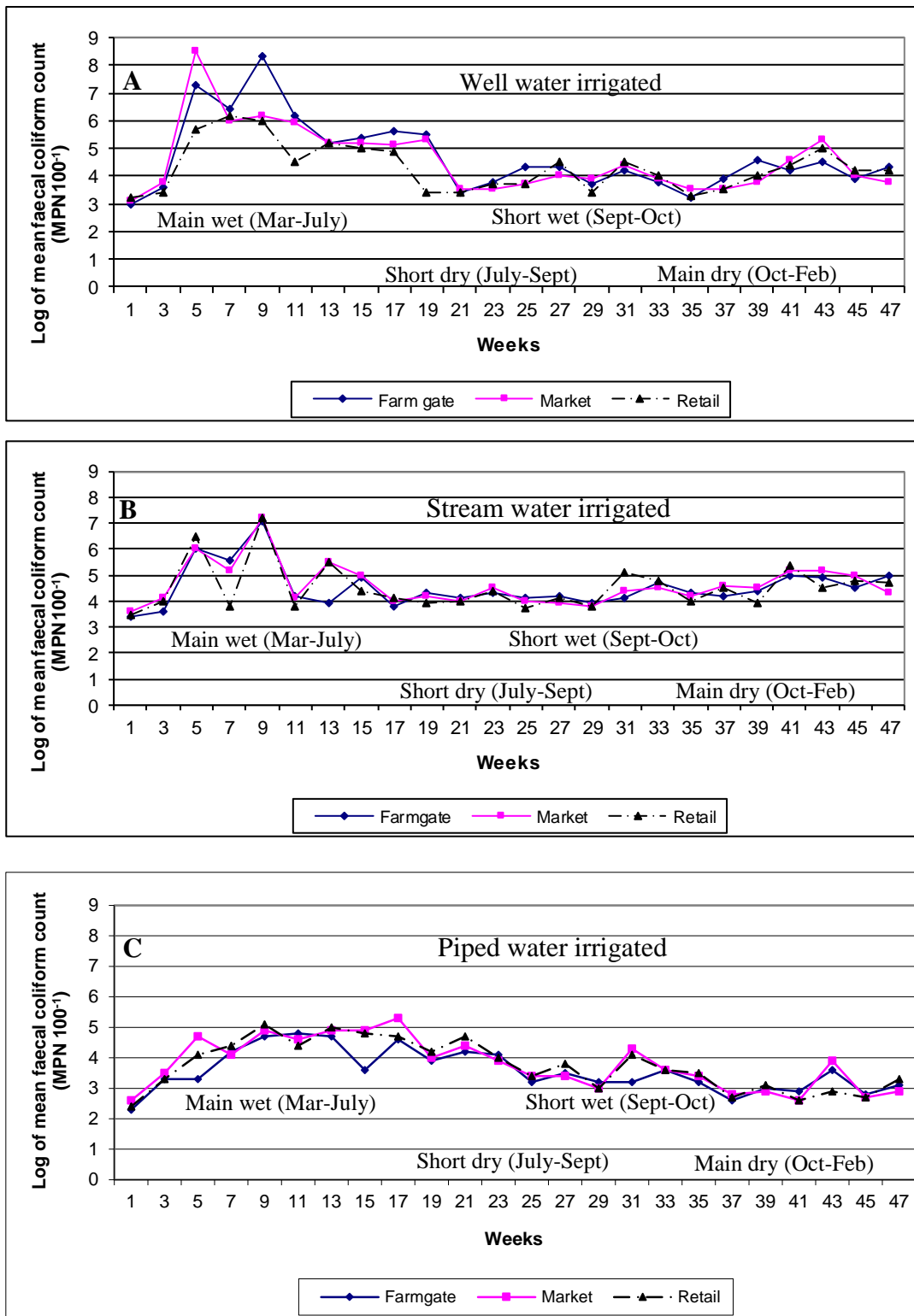


FIGURE 8.8. Faecal coliform levels at different entry points on production and consumption pathways of lettuce irrigated with water from well (A), stream (B) and piped water (C) in Kumasi (adapted from Amoah et al. 2007b, 2008).

## 8.2 Helminth Eggs

Helminths are worm-like parasitic organisms living in and feeding on living hosts, while disrupting their hosts' nutrient absorption, causing weakness and disease. Those that live inside the digestive tract are called intestinal parasites. Helminth eggs are commonly found in fecal matter-contaminated water and food. In Ghana, eggs of *Ascaris lumbricoides*, *Hymenolepis diminuta*, *Trichuris trichiura*, *Fasciola hepatica* and *Strongyloides larvae* are commonly detected on lettuce samples. Typical helminth egg populations analyzed on lettuce by Amoah (2007ab) ranged from 1 to 6 egg(s) 100 g<sup>-1</sup> wet weight with between 50 to 75% of the eggs being viable (Table 8.2).

**TABLE 8.2.** Arithmetic mean of helminth egg contamination levels at different entry points along the production consumption pathway<sup>1</sup>

City	Irrigation water source (n=15 each)	Helminth egg 100 g <sup>-1</sup> wet weight		
		Farm	Wholesale market	Retail
Kumasi	Well	4.1 ± (1.6) a <sup>2</sup>	4.9 ± (1.3) a	4.2 ± (1.3) a
	Stream	5.9 ± (1.4) b	4.9 ± (0.9) a	4.7 ± (0.6) a
	Piped water	1.9 ± (1.5) c	1.9 ± (1.2) b	1.2 ± (0.9) b
Accra	Drain	5.7 ± (1.1) a	5.9 ± (1.2) a	5.2 ± (1.5) a
	Stream	3.8 ± (0.9) b	3.1 ± (0.9) b	3.9 ± (1.2) ab
	Piped water	3.2 ± (0.7) b	2.1 ± (1.2) b	3.3 ± (1.0) b

<sup>1</sup> Mean numbers represent the mean of all the different types of eggs as well as *Strongyloides* larvae

<sup>2</sup> Numbers in the same column with the same letters showed no significant difference between water sources per city (p>0.05).

Figures in parentheses represent the standard deviation. Adapted from Amoah et al. (2007b).

In most cases, significantly (p<0.05) higher levels were detected in lettuce irrigated with polluted water than that from piped water-irrigated sources<sup>2</sup>. However, mean helminth egg populations on lettuce from the same original stock and irrigation water source did not show any significant difference from field to market (Table 8.2).

## 8.3 Heavy Metals

Heavy metal contamination on soils and vegetables could come from irrigation water (especially when wastewater is used), manures, chemical fertilizers and pesticides. Heavy

<sup>2</sup> As mentioned above, crops irrigated with clean piped water can still be affected by pathogens due to splash from soil, contamination through the application of fresh manure, or post-harvest contamination.

metal contamination of agricultural soils and crops is particularly likely in emerging economies where regulations and treatment facilities do not keep pace with industrialization, such as China and India (Sharma et al. 2006). While large-scale industrialization is not common in Ghana, smaller industries and businesses like vehicle repair shops are very common and the risk of wastewater contamination with heavy metals cannot be excluded (Akuffo 1998). Moreover, many urban farming sites are located in close proximity to roads with heavy vehicular movements, which can be additional sources of heavy metals.

Lente et al. (2012) analyzed heavy metal contamination of five different types of commonly grown vegetables that were sampled from four irrigated vegetable farming sites in and around Accra. The vegetable samples were analyzed for copper (Cu), zinc (Zn), lead (Pb), nickel (Ni), chromium (Cr), cadmium (Cd) and cobalt (Co). Table 8.3 shows the concentrations of heavy metals that were found on the vegetables. Most levels reported for chromium and cadmium were below detectable limits, with only leafy vegetables, i.e. lettuce and *ayoyo* having slightly elevated levels (1-2.5 times higher than the allowed maximum residue limit [MRL]). Similar levels of elevation (1-5 times higher than the MRL) were reported for cadmium in studies conducted in Varanasi, Harare and Addis Ababa (Sharma et al. 2007; Mapanda et al. 2007; Weldegebriel et al. 2012). However, Muchuweti et al. (2006) in a study done in Harare reported that local *Tsungu* vegetable leaves irrigated with wastewater contained 3.68 mg Cd kg<sup>-1</sup>, over 18 times that of the European standard. In Kumasi, a study done on vegetables grown on waste dumping sites showed high cadmium contamination of 0.68-1.78 mg kg<sup>-1</sup> (Odai et al. 2008). Cadmium is becoming an increasing health concern in wastewater irrigated agriculture, especially due to its association with damage to kidneys and bones and its potential carcinogenic nature (Suruchi and Khanna 2011).

***A note of caution:*** While most research reports we read calculate metal concentrations per dry weight of the vegetables, many of the commonly cited MRLs, like that of Cd, are based on intake of fresh vegetables, i.e. fresh weight. Given the commonly high water content (>90%) of most vegetables, an adjusted MRL based on dry weight would be much higher, and the often reported risk correspondingly lower.

In the Lente et al. (2012) study, zinc and copper concentrations on vegetables were below permissible limits. Mean concentrations were below 10 mg kg<sup>-1</sup>, corresponding to <5% of Cu and <2% of Zn MRLs. No reliable reference levels were obtained for Co. However, levels analyzed were < 2 mg kg<sup>-1</sup>, which seems tolerable. Similarly, though present in all vegetables,

levels obtained for Ni were much lower than the MRLs. In any case Ni concentrations should not be of much concern as higher threshold levels have been reported in other studies e.g. 68 mg kg<sup>-1</sup> by Weigert (1991) based on the argument that more than 90% of Ni consumption remains organically bound and will again be safely excreted.

**TABLE 8.3.** Concentration of heavy metals in vegetable crops (n = 240 samples)

Crop	Levels of heavy metals in vegetables (mg kg <sup>-1</sup> dry weight)						
	Cu	Zn	Pb	Ni	Cr	Cd	Co
<b>Wastewater irrigated</b>							
Cabbage	3.3±1.4	9.5±1.4	10.5±3.0	1.8±1.0	BDL	BDL	0.4±0.0
Lettuce	6.3±1.4	10.6±3.5	10.2±2.5	2.8±0.5	1.1±0.0	0.01±0.01	1.1±0.8
Green Pepper	7.8±2.1	6.9±2.0	9.4±1.5	1.8±0.8	BDL	BDL	0.2±0.0
Hot Pepper	5.3±2.8	5.1±1.5	7.6±1.8	1.7±0.9	BDL	BDL	0.4±0.0
Ayoyo	8.1±1.9	8.0±1.3	9.1±2.4	1.4±0.5	BDL	0.28±0.01	BDL
<b>Groundwater irrigated</b>							
Cabbage	2.6±0.4	9.5±1.5	6.7±4.2	1.4±0.1	BDL	BDL	1.0±0.0
Lettuce	3.3±2.7	9.8±1.0	8.0±5.2	2.8±3.2	BDL	0.50±0.01	1.5±0.0
Green Pepper	6.2±0.4	6.1±2.1	5.6±3.5	2.1±0.2	BDL	BDL	0.8±0.0
Hot Pepper	7.4±2.5	9.3±2.2	6.7±0.7	4.1±0.0	BDL	BDL	BDL
Ayoyo	5.9±7.0	5.4±5.0	8.3±1.2	1.3±0.1	BDL	BDL	1.5±0.1
MRL(mg kg <sup>-1</sup> dry weight)	200 <sup>b</sup>	500 <sup>b</sup>	3 <sup>a</sup>	680 <sup>b</sup>	23 <sup>c</sup>	2 <sup>a</sup>	-

MRL = maximum recommended limit; conversion of original wet weight values to dry weight done at mean 90% moisture content for all crops. Sources: <sup>a</sup>EC (2006), <sup>b</sup>Mapanda et al., (2007) based on UK and FAO/WHO standards, <sup>c</sup>Weigert (1991). BDL= below detection limit of 0.006 (Cr) and 0.005 (Cd, Co)

Source: Lente et al. (2012)

The concentrations of lead (Pb) on vegetables found by Lente et al. (2012) should be of concern as they were high in all samples. Mean Pb levels ranged between 5.0-10.51 mg kg<sup>-1</sup>, with highest levels reported in cabbage and lettuce. This was 1.8 to 3.5 times higher than the MRL standards used. Similar ranges were obtained by studies done in Kumasi (2.42-13.50 mg kg<sup>-1</sup>) and in Harare, where mean Pb concentrations of 6.77 mg kg<sup>-1</sup> were obtained (Odai et al. 2008; Muchuweti et al. 2006). High Pb levels in Ghana could probably be more attributable to vehicular exhaust fumes (Affum et al. 2008) than to irrigation water or contaminated soils.

Kylander et al. (2003) analyzed in Accra a Pb distribution following traffic density with levels reflecting a precatalyst situation in Europe and the United States. This study and that of Odai et al. (2008) show that heavy metals should be monitored while measures are needed to introduce strict vehicle emissions control.

#### 8.4 Pesticide Residues

Amoah et al. (2006) assessed the level of pesticide contamination on vegetables sold in nine major markets in Kumasi, Accra and Tamale. Table 8.4 shows pesticide prevalence on lettuce leaves and the respective maximum MRLs for consumption. In most cases, the pesticide residue levels observed exceeded the MRL. More than 60% of the lettuce samples had  $\geq 2$  pesticide residues. The data showed that 78% of the samples had chlorpyrifos residue. Only 14% had pesticide residue levels below detectable limits. There were no significant differences between pesticide residues levels observed on samples from the three cities except chlorpyrifos, for which significantly higher levels were recorded in Kumasi than in Accra.

**TABLE 8.4.** Pesticide prevalence: residue levels on lettuce (n = 60).

<b>Pesticide</b>	<b>% of lettuce with pesticide residues</b>	<b>Range of pesticide residue on lettuce (mg kg<sup>-1</sup>)</b>	<b>Average value of pesticide residue on lettuce (mg kg<sup>-1</sup>)</b>	<b>MRL<sup>1</sup> (mg kg<sup>-1</sup>)</b>
Lindane	31	0.03-0.9	0.3	0.01
Endosulfan	36	0.04-1.3	0.4	0.05
Lambda cyhalothrin	11	0.01-1.4	0.5	1.0
Chlorpyrifos	78	0.4-6.0	1.6	0.05
DDT	33	0.02-0.9	0.4	0.05

<sup>1</sup> Maximum residue limit (Pesticide Safety Directorate 2005).

Source: Amoah et al. (2006).

Dinham (2003) estimated that 87% of farmers use pesticides on vegetables. Insecticides are the most widely used among the different classes of pesticides with 41% pyrethroids, 37% organophosphates and the rest being organochlorines and carbamates (Ntow 2001; Okorley and Kwarteng 2002). Danso et al. (2002b) described how farmers mix cocktails of various pesticides to increase their potency in pesticide control. It is thus not surprising to read about evidence of chlorpyrifos contamination, for example in *waakye*, a popular Ghanaian dish (Johnson 2002). Lindane and endosulfan are restricted for the control of capsids on cocoa,

stem borers in maize and pests on coffee, whereas DDT is banned in Ghana. However, the data show clearly that these more potent agrochemicals are still being used irrespective of whether they are approved for vegetable production or not. Comparing the consumption risks, Amoah et al. (2006) concluded that the potentially negative impact of vegetable contamination through fecal matter is higher than through pesticides.

### **8.5 Estrogen Concentrations**

The concentrations of estrogens, natural estrone (E1) and 17  $\beta$ -estradiol (E2) and synthetic 17 $\alpha$ -ethynylestradiol (EE2) were monitored in spring onion, green bell pepper and lettuce during a six-week period from farms at Dzorwulu and Korle-Bu in Accra (see chapter 6). Vegetables sampled from the selected site at Dzorwulu were irrigated with potable water conveyed in municipal pipelines into dugouts on site while plants at Korle-Bu were irrigated with water from a central open drain carrying wastewater from the Korle-Bu Teaching Hospital and a combination of household and septage from surrounding houses as well as urban runoff. Vegetable samples for each site were collected in triplicate and extracted estrogens were quantified by liquid chromatography tandem mass spectrometry (LC/MS/MS). The limit of quantification for E1, E2 and EE2 in the plants was 0.1 ng l<sup>-1</sup>.

On most occasions, no detectable E1, E2 and EE2 levels were seen in onion or green pepper samples from both sites. Lettuce samples collected from Korle-Bu on the other hand, showed estrogen concentrations with levels reaching up to 1430 ng g<sup>-1</sup> and 35.5 ng g<sup>-1</sup> (dry weight) of E1 and EE2, respectively. The higher frequency of detection as well as higher concentrations of estrogens seen in lettuce compared to spring onion and green bell pepper suggested that either the lettuce roots were better capable of directly taking up the estrogens and translocating them into leaves or estrogens were being directly deposited on foliage during irrigation or as dust. Other studies have found that nonagricultural organic compounds associated with waste are more likely to be found as deposits on plant foliage left by waste application rather than through translocation from shoots (Overcash et al. 2005). No accumulation of estrogens in plant tissue was observed during the sampling period. Assuming the worst case scenario (highest estrogens detected in lettuce supplied by wastewater-irrigated farms during the study and thrice daily salad consumption), the daily EE2 equivalent dose of a person with vegetable ingestion per meal of 12 g (Amoah et al. 2007a) was estimated at 18  $\mu$ g day<sup>-1</sup>. This worst (and only theoretical) scenario dosage is comparable to therapeutic doses in

human female birth control pills (10-50  $\mu\text{g}$  EE2  $\text{day}^{-1}$ ).<sup>3</sup>

However, organic chemicals within the soil and taken up by plants usually undergo one or more phases of transformations including conversion through oxidation, reduction or hydrolysis, conjugation with glutathione, sugars or amino acids and or compartmentalization into plant tissues as bound residues non-extractable by chemical procedures (Ohkawa as cited in Dietz and Schnoor 2001). The actual and potential human health risks of the end products thus require further study.

### **8.6 Conclusions and Recommendations**

Both fecal and helminth contamination of vegetables (lettuce, cabbage and spring onion) produced and marketed at various selling points in Accra, Kumasi and Tamale exceeded the ICMSF recommended food safety levels. Fecal contamination was higher than the ICMSF-recommended level of  $10^3$  fecal coliform  $100 \text{ g}^{-1}$  fresh weight. Helminth contaminations were also high (0.42-2.74 eggs  $\text{g}^{-1}$ ). Results showed that except for piped water, all other sources of water used by urban farmers for irrigation showed fecal coliform levels exceeding common guidelines for unrestricted irrigation. The study identified the farm as the main point of microbiological lettuce contamination. Despite poor sanitary conditions in markets, postharvest handling and marketing did not affect the already high farm-gate contamination levels. Although lettuce irrigated with piped water had the lowest fecal coliform counts, contamination levels can still exceed common standards suggesting contamination through manure and the already contaminated farm soils, with postharvest contamination being again the comparatively lower risk factor in the case of Ghana while the situation can be different where irrigation water is much safer.

Comparing vegetables, it was observed that lettuce had the highest levels of fecal contamination, which is to be expected because of its open leaf structure. However helminth eggs were surprisingly higher on the green spring onion leaves in spite of lower surface area to volume ratio. Cross-market comparisons within cities showed in general no significant differences in contamination from fecal coliforms for lettuce and cabbage. Thus there is no particular market which could be recommended for the purchase of safe produce. This also concerns supermarkets which sell salad greens from the same sources. However, there was a

---

<sup>3</sup> Source: <http://contraception.about.com/od/contraceptionglossaryef/g/Ethinyl-Estradiol-Synthetic-Estrogen.htm>. Accessed 03October 2013.

tendency to safer produce where – based on consumers' demand – sellers changed the water they used to refresh their crops more often than in other markets. Comparisons among cities showed that in general, the quality of vegetables in Kumasi was better than that in Accra or Tamale. This may be indicative of the water source (often shallow wells near streams) or better postharvest handling (washing of vegetables) practices.

Comparing different pathogens through quantitative ex-ante risk modeling (see chapter 9 for details), rotavirus dominated the disease burden, followed by norovirus, while *Ascaris* posed the smallest risk. The main question of the authorities is where intervention should be placed to reduce health risks for consumers. The results suggest that due to high water pollution, any possible postharvest contamination was overshadowed by heavy contamination on farm. As most sellers wash (or refresh) different vegetables before selling them with the same water again and again, it is likely that there is postharvest contamination. This water can easily spread pathogens from one to another crop. To reduce the health risk associated with the consumption of contaminated lettuce, it is evident from the study that the problem should first be tackled through better water treatment and safer agricultural practices on farm, while precautions should not ignore the postharvest sector. A related multibarrier approach will be presented in chapter 14.

In view of heavy metals, chemical contamination on vegetables is generally within permissible limits. Compared with previous studies at the same sites, the data show that the risk from chemical contaminants is less significant than that from pathogen contamination. Nevertheless, continuous monitoring is needed in view of poor practices in pesticide application (Ntow et al. 2006) and the prospective growth in the industrial sector in Ghana. Importantly, estrogens were present in the analyzed vegetables at the Korle-Bu hospital site, although concentrations and occurrence varied among plant types. It appears from the limited data in the literature that most hydrophobic emerging contaminants are adsorbed by soil organic matter and are therefore not expected to translocate into and accumulate in harvested plants. However, the number of studies across Africa and the world are very limited (see Asem-Hiablie et al. 2013) and more are needed for any sound conclusions on uptake mechanisms (including foliar deposition) and associated human health risks. With increasing trends in dietary estrogen intake among women coupled with little improvement in wastewater treatment technologies, the overall estrogen load in wastewater is expected to increase.

## 9. Human Health Risks from Wastewater-irrigated Vegetable Farming

Pay Drechsel, Bernard Keraita, Razak Seidu and Robert C. Abaidoo

*Contamination levels of water and crops which exceed common standards are only a first indication of human health risks. This chapter shows estimates of human health risks from consumption of wastewater-irrigated vegetables based for example on dose-response modeling. The chapter focuses on human health risks and risk perceptions of microbiological and chemical contaminants such as heavy metals and pesticides.*

### 9.1. Risk from Wastewater Irrigation

The impact of poor sanitation services on the urban population in Ghana is felt through various channels and contact points. Disease transmissions via the fecal-oral route discussed in the context of this book are those where (waste)water-borne pathogens affect farmers in contact with the water, and those where the pathogens enter the food chain, thus affecting consumers (Figure 9.1). As explained in previous chapters, there is limited overlap between farmers and consumers in the case of exotic vegetables.

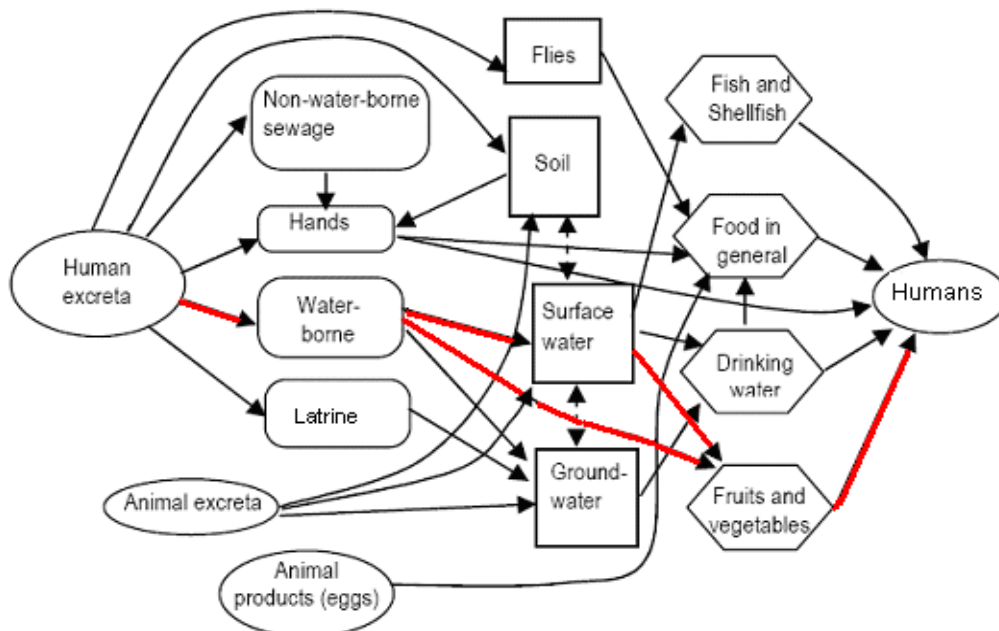


FIGURE 9.1. Common fecal-oral pathways affecting consumers (Fewtrell et al. 2007). Red lines indicate critical pathways related to irrigation with polluted water sources.

Wastewater contains a variety of pathogens and pollutants. Extensive studies on human health risks through wastewater irrigation, especially from pathogen contamination, were facilitated by the World Health Organization (WHO 2006). Table 9.1 is a simplified presentation of the main microbiological- or pathogen-related health risks, affected groups and exposure pathways. However, there are also other pollutants which can affect soils, crops and/or human health, such as salts, metals, metalloids, residual drugs, organic compounds, endocrine disruptor compounds and other residues from, for example, personal care products (Tchobanoglous et al. 1995). Discussions often focus on different types of pollutants depending on regional risk relevance. For instance, in low-income countries, risks from microbiological contaminants receive the most attention. This is because people in these countries are most affected by diseases caused by poor sanitation such as diarrhoeal diseases and helminth infections (Prüss-Ustün and Corvalan 2006). The situation changes significantly in transitional economies and is different in high-income countries, where microbiological risks are largely under control through comprehensive wastewater collection and treatment. In this context, chemical pollution (heavy metals, pesticides) and emerging pollutants (such as pharmaceutical residues) remain of concern.

In the Ghanaian context, urban dwellers in low-income and high density areas, such as Nima in Accra, are exposed to wastewater-related health risks due to the lack of toilets and/or wastewater collection and conveyance systems. With stormwater gutters taking over the function of grey water sewers especially children playing in the street have a high exposure probability (Labite, 2008; see below). Exposure related to urban vegetable irrigation can take place through (i) consuming irrigated produce (consumption-related risks); (ii) coming into contact with wastewater when working on farms (occupational risks); and (iii) by exposure to wastewater and wastewater-irrigated soils when walking in fields or children playing in fields (environmental risks). There are of course many other locations where children and others can be exposed more frequently to wastewater; thus a good risk assessment should consider the larger context of the potentially affected population, allowing authorities to use their usually limited budget for risk mitigation most effectively.

Constituents of most concern in wastewater are excreta-related pathogens and skin irritants (Blumenthal et al. 2000; van der Hoek et al. 2005). For consumption-related health risks, the primary concern is uncooked vegetables dishes such as salad (Harris et al. 2003). Several diarrhoeal outbreaks have been associated with wastewater-irrigated vegetables (Shuval et al. 1986; WHO 2006). There is also strong epidemiological evidence for *Ascaris lumbricoides*

infections for both adults and children who consume uncooked vegetables irrigated with wastewater, although not from Ghana (Peasey 2000). Helminth infections, especially *A. lumbricoides* and hookworm, have higher importance in relation to occupation-related risks compared to bacterial, viral and protozoan infections (Blumenthal et al. 2000). The most affected group is farm workers, owing to the long duration of their contact with wastewater and contaminated soils (Blumenthal and Peasey 2002; WHO 2006). Recent studies from Vietnam, Cambodia, India and Ghana have associated skin diseases such as dermatitis (eczema) to contact with untreated wastewater (Keraita et al. 2008a).

**TABLE 9.1.** Simplified presentation of the main human health risks from wastewater irrigation (modified from Abaidoo et al. 2010).

Kind of risk	Health risk	Who is at risk	Exposure pathway
Occupational risks (contact)	- Parasitic worms such as <i>A. lumbricoides</i> and hookworm infections	Farmers/ field workers	- Contact with irrigation water and contaminated soils
	- Bacterial and viral infections		- Contact with irrigation water and contaminated soils
	- Skin irritations caused by infectious and noninfectious agents – itching and blisters on the hands and feet	Marketeters of wastewater-grown produce.	- Contact with contaminated soils during harvesting
	- Nail problems such as koilonychias (spoon-formed nails)		- Exposure through washing vegetables in wastewater
Consumption-related risks (eating)	- Mainly bacterial and viral infections such as cholera, typhoid, ETEC, hepatitis A, viral enteritis, which mainly cause diarrhoea	Vegetable consumers	- Eating contaminated vegetables, especially those eaten raw
	- Parasitic worms such as <i>Ascaris</i>		
Environmental risks	- Similar risks as those exposed to occupational and consumption risks, but decreasing with distance from farm	Children playing in wastewater-irrigated fields People walking on or nearby fields	- Soil particle intake - Aerosols

## 9.2 Risks from Microbiological Contaminants

While the previous chapters showed that we can find pathogens in irrigation water and also on crops, this information is only a first indication of a possible health risk. To quantify the risk, it is important to assess human exposure.

For consumption-related risks, this includes, for example, the amount and frequency of vegetable intake, information about the person, like age, and needs to consider the dose-response function of individual pathogens. A common modelling tool is Quantitative Microbial Risk Assessment (QMRA) with 10,000 (so-called) Monte Carlo simulations. In Ghana, QMRA was applied extensively by Seidu (2010) and also other research teams; see for example Barker et al. (2014) for methodology and further references.

Seidu et al. (2008) evaluated the annual risks of rotavirus and *Ascaris* infections for consumers of lettuce irrigated with the different water qualities after postharvest handling and of farmers using different irrigation water qualities. A tolerable risk (TR) of infection of  $7.7 \times 10^{-4}$  and  $1 \times 10^{-2}$  per person per year (ppy) were used for rotavirus and *Ascaris*, respectively, as acceptable limit. The assessment revealed a high risk of *Ascaris* and rotavirus infections above the TR levels for farmers using different irrigation water quality and also the much larger number of consumers of irrigated lettuce. The risk of *Ascaris* infection was within a magnitude of  $10^{-2}$  ppy for farmers accidentally ingesting drain or stream irrigation water; approximately 100 ppy for farmers accidentally ingesting farm soil and 100 ppy for farmers ingesting any of the irrigation waters and contaminated soil. The median annual risks of rotavirus infection for consumers of drain- and stream-irrigated lettuce were of the same magnitude and above the WHO-TR: the annual risks of *Ascaris* and rotavirus infections were 100 ppy and  $10^{-3}$  for drain- and stream-irrigated lettuce respectively, with slight increases for rotavirus infections along the postharvest handling chain.

The risks of *Ascaris* and rotavirus infections recorded for consumers of irrigated lettuce were attributed mainly to the contamination of the lettuce on farm and to a lesser extent on postharvest handling. Such contamination was attributed to common irrigation practices involving watering cans and the application of fresh poultry manure (Amoah et al. 2005). As current on-farm arrangements do not allow any time lapse for pathogen die-off between the last irrigation/manure application and harvesting (Obuobie et al. 2006) attention should also be given to soil contamination. In fact, trials with tap water showed that soil contamination levels may pose a significant health risk above TR levels even when the irrigation water quality or the related crop exposure is temporarily improved to meet international standards.

Two notes of caution are required in view of contamination during harvest and postharvest activities:

- a) Traders normally buy their crops on farm following their agreements with farmers at the start of the growing cycle. At least in Kumasi, it is a common practice to wash the vegetables while on farm to remove soil particles in the same water used for irrigation with obvious contamination consequences. This was not observed where the water source is a drain.
- b) Due to very high contamination on farm, any likely postharvest contamination at wholesale or retail outlets and in street food restaurants is 'hidden'. Studies in locations where the irrigation water had lower fecal coliform counts showed clearly that significant contamination can take place during vegetable transport and marketing (Ensink et al. 2007).

The QMRA assessment estimated a loss of about 12,000 disability-adjusted life years (DALYs) annually in Ghana's major cities through the consumption of salad prepared from wastewater-irrigated lettuce (Drechsel and Seidu 2011). This figure represents nearly 10% of the WHO-reported DALYs occurring in urban Ghana due to various types of water- and sanitation-related diarrhoea (Prüss-Üstün et al. 2008; GSS 2004). Barker et al. (2014) re-assessed the risk for consumers in the case of Kumasi using more conservative data when running QMRA but also concluded that rotavirus dominates the disease burden, while *Ascaris poses* smaller risk. Rotavirus exposure doses were sufficiently high in most scenarios that annual probability of illness was ~1 resulting in a maximum annual disease burden of  $\sim 10^{-3}$  DALYs ppy. Important to note is that even if the risks from both rotavirus and *Ascaris* were eliminated, the risks from norovirus can remain significant. The Barker study concluded that risk assessments based on water analysis are not recommended.

Under the umbrella of the EU funded SWITCH project, another QMRA was undertaken in Accra to assess different water- and sanitation-related exposure pathways leading to diarrhoeal diseases. The study compared the disease burden associated with contaminated drinking water, flooding, playing at open drains, swimming at urban beaches and occupational contact with fecal matter (Labite 2008; Lunani 2007) and consumption of wastewater-irrigated vegetables.

If we compare the calculated loss of healthy life years (DALY) with the QMRA data reported above for the same population size in Accra, the consumption of wastewater-irrigated vegetables is probably the second largest challenge next to the risk of children exposed to open drains (which is possible everywhere in Accra), in terms of DALYs lost (Figure 9.2).

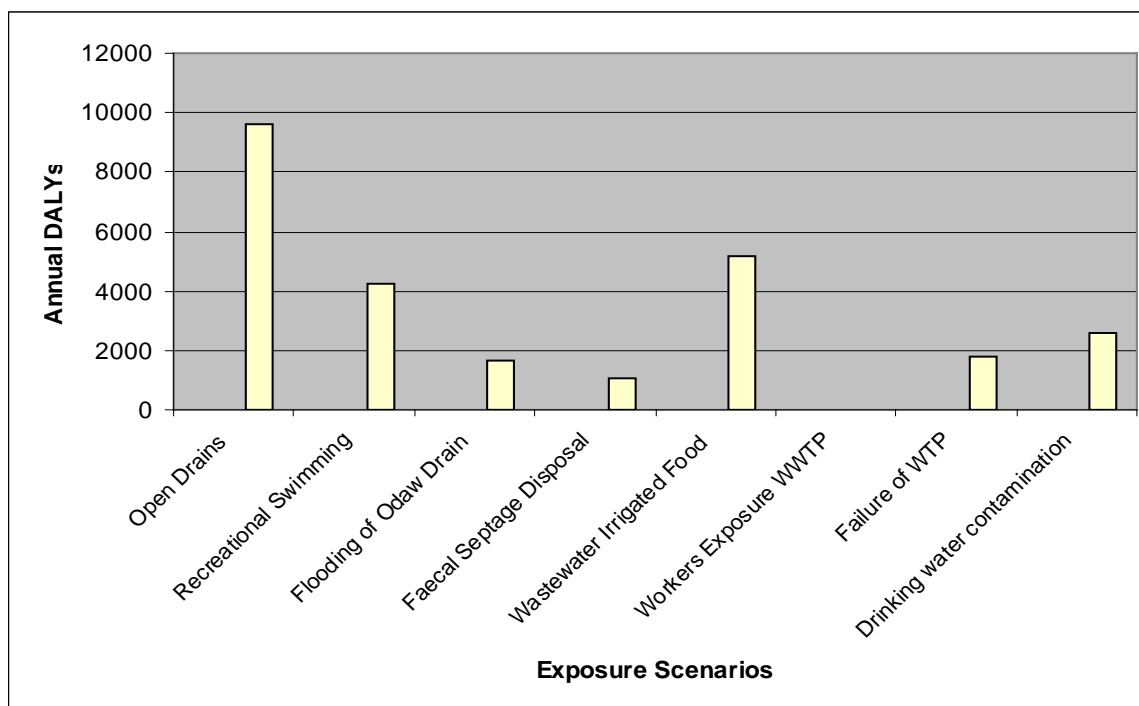


FIGURE 9.2. DALYs per exposure scenario (estimates for Accra; IWMI, unpublished).

In view of risk reduction, and based on the numbers of affected urban dwellers along the food chain (see chapter 5), the studies in Ghana focused on the large group of consumers. Compared with about 800-1000 farmers using wastewater in Accra, every day probably more than 200,000 urban dwellers eat fast food with contaminated raw vegetables (lettuce, cabbage) in street restaurants (Amoah et al. 2007b). The number is higher if canteens and other restaurants are also considered (Table 9.2).

**TABLE 9.2.** Target groups for risk mitigation (estimated number of affected farmers, consumers per day, and street food kitchens) based on city survey data (IWMI estimates, 2008; adjusted 2014, unpublished).

City	Consumers eating dishes with raw salad component	Street food kitchens serving raw salad (usually as side dish)	Urban farmers producing exotic vegetables
Accra/Tema	160,000-300,000	1,050-1,750	800-1000
Kumasi	140,000-240,000	1,100-1,400	>330
Cape Coast	15,000-35,000	110-170	ca. 30
Tamale	20,000-40,000	190-300	>400
Takoradi	15,000-35,000	120-200	80
Other cities	150,000	1,000-2,500	100-200
Total	500,000-800,000	3,570-5,320	1740-2040

Although the risk reduction studies focused on consumers, many of the recommended practices (see chapter 14) to reduce crop contamination, like drip irrigation, will also reduce farmers' occupational exposure.

To reduce the risk for consumers, an analysis of the marketing and contamination pathways from irrigation water source to farm as well as wholesale market, retail and consumer outlets showed key entry points for risk-reducing interventions. These are (a) the farm, where by far the most contamination takes place and (b) the kitchen, where most salads are eventually prepared for sale/consumption:

- a) Emphasis was given to interventions on the farm, as this is the place where probably 90% of vegetable *contamination* takes place, much of it being avoidable. The key contamination source is the polluted irrigation water. Another source is the farm soil which is contaminated by the irrigation water, thus soil particles rain-splashed on the crop contribute to its contamination. Another contamination source, but with less significance as it is only temporarily used, is fresh poultry manure, broadcast over fields and crops.
- b) Interventions in the (street food) kitchens, popularly called 'check-check' bars, were also given priority as these locations can combine easy ways to *eliminate pathogens* while vegetable washing with the incentive that the kitchens serve the actual consumer who might be affected (while a farmer might never see the consumer). Moreover, nearly all kitchens already wash salad greens before serving them, but – as verified – certainly not effectively enough to kill pathogens (Amoah et al. 2007a, 2011).

There was an additional suggestion to consider wholesale markets as an entry point for risk reduction, as these markets offer a convenient single geographical transfer station for most of the traded salad greens in the city, involving only a few wholesalers, compared to the many farm sites and even more retail markets and plethora of street restaurants. However, as the crops pass through the wholesale markets in large packed bundles, opening them for washing purposes was eventually considered risky in terms of additional exposure and risk of contamination. Thus, instead of direct interventions in markets, Amoah et al. (2007ab) advocated 'good handling practices' in markets to avoid *additional* contamination. The effectiveness of tested inventions to reduce *already existing* contamination was generally limited to one log unit (Amoah et al. 2011, see chapter 14).

### 9.3 Risks from Heavy Metals

Heavy metal intake by consumers normally occurs through metal absorption from contaminated soils via crop roots or by deposition on crop surfaces (Sawidis et al. 2001; Jassir et al. 2005). Uptake through roots depends on many factors such as the soluble content of heavy metals in soil, soil pH, humidity, plant growth stages as well as type of crops, fertilizers and soil (Sharma et al. 2006; Ismail et al. 2005). Deposition of heavy metals from industrial and vehicular emissions on crop foliar surfaces may occur during production, transportation and marketing (Sawidis et al. 2001; Jassir et al. 2005). In vegetables, these heavy metals accumulate in edible parts (leaves and roots). Heavy metals most often found in vegetables include As, Cd, Cu, Co, Mo, Zn, Mn and Pb. When in trace quantities, some of these heavy metals are micronutrients. However, in elevated concentrations or after prolonged dietary intake, they can pose a significant health risk to humans, leading to various chronic diseases (Gupta and Gupta 1998; Sharma and Prasad 2009). Other than safety concerns, excessive heavy metals also contaminate soils and affect crop growth and quality (Fergusson 1990). In fact, for some metals, like Cu, Mn., Ni and Zn, crops function as a safety barrier in the food chain as they would stop growing or die before harvesting if content was excessive (Table 9.3). Routine monitoring of heavy metal concentrations in soils and crops remains essential to know the levels and devise strategies to minimize contamination, hence reducing risks to human health. This is particularly applicable to Cd (Table 9.3).

**TABLE 9.3.** Heavy metal bioavailability grouping.

Group	Metal	Soil adsorption	Phytotoxicity	Food chain risk
1	Ag, Cr, Sn, Ti, Y, and Zr	Low solubility and strong retention in soil	Low	Little risk because they are not taken up to any extent by plants
2	As, Hg, and Pb	Strongly sorbed by soil colloids	Plant roots may adsorb them but not translocate to shoots; generally not phytotoxic except at very high concentrations	Pose minimal risks to the human food chain
3	B, Cu, Mn, Mo, Ni, and Zn	Less strongly sorbed by soil than Groups 1&2	Readily taken up by plants and phytotoxic at concentrations that pose little risk to human health	Conceptually the 'soil-plant barrier' protects the food chain from these elements
4	Cd, Co, Mo, and Se	Least of all metals	Pose human and/or animal health risks at plant tissue concentrations that are not generally phytotoxic	High probability of human bioaccumulation through the soil-plant-animal food chain

Source: Hamilton et al. (2005).

### Estimation of Daily Intake of Heavy Metals

The degree of toxicity of heavy metals to human beings depends upon daily intake and the concentration of heavy metals. Amoah et al. (2007b) estimated daily intakes of vegetables (fresh weight) as follows:

- Lettuce: Mostly eaten as raw salad. Estimated 30 g per person eaten on average three times in a week with, for example, fried rice and chicken (*check check*) = 12.86 g per person per day (pppd);
- Cabbage: Consumed as raw salad and stew. Frequently eaten in Ghana but not necessarily in addition to lettuce. Estimated 50 g per person eaten five days in a week = 35.71 g pppd;
- Hot pepper: Usually eaten with local diets like *kenkey* and *banku*. Can be added to stews also for flavor. Eaten about five days in a week and about 5 g each time = 3.57 g pppd;
- Green pepper: Green pepper is sometimes also eaten as salad and to make stews. Estimated 10 g per person eaten five times in a week = 7.14 g pppd;
- *Ayoyo*: Typical in local diets to make stew. Not frequently eaten, about twice a week but amounts consumed are high, on average so about 200 g = 57.14 g pppd.

Based on these estimates, Lente et al. (2012) calculated the daily intakes of heavy metals via irrigated vegetable consumption assuming a ‘worst case’ scenario that all vegetables are consumed and not one or the other (Table 9.4). The calculated values were compared with the Minimal Risk Levels (MRLs) as provided by the US Agency for Toxic Substances and Disease Registry (ATSDR). It could however be more appropriate to use safe limits from more universal institutions like WHO or FAO and their Expert Committees on Food Additives, but coverage of heavy metals (referred to as contaminants) is not comprehensive. So while there could be varying MRLs or Potential Tolerable Daily Intake (PTDIs) values in different publications, ATSDR values were used as they cover most heavy metals and are relatively recent (current version at print, July 2013).

The levels obtained by Lente et al. (2012) in Accra were all below the MRLs and PTDIs obtained in the literature. Pb, though not elevated, showed the highest ratio with its MRL. For example, the highest concentration of Pb was in wastewater-irrigated cabbage (35% of the MRL). All others were less than 10% of the MRL values. In a related study done on

wastewater-irrigated vegetables in Harare, Zimbabwe where similar heavy metal elements were analyzed, Mapanda et al. (2007) showed that all heavy metal elements were below the MRLs, except Cd which was in all cases above the MRL of  $12 \mu\text{g Cd day}^{-1}$  (which is slightly stricter than the one suggested today by ATSDR), and might indicate a specific Cd source in the study area. However, also compare with this MRL, all samples in Accra are far below the threshold. Another study conducted in Varanasi, India, showed that contributions of irrigated vegetables to daily intake of Cu, Zn, Cd and Pb could be as high as 13, 1, 47 and 9% of the PTDI, respectively (Sharma and Prasad 2009).

**TABLE 9.4.** Estimated daily intake of heavy metals from consumption of irrigated vegetables in Accra (Source: Lente et al. 2012).

Water Source	Crop	Estimated daily intake ( $\mu\text{g day}^{-1}$ )						
		Cu	Zn	Pb	Ni	Cr	Cd	Co
Wastewater Irrigated	Cabbage	23.78	68.21	75.06	12.64	0.01	0.01	3.14
	Lettuce	8.05	13.64	13.10	3.58	0.00	0.01	1.38
	Green Pepper	11.14	9.91	13.48	2.50	0.00	0.00	0.34
	Hot Pepper	5.62	5.42	8.15	1.80	0.10	0.00	0.43
	<i>Ayoyo</i>	46.40	45.48	51.71	8.17	0.01	1.60	0.01
Groundwater irrigated	Cabbage	18.93	68.21	47.71	10.28	0.01	0.01	7.14
	Lettuce	4.27	12.05	10.28	3.59	1.44	0.06	1.87
	Green Pepper	8.78	8.65	7.98	2.93	0.00	0.00	1.13
	Hot Pepper	7.90	9.95	7.15	4.34	0.00	0.00	0.00
	<i>Ayoyo</i>	33.66	30.91	47.60	7.43	0.01	0.01	8.63
MRL		600	18000	214	720	300	30	600

MRL: Minimal Risk Levels stated as  $\mu\text{g/day}$  for a 60 kg person

MRL sources: ATSDR, 2013, FAO/WHO, 2010 (Pb) and WHO, 2005 (Ni)

### Hazard Index Values

All heavy metals analyzed had a hazard quotient of less than one ( $\text{HQ} < 1$ ) with lead reaching the highest value of 0.35 in wastewater irrigated cabbage. On average, chromium had the lowest HQ, and lead the highest ( $\text{Cr} < \text{Cd} < \text{Co} < \text{Zn} < \text{Ni} < \text{Cu} < \text{Pb}$ ). The HQs on these urban farming sites are probably typical for West Africa with low industrial development but differ from HQs obtained from emerging economies like China and India, where several studies have shown HQs of more than 1 (e.g. Singh et al. 2010; Cui et al. 2004). Wastewater irrigated cabbage had with 42 % the relatively highest risk followed by wastewater irrigated *ayoyo* (38 %). Only the consumption of all analyzed vegetables would result in a cumulative Total HI of about 1 under wastewater irrigation, compared to 0.7 under groundwater irrigation (Figure 9.3).

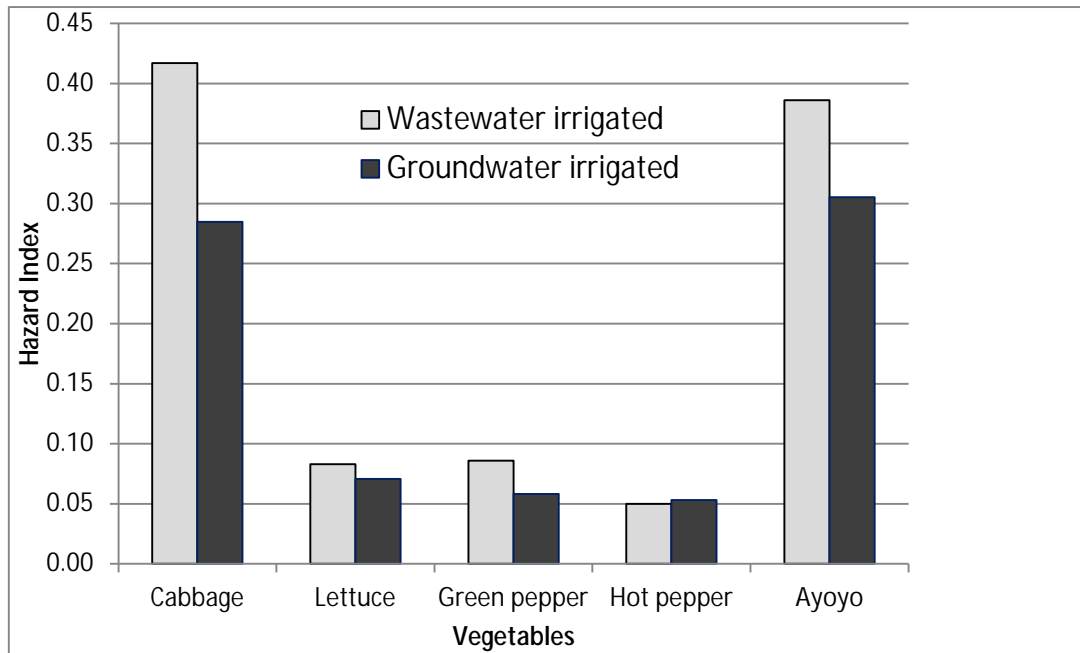


FIGURE 9.3. Hazard Index values for different types of vegetables (Lente et al. 2012).

#### 9.4 Risks from Pesticides and Emerging Contaminants

Although irrigation water might contain pesticides, the main exposure to crops is direct pesticide application. The findings by Amoah et al. (2006) which showed that some residue pesticide levels exceeded their acceptable thresholds are strongly indicative of potential health risk to consumers. For example, all 47 (78%) lettuce samples with detectable chlorpyrifos contamination exceeded the recommended residue level of  $0.05 \text{ mg kg}^{-1}$  indicating a high probability of exposure to this chemical. Although an assessment of actual pesticide intake will be needed to ascertain the actual risk, a rough calculation can show the risk potential. For example, the acceptable daily intake (ADI, i.e. the measurement of the quantity of a particular chemical or food that, it is believed, can be consumed on a daily basis during a lifetime without harm) of chlorpyrifos is  $0.01 \text{ mg g}^{-1}$  body weight (WHO 1997). To exceed the ADI, a child weighing  $30 \text{ kg}$  would have to consume at least  $0.3 \text{ mg day}^{-1}$ . With a residue level of  $1.6 \text{ mg kg}^{-1}$  lettuce, the child would have to eat close to  $200 \text{ g}$  of lettuce/day. The amount of lettuce (usually served with other staples such as rice) is usually less than  $30 \text{ g}$ , indicating that even persons of low body weight are not presently at risk. Amoah et al. (2006) concluded that urban dwellers face in fact a much higher pathogen than pesticide risk from vegetable consumption.

Of the group of the, so-called, emerging contaminants, only selected estrogens have been analyzed so far in Ghana. These preliminary studies targeted irrigation water and irrigated vegetables as reported in the previous chapters, and also in catfish grown in wastewater treatment ponds (Asem-Hiablie et al. 2013). Given the paucity of data, it is still very difficult to establish any reference values or dose-response function for humans to estimate the possibility of risk, especially in the long term. Compared to the data available on pesticide contamination, it appears as if the analyzed estrogen levels are of limited concern for now.

## 9.5 Conclusions

Human health risk assessments are so far based on the comparison of analytical values found in the environment (water, produce) with thresholds established in the literature. Some assessments use modelling to better predict the potential risk. However, to date no detailed epidemiological study has been carried out to (re)confirm the risk and compare it with other risk factors that farmers and consumers face. Also the ex-ante modelling of microbial risk (QMRA) is only a tool and the quality of its estimates has to be verified in the local context as it uses dose-response functions from other parts of the world with other actors and, for example, immunity levels.

In other words, we have very sound indications of health risks and can probably rank some risks according to priority, but more research is needed to actually verify the occurrence of disease. This is also important as according to farmers' perceptions (see chapter 10 for details and a related discussion) their risks are low.

In view of heavy metals, the few studies available indicate that chemical contamination of vegetables is generally within permissible limits. Compared with previous studies on the same sites, the data show that the risk from chemical contaminants in general, i.e. including pesticides and other organic chemicals, like the so-called emerging contaminants, appears possible but currently is less significant compared to microbial (pathogen) contamination. Nevertheless, continuous monitoring is needed in view of poor pesticide management practices (Ntow et al. 2006) and the prospective growth of the industrial sector in Ghana as well as oil discoveries near the coastline. Importantly estrogens were present in the analyzed vegetables although concentrations and occurrence varied among plant types. It appears from the limited data in literature that most hydrophobic emerging contaminants are adsorbed by soil organic matter and are therefore not expected to translocate into and accumulate in harvested plant parts. However, the number of studies across Africa is very limited and more are needed for any sound conclusions on uptake mechanisms and associated human health risks from emerging contaminants.

## 10. Health Risk Perceptions of Stakeholders in Irrigated Urban Vegetable Farming

Emmanuel Obuobie, Bernard Keraita, Lesley Hope and Sampson K. Agodzo

*This chapter presents a compilation of survey results on perceptions of urban vegetable farmers, traders and consumers, and of local authorities/officials on urban open-space vegetable farming in general and irrigation with polluted water sources in particular. Information presented is based on surveys conducted in 2002 to 2003 and 2005 to 2006 involving over 1,000 vegetable consumers, 150 vegetable sellers, 24 city officials and over 140 farmers in Accra, Kumasi and Tamale. Reviews from other related literature have also been included.*

### 10.1 The Importance of Stakeholder Perceptions

Unlike rural farming, which is generally perceived as the backbone of the African economy, urban agriculture in general and irrigated urban vegetable production in particular often receive mixed reactions. In contrast to recent trends in developed countries, urban farming is often perceived as an anachronism and possible hindrance to modernization (Drechsel et al. 2006). If wastewater is used for washing of vegetables or irrigation purposes, risk perceptions will increase negative attitudes. It is therefore crucial to understand the perceptions of stakeholders to support informed decision making. This is also important because the knowledge and perceptions of risks influence how risks are managed and hence final exposure to them (Stewart-Taylor and Cherries 1998). Understanding the knowledge and risk perceptions of stakeholders has been seen as the most important first step in the process of understanding attitudes towards different processes and technologies and to steer impact-oriented research (Frewer 2003). Conducting an analysis of stakeholder perceptions is particularly important as risk perceptions between experts and farmers are usually very different (Lazo et al. 2000). Moreover, in an urban setting, many more stakeholders are directly or indirectly involved in urban farming than in a rural setting, which adds to the complexity of studying urban farming and also related decision making (Campilan et al. 2001).

In a typical urban vegetable farming situation in Ghana, the core stakeholders involved are the farmers and their families, the market vegetable sellers who earn a living from the sale of the produce, the extension services, if any, the consumers who may or may not be aware of the

source of their purchases, the various local authorities/officials (land use, agriculture, sanitation, health) who are responsible for regulating the practice, especially if polluted water sources are used, the tenure holders of the occupied land and the media with the power to influence opinions. Assessing their views and perceptions is a sensitive task where many mistakes can occur. The most typical flaws observed among our students were a tendency to

1. Bias by the interviewer who might ask ‘leading questions’ which reveal his/her own perceptions, and push the interviewee in a particular direction;
2. Multiple choice answers (instead of open questions) which do not facilitate free expression of thoughts;
3. Ignorance that others had asked similar if not the same questions on the same farm previously.

A **note of caution** regarding item 3: A negative side effect of our attention to urban vegetable farming and the research we supported or stimulated over more than a decade is that the farmers continuously experienced individual and even groups of local and foreign students, resulting in part in ‘interview fatigue’ or disapproval if the research tended to increase negative public response (in view of health risks) rather than assistance in addressing any of farmers’ expressed challenges, including poor irrigation water quality.

In the following sections we have compiled typical views and perceptions which were compiled from key stakeholders in irrigated urban vegetable production. The data were derived from many IWMI-commissioned interviews and surveys or student work and have already been presented, in part, in the first edition of this book (Obuobie et al. 2006).

## 10.2 Perceptions of Urban Vegetable Farmers

### Farming Constraints

In all the cities surveyed, farmers encountered numerous constraints in producing vegetables. Typical production constraints mentioned in Kumasi, Accra, Takoradi and Tamale were:

- Marketing of produce: vegetable market women/sellers dictate produce prices at harvest;
- High cost of inputs (pesticides, farm tools, labor, fertilizer, etc.);
- Pest and disease threats to crops;
- Inadequate amounts of cheap soil inputs (compost, poultry manure, etc.);

- Lack of available land and tenure insecurity due to urban development;
- High labor input (personal or paid) for watering of vegetables;
- Dry-season access to (safe but cheap) water for irrigation;
- Poor seed quality (lettuce, cauliflower, cabbage);
- Lack of capital funding sources: farmers have to fund themselves or make an arrangement with the market women for advance payment to be settled with delivery of their produce;
- Limited support by extension services.

Farming inputs, water, crop diseases and marketing were identified as more ‘important’ by farmers in Accra and Kumasi (Table 10.1).

**TABLE 10.1.** Key constraints identified as important by farmers

<b>Constraints</b>	<b>Accra (%)</b>	<b>Kumasi (%)</b>
Marketing	42	35
Inputs *	82	69
Water	75	53
Crop disease	48	55

\*Seeds, fertilizer/manure, tools.

Farmers specified the nature of each constraint as shown in Table 10.2. More than half (56%) of the farmers in Accra mentioned water shortage between December and March as the main problem associated with available irrigation water sources. This was followed by water cost (24%) and quality (22%). Exceptionally for Accra, 11% of the farmers indicated that ‘public criticism’ of the sources of water they use for irrigation is the constraining factor to urban vegetable production. In Kumasi, ‘lack of adequate supply’ throughout the year and dry-season shortages were the main problems for irrigation water. Regarding inputs, between 47and 68% of farmers in the two cities complained that cost of seeds was the main constraint, followed by quality of available seeds. In the marketing of produce context, 59% of the farmers in Kumasi specified ‘low seasonal demand’ as a significant problem while 32% of farmers in Accra identified ‘no direct market access/cheap pricing of produce’ as an obstacle. More than two-thirds of respondents in each city indicated threats from crop diseases resulting in crop damage (or failure). Farmers are actively experimenting with various known chemicals – if permitted, or not, for vegetables – such as lindane, chloropyrifos, endosulfan, etc. as well as local soap and other products, to combat pests.

**TABLE 10.2.** Specifications of ‘important constraints’ (IWMI).

Nature of constraint	Water (%)		Input (%)		Marketing (%)		Crop disease (%)	
	Accra	Kumasi	Accra	Kumasi	Accra	Kumasi	Accra	Kumasi
Lack of adequate supply	2	45						
Public criticism	11	0						
Conveyance	2	31						
Quality	22	0	20	26				
Cost	24	8	47	68				
Shortage	56	42	6	0				
Viability of seeds and chemicals			27	20				
Lack of tools and equipment			12	0				
Seasonal low demand					28	59		
No direct market access/poor returns					32	29		
Yield reduction							31	22
Crop damage					12	18	69	78

The results of the average ranking of constraints to irrigated vegetable farming and the degree of importance of each constraint to the others are presented in detail in Table 10.3. The top challenges were water, inputs (mostly seeds) and pests.

**TABLE 10.3.** Ranking of constraints to irrigated urban vegetable farming (IWMI).

Constraints	Mean ranking	
	Accra	Kumasi
Inputs	2.27	2.59
Water	2.27	2.99
Crop disease	2.87	2.80
Marketing	3.43	3.39
Credit/capital	3.80	3.61
Soil fertility	3.85	3.71
Land	3.87	4.00
Crop theft	3.90	3.84
Lack of extension services	3.97	3.39
Expired chemicals	3.97	4.00
Labor	4.00	3.76

Scale 1-4, with 1 = most important; 4 = least important.

None of the constraints was ranked on average as ‘most important’ indicating variation between the main challenges farmers face. In Accra, water and input were ranked the same (‘high importance’), while in Kumasi with easier water access in inland valleys, farmers ranked them as only ‘important’. Crop diseases and marketing were both ranked as important constraints in the two cities. Soil fertility, land, credit/capital, lack of extension services, crop theft, labor, etc., were all ranked as ‘less important’ in both cities. Regression analyses of the influence of education, experience (years cultivating), irrigation water source and type of land tenure on the mean ranking of constraints were conducted, but did not result in statistically significant ( $p < 0.05$ ) relations.

### **Reliability of Irrigation Water**

About two-thirds (65%) of the 138 farmers interviewed in Accra expressed satisfaction with the sources of water they used although only a smaller share had access to safe water. Their reasons for using such water were due to the many benefits they derived from the water. For such farmers, wastewater/urban runoff provide reliable water supply because flow is relatively continuous (mentioned by 36% of the farmers) and they do not pay for the water (32% mentioned this) as some of the other farmers who only have access to costly pipe-borne water do. Tap water in addition is often in short supply (general water supply gaps can last days, or longer, like in Tamale) thereby making it an unreliable source. Less than 5% of the farmers referred to nutrients in the water as a reason for using it; generally, farmers do not give consideration to the nutrients present in wastewater possibly because it is often diluted to different extents. Farmers use the water mainly because it is the only source and usually apply poultry manure as a (low-cost) source of crop nutrients.

### **Health Risks**

Given the importance of health in the context of wastewater use, many surveys targeted risk perceptions. Typical results are presented here. In Accra, of about 10% of the 138 farmers interviewed mentioned skin irritation/diseases and bad odor as the health risks associated with the use of their irrigation water. Most of the remaining farmers (71%) thought that there is no actual risk to themselves or to consumers. This is how many of them put it:

*Ever since I was born, my father has been doing this work [farming] and it is the same drain water [wastewater] we have been using with no health problem...*

Similarly, in Kumasi, Keraita (2002) reported that only few farmers complained of body rashes for example from the use of irrigation water. Their confidence in the low levels of risk was also attributable to no complaints from consumers (or the traders in the interface) about their products:

*There is nothing wrong with the water. Nobody has ever complained of any disease after eating our vegetables.*

The rest (19%) hold dual opinions on the health issue. They indicated that they have not encountered any actual problems themselves and believe this also applies to consumers. However, they also think that the use of 'wastewater' might potentially be associated with some diseases due to the presence of germs in the water which might manifest sickness later on. The limited risk perception has to be understood in the context of farmers' general living conditions. Like most city dwellers, they experience daily many potentially health-affecting factors such as poor sanitation, unreliable supply of potable water and malaria which are routine parts of their lives. In this context, to emphasize a single risk factor as more important than any other is difficult and actual risk perception is in fact likely to be very low.

A more detailed qualitative survey gave further perspectives on farmers' perceptions on health risks (Keraita et al. 2008a). Table 10.4 shows the health hazards farmers related to vegetable farming in focus group discussions. Occupational hazards like muscular pains and headaches were perceived to have the highest health impact. These were related to physical strain and hence had higher rating by more established, older farmers. Such strain was linked to manual water fetching and irrigation with watering cans which is very arduous. The occupational health risks were rated higher in Accra than in Kumasi, which was attributed to different walking distances between water source and field. Considering that irrigation can take 40 to 75% of the time farmers spend on the farm (Drechsel et al. 2006), walking distance matters. The fact that more farmers in Accra use streams and drains which collect all types of wastes might explain the higher rating of bad odor in Accra than in Kumasi. Established farmers gave odor and skin infections less significance than new farmers. In Accra, 19% of the farmers interviewed in the survey temporarily wear protective clothing, mainly boots, when irrigating or applying manure while 14% perceived the use of protective clothing as uncomfortable. Farming in low-lying areas with high water tables in Kumasi meant that farmers' feet had more contact with water and that is probably why feet infections were rated higher in Kumasi than Accra.

**TABLE 10.4.** Health risks that vegetable farmers associated with wastewater irrigation and other practices in Accra and Kumasi (Source: Keraita et al. 2008a).

Perceived health risks	Accra		Kumasi	
	New farmers (n=16)	Established farmers (n=12)	New farmers (n=18)	Established farmers (n=14)
<b>Occupational</b>				
Skin infections	3.1 <sup>b</sup> ±0.7 <sup>c</sup>	1.9 ±0.8	2.1 ±0.9	1.4 ±1.1
Sore feet	2.1 ±1.1	1.3 ±0.8	3.2 ±0.7	2.0 ±1.0
Bad odor	4.3 ±0.7	1.1 ±0.9	1.2 ±0.9	1.1 ±0.9
Bilharzia	1.2 ±1.0	0.3 ±0.5	1.1 ±0.8	1.0 ±1.0
Muscular pains	3.4 ±0.8	3.2 ±1.0	2.9 ±1.1	3.4 ±0.9
Headaches	2.1 ±0.9	2.3 ±0.9	1.3 ±1.0	0.9 ±0.7
<b>Consumption/intake</b>				
Diarrhoea <sup>d</sup>	2.0 ±0.9	1.3 ±1.1	1.1 ±0.9	1.2 ±0.4
Abdominal pains	1.3 ±0.7	2.3 ±0.9	1.2 ±0.9	0.3 ±0.5
Cholera	0.9 ±0.8	0.8 ±0.7	0.2 ±0.4	0.4 ±0.5
Typhoid	1.2 ±0.8	1.0 ±0.6	0.4 ±0.7	0.4 ±0.6
<b>Other risks</b>				
Pesticides: Impotency	4.3 ±0.7	3.2 ±1.3	4.8 ±0.4	4.2 ±0.7
Pesticides: Skin burns	3.3 ±0.9	2.3 ±1.0	3.3 ±0.9	2.4 ±1.0
Fertilizers: Skin burns	3.4 ±0.9	2.1 ±0.8	1.2 ±0.9	0.4 ±0.5
Manure: Bad odor	1.9 ±0.9	0.9 ±0.8	3.4 ±1.2	1.9 ±0.9

<sup>a</sup> New farmers: cultivating with wastewater < 2 yrs; established farmers: > 2 yrs

<sup>b</sup> Risk range: Lowest risk = 0, Highest risk = 5

<sup>c</sup> Standard Deviation

<sup>d</sup> As mentioned by farmers, although symptoms can also refer to other diseases mentioned.

Farmers usually do not eat the exotic vegetables they produce, so the listed consumption-related risks were based on hear-say but not experience. There were very few farmers who occasionally ate their own produce and those who did indicated that they had never had any health problem. This opinion echoed the results of the survey where most of the farmers interviewed (71%) thought that there has never been any actual risk to themselves or to the consumers (see above). Similarly, in Kumasi, Keraita (2002) reported that only a few farmers complained of body rashes from the use of irrigation water, although many were aware that wastewater carries unhealthy components. It is of course difficult to distinguish if the majority

of farmers did not experience any problems, or if they downplayed them to protect their business interests.

Farmers in Accra rated the possibility of consumption-related risks higher than the Kumasi farmers. Nevertheless, in both cities, consumption-related risks were perceived to be of less importance than occupational risks. However, non-wastewater -related occupational risks, especially from pesticide use, were perceived to have a much higher risk. The higher rating of pesticide risks could be attributed to the high level of awareness created by NGOs in the area advocating for Integrated Pest Management (IPM). There have also been reports from an irrigation scheme near Kumasi (Akumadan) where intensive tomato farming is practiced linking pesticide use with impotency. This might explain why, especially, the group of younger unmarried farmers perceived this as a very significant risk (cf. Obuobie et al. 2006).

Another follow-up study in Accra that compared perceptions on disease infections among farmers using wastewater and those using pipe water, found no significant differences between the two groups (Gbewonyo 2007). Similar findings were reported from Ouagadougou, Burkina Faso, that involved 750 households in two groups; one engaged in irrigated urban agriculture and the other in non-agricultural control activities (Gerstl 2001). A follow-up perception study in Ouagadougou showed that farmers did not see any possible link between irrigation water quality and health (Ouedraogo 2002). They argued that there was no basis for irrigation water to be labelled as a source of diseases. In their opinion diseases were attributable to other factors that ‘scientists blame on wastewater irrigation’. They qualified this with a proverb, *when an abscess is on a camel’s back, do not pierce the donkey’s back*. In another study in Hanoi, wastewater was perceived to be the main cause of skin problems such as rashes but was not viewed as harmful as bad odor which ‘enters’ the body (Knudsen et al. 2008).

Keraita et al. (2008a) noted that farmers’ risk perceptions have to be taken seriously in any risk awareness program, especially if farmers:

- Have no education about invisible risk factors like pathogens and how they can affect human health;
- Usually do not eat exotic vegetables and, therefore, have no experience of a possible impact;
- Live in poor suburbs that lack good sanitation and improved water supply, which could in fact be more associated with these risks than vegetable farming;
- Could have adopted defensive strategies to show that their farming is safe as a response to pressure from the public and media.

It should also be stressed that so far no detailed epidemiological study has been carried out and the health risk estimates like those presented in chapter 9, are only based on ex-ante risk modelling (Quantitative Microbial Risk Assessment) using dose-response functions from other parts of the world with other actors and partial immunities.

### **Sources of Health Risks**

From a participatory cause-effect analysis, farmers in both cities identified contaminated soils, inappropriate use of pesticides and polluted irrigation water as possible sources of health risks (Keraita et al. 2008a). In view of water quality, some farmers in Accra noticed increasing levels of pollution as perceived from its foul smell, solid waste in the water and its dark color. They attributed the pollution mainly to the failure of the local authority to properly collect, treat and dispose of wastewater. But they also acknowledged the common (irresponsible) local behavior, where solid waste, including faeces in polythene bags ('flying toilets') is dumped into drains and waterbodies. Similar reasons for water pollution were given by vegetable farmers in Kumasi who use urban streams for irrigation. However, more than 80% of farmers in Kumasi use shallow groundwater and on-farm ponds as sources of irrigation water. Although farmers considered the ponds to be less contaminated than the streams, they observed that when it rains, the shallow wells and ponds collect storm water from upstream villages and farms causing pollution, as the dugouts are not protected against inflow. In general, farmers easily associated wastewater irrigation with health risks in farming sites where polluted urban streams, household effluents and drains were used for irrigation. This awareness appeared, however, to be influenced by previous related interviews as well as media reports on the subject of pollution and food safety.

Soils were considered another health risk factor. Farmers in both cities observed that some soils were 'contaminated' naturally while other soils were affected by inputs that farmers use. In Accra, farmers closer to the sea said that their soils were increasingly tasting salty and hence becoming less productive. This was associated with natural salt intrusion from the sea. Contamination from poultry manure, which is extensively used as fertilizers in urban farms especially in Kumasi, was considered possible, and linked to chemicals that are used to sanitize poultry (farms) and not to microorganisms in the manure itself.

The perceptions of farmers differed to some extent by farmers' age, education and gender (Owusu et al. 2012).

**Farmers’ Knowledge of Measures to Reduce Health Risks**

To move towards risk mitigation, understanding farmers’ knowledge and perceptions on risk-reduction measures, particularly the factors they use to assess whether technologies are appropriate for them, is very important. This assessment of whether a measure is appropriate does not necessarily consist of an absolute ‘yes’ or ‘no’ answer. It usually consists of a ranking of the measures from more to less appropriate. Knowing how to elicit these perceptions, translate them into criteria for evaluating a risk-reduction measure and use them to rank alternative measures is crucial for working with farmers to jointly develop and assess risk-reduction measures with the potential for acceptance and adoption.

In a related participatory study, farmers were encouraged to identify suitable risk-reduction measures from their perspectives (Keraita et al. 2008a). Measures identified are presented in Table 10.5.

**TABLE 10.5.** Measures identified by farmers to reduce health risks in wastewater irrigation

Primary measures <sup>a</sup>	Secondary measures <sup>b</sup>
<ul style="list-style-type: none"> <li>· Provision of safer irrigation water like shallow groundwater</li> <li>· Protection of water sources</li> <li>· Treating water with chemicals</li> <li>· Filtration of irrigation water</li> <li>· Using boots when stepping in water sources</li> <li>· Treating soils</li> </ul>	<ul style="list-style-type: none"> <li>· Leaving water in irrigation sources to settle and not stepping inside</li> <li>· Applying water to roots, not on leaves</li> <li>· Using correct amounts of water</li> <li>· Stopping irrigation days before harvesting</li> <li>· Reducing soil splash on vegetables</li> <li>· Better timing of manure application and using the correct amounts</li> <li>· Using well-composted manure</li> <li>· Using gloves when applying manure</li> </ul>

<sup>a</sup> Measures initially identified by farmers only

<sup>b</sup> Measures identified following discussions with scientists

Source: Keraita et al (2008a)

These measures are very different from measures suggested by scientists, such as in WHO guidelines, like crop restrictions, conducting health programs and human exposure control. Scientists seemed to propose measures based only on their effectiveness to reduce levels of pathogens (WHO 2006), while farmers looked at the larger picture considering loss of yields, level of investment needed, loss of income and land tenure before they could propose measures. Generally, and maybe not surprisingly, farmers considered slight changes in their current practices and those, which required low investments, as most suitable for implementation. Similar findings have been reported in other studies done in resource-poor communities (Marenya and Barrett 2007; Avila and Jabbar 1992). The findings support the psychometric approach which suggests that lay people perceive risks multi-dimensionally,

which also affects risk management measures they put in place (Slovic 1987). Scientists thus need to start thinking multi-dimensionally and work much closer with farmers to develop appropriate and adoptable risk management measures.

Observations made from an anthropological study conducted among wastewater farmers in Hanoi showed that the use of protective clothing was gender-dependent (Knudsen et al. 2008). Women consistently wore more protective gloves and boots compared to men. The differences were mainly attributed to farming activities which were different between both genders, with men walking around the farms much more than women, and in larger need of light gear, if any, to reduce sweating. In fact, both groups felt that protective clothing constrained their work. These observations have also been made in studies conducted in Ghana among farmers dealing with wastewater and human excreta (Keraita et al. 2010; Seidu et al. 2009). In the Ghana study, which involved 138 vegetable farmers in Accra using wastewater, only 19% wore protective clothing, mainly boots and gloves, while irrigating (Keraita et al. 2010). In some cases, farmers wore protective clothing not because of health risks, but to protect them from cold and physical injuries (Knudsen et al. 2008).

### **10.3 Perceptions of Urban Vegetable Sellers**

#### **Knowledge About the Origin of Vegetables**

Sellers have different mechanisms for sourcing their produce. Some of them, especially urban traders, select their crops on the field and even harvest themselves, while others buy at distribution points where the source may not be known. In general, over 85% of the traders of exotic vegetables interviewed in Accra, Kumasi and Tamale were aware that their vegetables are produced from within the cities they live in.

#### **Benefits and Problems of Urban Vegetable Farming**

Over two-thirds of the 50 vegetable sellers in each city mentioned the following as benefits of urban open-space vegetable farming (in no particular order):

- Employment for farmers and sellers;
- Easy access to fresh vegetables;
- Reduced cost and time of transportation for sellers;
- Usually lower prices of vegetables (as transport costs are lower);
- Increased supply of vegetables on city markets (because of easy access);
- High profit through high turnover; and
- Ability to supplement family food intake (for traditional vegetables).

Owing to these advantages, sellers were supportive of agriculture within cities, and mentioned that city authorities should give it more attention. Half of the sellers interviewed in Accra<sup>1</sup> but only 8 to 10% in Tamale and Kumasi were aware of possible health risks associated with irrigated urban vegetable farming. When they were asked to specify the nature of any perceived risks, nearly all sellers in Accra but only half of those in Tamale identified irrigation with polluted drain water as the main hazard. They also mentioned that this could infect consumers with diseases (through vegetable consumption) but they were unable to specify what type of disease.

### **Perceptions of Vegetable Sellers on the Quality of Vegetables**

All sellers in Accra, Kumasi and Tamale are highly concerned about the physical appearance of their produce, which determines its 'quality'. Consumers buy only what looks 'proper' and anything short of this will mean loss of /income for the sellers. Thus, quality of vegetables was in this context associated with visible characteristics but not contamination levels. Vegetable sellers in all of the three cities have common criteria for evaluating the quality of vegetables which are size, shape, freshness of leaves, color, firmness of leaves (particularly with cabbage) and presence of spots, dirt, holes, etc. Buyers use the same criteria (see below).

Observations revealed that vegetable traders who buy on farm also wash these vegetables, mostly lettuce, in the local irrigation water (Hope et al. 2008). The main reasons given by vegetable sellers for washing vegetables on farm was to remove soil particles, insects and earthworms that are attached to leaves and roots. They said that this makes the lettuce more attractive and reduces its weight, which is important when the lettuce has to be carried to markets. Washing also helps to keep vegetables fresh, especially when kept overnight before selling. Lettuce intended for long distance transportation however was not washed because washing makes it 'soft' (flaccid) and induces rot faster during the long hours of transportation in intense heat, as it is not refrigerated.

### **Perceptions on Sources of Water and Influence on Purchasing**

Over 70% of the sellers interviewed in each city were aware of the various sources of water being used by farmers cultivating vegetables in the cities. However, sellers were not specific

---

<sup>1</sup> This awareness might be a reaction to the fact that only in Accra did the media target wastewater use followed by attempts by the authorities to prosecute farmers using polluted water for irrigation (see Obuobie et al. 2006).

about the quality of the various sources of water mentioned except for holding the general notion that pipe-borne water has the best quality because it is treated.

Between 20% and 50% of the sellers in the three cities said that they enquire about the geographical source (farm area) of the crop. This was particularly so in Accra where 88% of the sellers indicated that sometimes consumers ask about the source of vegetables or the water used.<sup>2</sup> In Kumasi and Tamale, the situation is rather different with less than 20% of the sellers being sometimes asked about the source. Asking about the 'source' is, however, not a direct indicator of risk awareness but can also be related to belief or experience that, for instance, carrots from Togo are better than those produced in Ghana without actually knowing the reason. In response to a direct question about what sellers think of vegetable production with wastewater, nearly all the sellers in the three cities replied (as expected) with negative opinions, indicating that consumers could catch disease from the produce. Nearly 30% of sellers in Accra and Kumasi thought that farmers involved in such practices should be stopped without any compromise.

When asked if they would offer higher prices for vegetables produced with 'good' quality irrigation water (like piped water), 76% of the respondents in Accra answered 'Yes', while only 14% and 28% in Kumasi and Tamale respectively, answered similarly. This answer showed again that the higher degree of public awareness in Accra can influence perceptions. However, sellers who were not willing to offer higher prices for vegetables grown with good quality water indicated that in practice this would result in selling vegetables at higher prices without having a corresponding demand as the normal customer is only interested in visual produce quality. This reply appears to be more insightful (see also Danso et al. 2002b).

#### **10.4 Perceptions of Urban Vegetable Consumers**

##### **Knowledge About Vegetable Sources**

The survey results showed that 60 to 94% of the consumers were aware that urban agriculture was the main source of their vegetables (94% in Tamale, 80% in Accra and under 60% in Kumasi). Awareness was higher in Accra and Tamale than in Kumasi because in Accra and Tamale vegetable farming is done mostly in the core areas of the city, close to urban dwellings while in Kumasi many of the vegetable farms are located at the fringe around the local university. However, it is impossible for customers to distinguish between vegetables

---

<sup>2</sup> However, no seller would reveal that her source might be an inner-urban place with questionable water quality.

grown on different farms or with different water sources as in wholesale and retail markets the products from different farms become mixed.

### **Benefits and Problems of Urban Vegetable Farming**

Like vegetable sellers, consumers had a similar perception of benefits and potential problems of urban vegetable farming in Ghana, including possible risks from polluted water. Consumers also mentioned that some urban farmers use agrochemicals incorrectly, which could also have health implications. On the question of how urban agriculture could be better organized, given the benefits mentioned, some of the consumers suggested that parts of government land should be allocated specifically for vegetable farming in the cities. They further mentioned that additional land could be acquired in peri-urban areas through negotiations with traditional authorities and farmers could pay a token fee to landowners.

### **Perceptions of Consumers on the Quality of Vegetables**

Most of the consumers interviewed in each of the three cities are concerned about the quality of the food. Consumers use similar quality characteristics as vegetable traders, such as color (greenish leaves represent good quality and yellowish represent bad quality), shape, cleanliness, freshness, having no spots and so forth. The standard discussion held with sellers concerned the price, not the origin of the produce or possible contamination. Anyway, it would be difficult to distinguish between likely contaminated and uncontaminated crops, and it is very unlikely that any seller would reveal a questionable vegetable source which could reduce the market value of the crop.

### **Perceptions on Sources of Water and Influence on Purchasing**

Though consumers' criteria for determining crop 'quality' do not include pathogen contamination, many consumers (45% in Accra, 40% in Kumasi and 58% in Tamale) – if directly asked – thought it important to know where the vegetables were produced in order to avoid contaminated produce. When asked if they would buy wastewater-irrigated vegetables if they had a choice, 75 to 96% answered negatively. Like sellers, consumers mentioned the risk of contracting diseases as the reason why they would not buy wastewater-irrigated vegetables. Others, however, thought that wastewater-irrigated vegetables could be cleaned adequately to remove any disease-causing organism. Consumers' reactions as to what they would do in a scenario where all vegetables on urban markets were grown with wastewater were analyzed too. Nearly 40% of the respondents in Tamale said they would clean

vegetables adequately and use them instead of avoiding them. At least 30% would either cultivate vegetables themselves or buy from rural areas. Between 60 and 80% of the respondents in Accra and Kumasi pointed out that they would prefer to stop buying vegetables from the market, though they could not say where they would go for safer produce. About 20 to 40% mentioned that they would adequately clean such vegetables.

However, these answers have to be taken with caution as knowledge about a problem does not automatically translate into a change of behavior. So far risk awareness is more ‘dormant’ and the crop quality criteria discussed between traders and customers only concern crop size, weight and clean (neat) appearance.

**Cleaning of Vegetables**

Cleaning vegetables at home and in street food kitchens is common. In a survey reported by Amoah et al. (2007a) over 90% of the consumers in Kumasi, Tamale and Accra said that they washed purchased vegetables at home, using a variety of methods (Table 10.4). However, tests in the laboratory showed that the common washing practices are not very effective in view of microbiological threats and require adjustments (see chapter 14).

**TABLE 10.4.** Common methods used by consumers to clean vegetables (Amoah et al. 2007a).

Cleaning method	% Respondents		
	Accra	Kumasi	Tamale
Washing with warm water in a bowl	55	53	51
Washing with salty water in a bowl	34	34	14
Washing with salty water and vinegar or potassium permanganate in a bowl	6	11	10
Washing with water and vinegar in a bowl	4	1	2
Washing twice with tap water or with water in a bowl	1	1	23

**10.5 Perceptions of City Officials**

Generally, the existence of agriculture in Ghanaian cities is recognized as there are bylaws regulating the types and number of crops and animals that can be cultivated or raised (AMA 1995, pp. 171-202). Though the bylaws do not specifically promote urban farming, they do recognize (the possibility of) its existence and seek to control it in order to maintain good sanitary conditions in the city (see chapter 15). Moreover, both the national and local

governments (district assemblies) have shown their recognition of urban open-space farming in two ways:

- Under the decentralization policy of the Ministry of Food and Agriculture, a Food and Agriculture Directorate for Accra District was established, which is responsible for agriculture and marketing within the city boundaries. The Directorate has its own extension staff responsible for open-space farming.
- Throughout the country, top district, regional and national farmers are annually rewarded (Figure 10.1), including those at the metropolitan level labelled as the ‘Best Urban Farmer’ or ‘Best Metro Farmer’ (Annang and Drechsel 2005).

However, as the following chapter and many other studies have pointed out for West Africa, and Ghana in particular, official recognition of urban agriculture is not reflected in city planning and development (Obosu-Mensah 1999; Drechsel et al. 2006). The planning of many Ghanaian cities is based on a master plan concept dating back to colonial administrators, which does not consider the category of urban farming, although the practice of inner-urban vegetable production probably started with the construction of the first European forts and castles in the sixteenth century (Anyane 1963).



Figure 10.1: Martin Kumah of Ghana during the award ceremony on National Farmers’ Day, 2004. In 1998, Martin Kumah was the Best Urban Farmer (Kumasi), in 1999, the Best Regional Aquaculture Farmer (Ashanti Region) and in 2002, the Best National Aquaculture Farmer. In 2004, he received the award for the first runner up in the most prestigious ‘Best National Farmer’ contest (Annang and Drechsel 2005; photo: courtesy M. Kumah).

As one of the Resource Centres on Urban Agriculture and Food Security (RUAF), for many years IWMI has facilitated (with the support of local and national partners) a policy dialogue<sup>3</sup> on urban agriculture in Accra (Amerasinghe et al. 2013). The work showed that officials interviewed in all major cities in Ghana usually acknowledge the importance of urban agriculture in providing food and jobs for unemployed urban dwellers or its contribution to preventing encroachment (housing, trade) on both government and private lands. Authorities also believe that vegetable production in and around Ghanaian cities contributes to the supply of vegetables, which improves the nutritional level of urban diets. However, in all cities, concerns were expressed that without proper monitoring open-space vegetable farming in particular can compromise the health of city dwellers. Most officials complained about possible crop contamination from two sources: untreated wastewater and inappropriate use of agrochemicals. Thus, although urban farming is increasingly recognized as an activity, it is not without questions, and also not among priority urban issues such as water supply, sanitation and waste management.

### **10.6 Perceptions of the Government**

In Ghana and Nigeria, urban [backyard] gardening was indirectly encouraged in the 1970s through programs like ‘Operation Feed Yourself’ and ‘Feed the Nation’, launched by respective governments. Despite several projects funded in the meantime, for example, by the Food and Agriculture Organization of the United Nations (FAO), the Department for International Development (DfID, UK), The Directorate General for International Cooperation of the Netherlands (DGIS) and The International Development Research Centre (IDRC) on urban food supply, the peri-urban interface and so forth, urban farming did not receive much political attention. A noteworthy milestone was the national policy seminar on ‘Urban and Peri-urban Agriculture’ organized in 2005 by RUAF as a follow up to a corresponding Multi-stakeholders Forum. The policy seminar was co-organized by the Ministry of Food and Agriculture (MoFA), the Science and Technology Policy Research Institute of the Council for Scientific and Industrial Research (STEPRI-CSIR), FAO and IWMI. The Honorable Clement Eledi, Deputy Minister of Food and Agriculture at that time, commented during the seminar that urban and peri-urban agriculture is a reality that has come to stay contributing to household income and poverty reduction. However, it also requires

---

<sup>3</sup> A challenge is that after any election with a change of the leading political party and its public sector representatives, the dialogue has to start again unless the topic is acknowledged in long-term plans and strategies.

strong leadership at both the local and national levels. The Minister promised that MoFA will ensure the provision of safe water for urban farmers and from 2006 on, MoFA would give an award to the *national* best urban and peri-urban farmer during the annual 'Farmers Day' celebrations. The seminar closed with a joint statement on urban and peri-urban agriculture, reproduced in Box 10.2.

**BOX 10.1. Statements of the Vision on Urban and Peri-urban Agriculture (UPA) in Accra**

- UPA plays an important complementary role to rural agriculture in contributing to food security, employment and income generation, especially for the urban poor.
- While contributing to livelihoods and food security, it is recognized that UPA faces numerous challenges and constraints such as limited availability of land, access to safe water and other production resources, and market constraints.
- There is the need to overcome current and emerging challenges facing UPA by coordinating all stakeholders, streamlining its operations and creating an enabling environment for its sustainability
- As urban population soars, the role of UPA in supplying perishable food to cities of Africa becomes increasingly important and needs a supportive policy and legislative framework.
- Overcoming the challenge calls for the recognition of UPA in the sector ministries and agencies and for policies to effectively integrate UPA in urban planning and development.

**Statement of Consensus**

We call for the promotion of a shared vision on UPA that takes into account the specific needs and conditions in the country and urge Policy makers, in partnership with Development Partners, to develop gender sensitive policies and appropriate instruments that will create an enabling environment for integrating and supporting UPA into our economies.

Endorsed on 13. 12. 2005 by the participants in the presence of Honourable Clement Eledi, Deputy Minister of Food and Agriculture.

A prominent example of the recognition of irrigated urban agriculture is Ghana's National Irrigation Policy which covers also the informal irrigation sector, including irrigated urban and peri-urban agriculture (see chapter 15). The importance of the informal irrigation sector is highlighted by the case of peri-urban Kumasi with about 12,000 hectares (ha) are under informal dry-season vegetable production which is twice the area under formal irrigation in the whole of Ghana (Cornish and Lawrence 2001).

## 10.7 Perceptions and Role of the Media

Like in other low-income countries, public services in Ghana are constrained by a variety of factors and remain far behind targets. In this situation, some media feel the obligation to point at problems the authorities should address. These 'appeals' are powerful instruments as they

steer public perceptions of problems. Consequently, authorities give them, whenever possible, priority attention. Sanitation and waste are ‘hot’ issues in Ghana, like other African countries, and are an easy target for the media. Due to the use of polluted drain water, irrigated urban vegetable production is frequently featured on TV and in the printed media (Figure 10.2).



FIGURE 10.2. Irrigated urban agriculture in the press in 2002 to 2005 (Ghana’s Daily Graphic).

Figure 10.2 shows the tension under which urban farmers have to operate in Accra and the pressure on the authorities. Although some journalists and media focus solely on problems, others looking for constructive solutions are on the rise. They could become crucial stakeholders in sustaining risk-reduction programs. They could assist authorities and consumers in giving public attention to, for example, farmers using safer irrigation practices while putting pressure on those not using them.

## 10.8 Conclusions

Urban irrigated vegetable farming in open spaces in Ghana is confronted with numerous constraints such as marketing, lack of input, low-quality water, limited credit/capital access, crop disease, low soil fertility and crop theft. Of these constraints, farmers identified and ranked lack of input, water access, crop disease and marketing, as the most important.

Farmers mentioned the importance of their water sources for continuous irrigation and income, but they do not wish to be openly associated with low water quality, owing to the media and some public criticisms, out of fear that such an association may possibly influence the sale of their produce and livelihoods. They do not seem unduly concerned about water contact-related health consequences and also do not appear to believe in other problems, given that according to many of them, they have rarely received complaints about the quality of vegetables they produce. In fact, although vegetable sellers and consumers are generally concerned about the quality of the food they sell or buy, their criteria of quality do not include invisible risks like pathogen contamination.

City officials generally recognized urban farming, but remain concerned about the irrigation water quality. Ghana's media nurtures these concerns. Though authorities oppose the use of unsafe water, alternatives are missing and to date they tolerate the practice, while expecting that one day the activity will be a planned and regulated so as not to compromise the health and well-being of city dwellers. Efforts to provide safer well water remained in many cases unsuccessful due to water salinity, the costs of drilling or tenure issues.

The levels of risk awareness shown by various stakeholders indicate that there is some degree of reflection about the practice, likely supported by media and also research attention. This is encouraging as educational campaigns could build on the interest of consumers, for example, to clean vegetables at home. However, large parts of the population lack an appropriate education to understand the risk and its pathways. The risk awareness of those with better education is probably 'dormant' and thus does not (yet) affect their decision making during vegetable purchase, probably for two reasons:

- The specific risk factor might not have priority (as other risk factors take attention, or as it is believed that the risk is under control);
- Health is in general a neglected incentive, as consumption habits generally show.

However, at least farmers appear to be increasingly interested in practical innovations for risk reduction and are ready to invest in them, but more to avoid pressure from the authorities and the media than based on risk perception.

## 11. Strengthening Urban Producer Organizations

Theophilus. O. Larbi, Olufunke O. Cofie, Philip Amoah and René Van Veenhuizen

*The chapter presents the process and results from a project implemented in Accra by the Resource Centres on Urban Agriculture and Food Security (RUAF) Foundation to strengthen farmers' organizations for innovative irrigated vegetable farming and marketing. One hundred urban farmers were organized into eight producer groups and trained on technical and organizational innovations along the vegetable value chain towards improved yield and income. Training was delivered through Urban Producer Field Schools (UPFS) on topics ranging from integrated plant production and protection principles, food safety and risk-minimization in wastewater use for irrigation to value addition for marketing. Farmers were also engaged in organized marketing, targeting niche markets.*

### 11.1 Farmers' Production and Organizational Development

In contrast to rural farming, urban farmer organizations in Ghana are less common and also less recognized by authorities. Probably as it is seen as a temporary land-use form urban and peri-urban agriculture (UPA) is neither valued for its multiple benefits nor accepted as formal urban land use and thus remains largely informal. The challenges urban farmers face (see previous chapter) include restrictive or prohibitive institutional policies and limited support, while internally farmer groups face a higher diversity of members, often including part-time or transient farmers which is not typical in rural areas. These farmers are therefore more difficult to organize and urban producers' organizations often remain loosely organized groups and informal networks. The formal producers' organizations are struggling with management and performance, for example Ghana's National Association of Farmers and Fishermen (GNAFF).

Urban producers have limited support and access to advice, training, credit and other resources. Without organizing themselves, low-income producers have little opportunity to improve their conditions. As individuals, they often lack access to production resources. Whilst they may find space to grow food for themselves and sometimes for sale, their options are severely limited while they act alone. Improving access to production factors, advice, training and so forth become achievable goals once urban producers become organized (FAO 2007). Next to improving their organization and production technologies, urban producers also need to enhance their income by engaging more directly in processing and marketing.

However, most projects and institutions working in micro-enterprise development and marketing are disconnected from the urban producers, often by mandate which focuses on 'rural' stakeholders.

## **11.2 Farmers' Indigenous Knowledge and Innovations**

Farmers have been innovating for centuries. In certain instances, their curiosity, creativity and experimentation have served as foundations for modern agricultural science and engineering. Innovating in the agricultural value chain provides solutions for increasing agricultural productivity and can generate answers to reducing poverty and achieving development goals. Farmers' innovations, however, need to be stimulated and often need to be improved through participatory innovation development processes (Critchley 2007). However, participatory technology development with farmers is more difficult in the urban context due to the variable farming strategies, less organization, diverse personal backgrounds and ongoing commitment to other jobs. The technical knowledge and skills of urban producers may thus be restricted or of less value (Prain and de Zeeuw 2007). However, urban producers may have other factors that are highly relevant for the innovation process such as a high degree of flexibility, mobility and resilience to cope with the risk of eviction. Against this background, it is understandable that good results have been achieved with approaches like Farmers Field Schools (FFS) that combine elements of training with experiential learning and experimentation. This chapter discusses the example of Accra as part of the global RUAF 'From Seed to Table' program (Amerasinghe et al. 2013) which used, among others, the FFS approach to facilitate innovations in the production systems of farmers, to improve their marketing and also to develop the organizational capacities of urban farmer groups.

## **11.3 From Seed to Table (FStT) Program**

### **The Conceptual Framework**

Based on thorough situational analyses of urban farming in 20 selected pilot cities worldwide a number of priorities for intervention and support were determined and these formed the focus of RUAF activities in pilot cities, like Accra, from 2009 to 2010. The main intervention areas for UPA development in Accra were capacity development in and support for:

- Strengthening of urban farmer groups and the networking between them;
- Participatory technology development, like in Integrated Pest Management (IPM) to enhance the productivity and sustainability of urban farming systems;
- Development of the marketing strategies for urban farmers and their organizations;
- Micro-enterprise development related to processing and packaging of UPA produce;
- Financing of urban farming activities.

The main aim of the FStT innovation project was to enhance the capacities of urban producers vis-à-vis farming system innovation in the context of a stronger market chain. Secondary goals were to enhance the benefits that producers receive from their agricultural activities, as well as to improve the sustainability of their farming systems. The main components of the FStT innovation project were:

- Technical changes in the farmers’ production and marketing systems;
- Strengthening of farmer group organization;
- Participatory monitoring and evaluation as well as systematization of lessons learned.

The technical changes were delivered through the Urban Producers’ Field School (UPFS) concept (Figure 11.1).

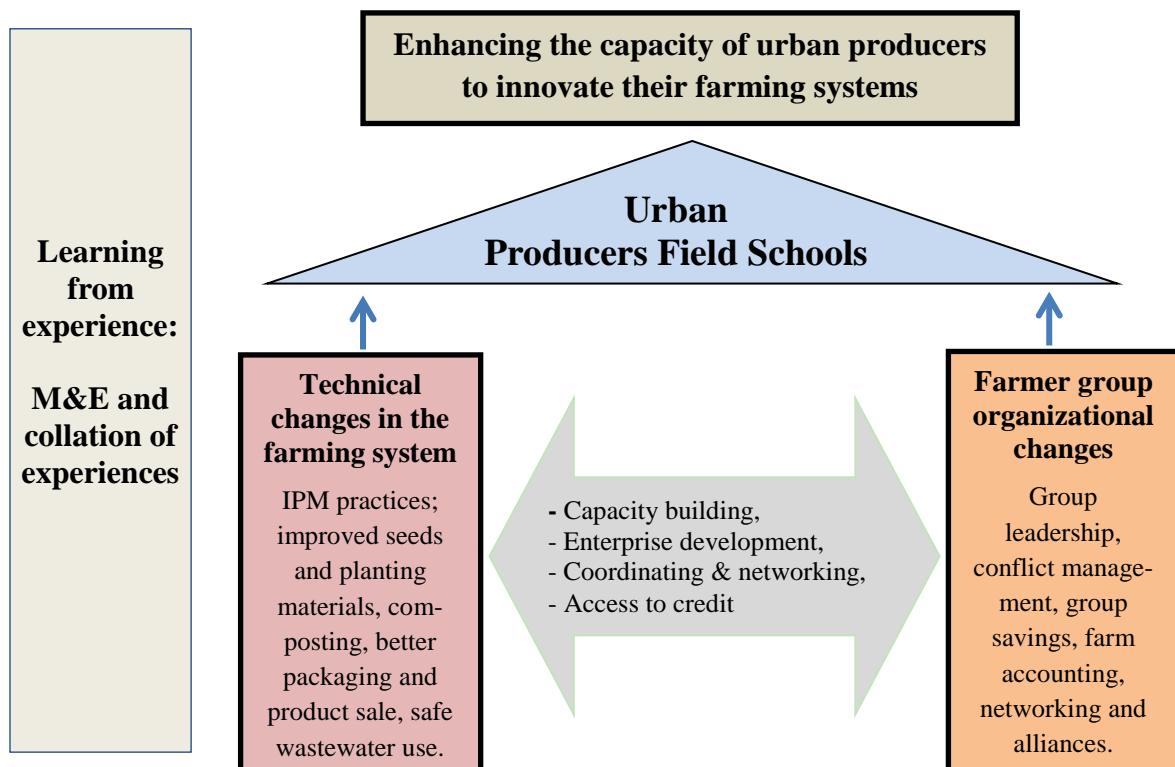


FIGURE 11.1. Main components of the UPFS concept.

### The RUAF FStT Methodological Approach

The FStT approach consisted of three main steps: diagnosis and local context analysis; the action planning stage; and the implementation, monitoring and evaluation stage (Figure 11.2).

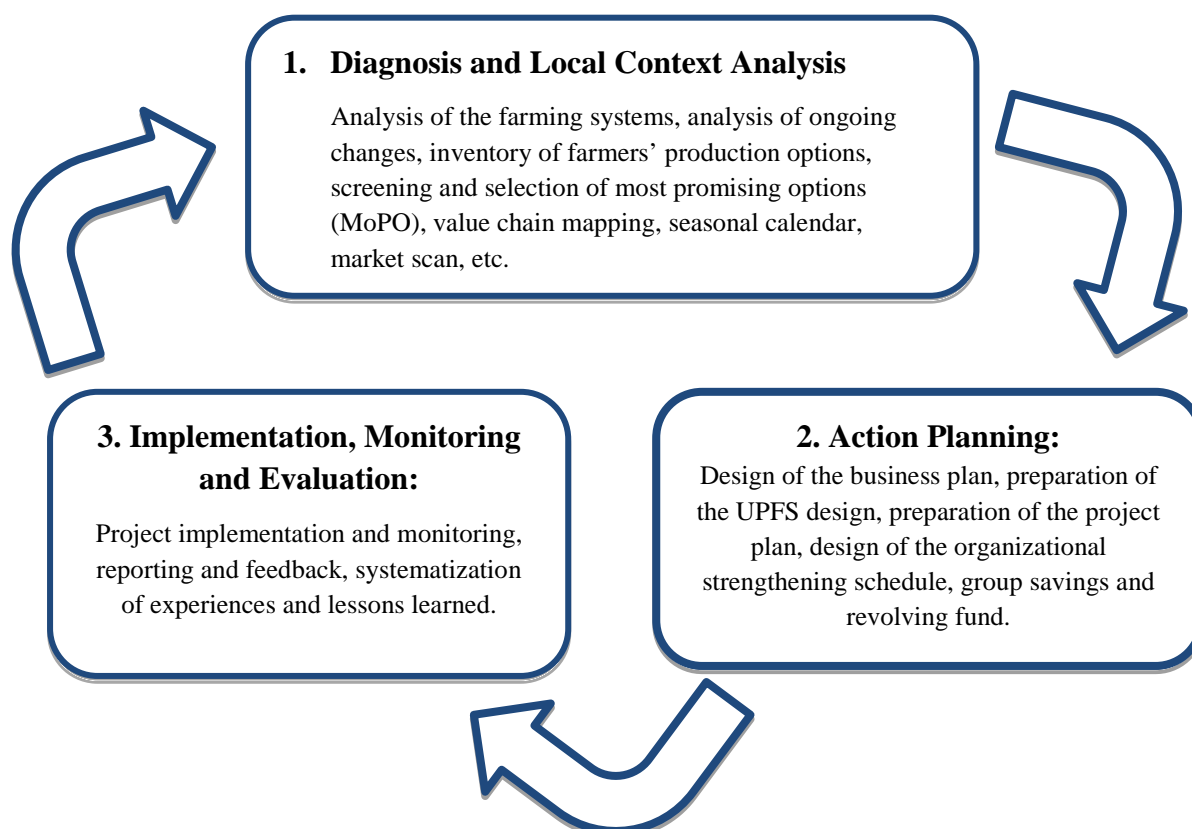


FIGURE 11.2. RUAF FStT methodological approach.

**Diagnosis and local context analysis:** Sample farmers from each of the subgroups, as well as key informants from different organizations and professional backgrounds related to UPA were interviewed to collect information on the farming systems and to document the major ongoing changes due to urbanization. Focus group discussions (FGD) with farmers and interviews with key informants were used. Secondary data were also reviewed and analyzed. A better perspective of the ongoing changes in urban farming due to urbanization in the target cities was thus obtained.

In the case of Accra, an inventory of farmers' production systems and technologies was conducted with about 30 farmers covering 11 crops (sweet pepper, cabbage, lettuce, spring

onions, carrots, cauliflower, white radish, spinach, mint, beat root, Chinese cabbage) using FGD. An inventory of potential innovations in these farming systems was obtained through interviews with subject-matter specialists. A market scan was conducted on the selected crops in both local/domestic markets and with restaurants/institutional cafeterias. A prescreening of crops with innovation potential was done covering criteria like innovation affordability and acceptability, ease of technology use, possible economic benefits, number of beneficiaries and availability of support services and land for production. Through this process, the 11 crops identified in Accra were reduced to five. Each of the selected five vegetables was then analyzed in detail for possible value chain improvements.

A final screening and selection of the MoPO was conducted with the farmer groups. Lettuce was selected by the exotic vegetable farmers in Accra and amaranth by those more interested in indigenous vegetables. For the selected crops more detailed information on market demand, pricing and distribution was collected. The value chains of the selected crops were mapped to identify strengths and weaknesses as well as possible market chain improvements. A seasonal calendar for each crop was developed with the farmer groups to have a better understanding of the production cycle of each crop and for planning the innovation project with the farmers.

The technical and organizational innovations in the product value chain of the MoPO were proposed and discussed with the various farmer groups for their final approval and commitment. Criteria for participating in the FStT innovation project were developed and discussed with the farmers. Agreements were reached on the next steps and willing and committed farmers were registered for participation in project activities. A total of 100 farmers were registered in Accra. As part of the process, an analysis of the farmer groups was conducted to identify the organizational issues for both the MoPO and the functioning of the groups. Training needs were identified for technical and organizational changes. Training areas included developing the group norms and constitution of the eight subgroups, facilitating the formal registration of the subgroups with the recognized government institution (e.g. the Department of Cooperatives in Accra for training the farmer groups on group processes [leadership and management skills, team building, group dynamics, conflict management]), resource management (accounting, financial management/group savings and revolving fund) and training the farmer leaders on networking and collaboration strategies.

**Action planning stage:** Information obtained during the diagnosis phase was used as the basis for defining concrete intervention areas for value-chain improvement of the selected crops. The technical innovations to be introduced along the value chain of the two crops became the core of the UPFS. Business plans for the production and marketing of lettuce and amaranth were developed with the farmer groups. The business plans detailed the steps to be followed in the organization of the production and marketing of the selected crops from seed to market, including economic analysis (costs/benefits), operational plans (activities to develop the value chain of the selected crops, formulation of the expected results and time frame), financing plans (budget, funding) and marketing plans (harvesting, packaging, distribution and sale). Schemes for the implementation of the business plans were also developed, comprising main objectives, activities to be undertaken, tasks and responsibilities, time schedules, budget, funding sources and a monitoring and evaluation (M&E) plan.

**Implementation, monitoring and evaluation stage:** Project implementation, monitoring and evaluation was done through a local team comprising representatives from the farmer groups, a local NGO [Enterprise Works] in Accra) and representatives from the local Ministry of Agriculture. Capacity development of the farmers' groups was conducted through the UPFS and direct training was based on the UPFS and group strengthening schedules. Specific monitoring indicators and the M&E framework of the project were developed for both outcomes and impact monitoring.

The local teams had monthly meetings to plan, report and receive feedback. Such meetings were also used to review the work plans and make adaptations where necessary. Lessons learned and experiences were documented and analyzed. Concomitantly, various funding mechanisms to finance farming and to sustain its development were explored through a credit study in Accra (see chapter 12). The initiative was to enhance the direct involvement of credit organizations to increase awareness and commitment to urban farmers' needs, and for multi-stakeholder fora through which principles of shared and participatory budgeting could be applied (among farmers' organizations, local governments, civil society groups and the private sector).

#### **11.4. Results and Outcomes**

**Capacity development:** The technical capacities of local team members, comprising farmer representatives and participants from the local NGO and Ministry of Agriculture in Accra, have been built in value-chain development as well as for adult learning and reflective

learning. They have also been trained on participatory data collection and analysis methods, participatory technology development principles, market analysis and work planning. Similarly, the 100 farmers in the city have been trained on technical innovations such as composting, seedbed and vegetable nursery management, sand-seed mixture to obtain uniform plant stands, IPM principles using *Azadirachta indica* (neem) extracts for example, on-farm risk minimization where the irrigation water is of questionable quality, alternative harvesting methods and techniques, and produce packaging.

The monitoring showed that farmers started experimenting with some of the innovations within their production and marketing activities, for instance seed drilling, use of compost, on-farm risk minimization techniques for polluted water use, IPM and so forth.

**Farmer group organizational development:** Before project inception, all farmer groups in Accra were loosely organized, if at all. The project helped them to change this, for example, by establishing functional executives and formal structures in terms of group regulations and a cooperative incorporation certificate from the Department of Cooperatives, which provides legal status (Figure 11.3). The group executives received training in group leadership and management, conflict management and team building.



FIGURE 11.3. Farmer group executives from the Plant Pool receive their cooperative group regulations and registration certificate from the Accra Metro Cooperative officer (left). (Photos: IWMI)

**Improved production infrastructure and marketing:** As a result of the improvement in the internal organization of the groups in Accra, entrepreneurial abilities and awareness of market-oriented approaches have been enhanced. This, in combination with the enhancement of their technical capabilities, has led to the exploration of niche markets for their produce. The value proposition of the farmers was based on produce safety (via wells or piped water

for irrigation), safe on-farm washing and the use of a packaging shed for protecting produce against sunlight and flooding. The project piloted the establishment of two dedicated sales kiosks and a packaging shed on one farm (Figure 11.4) but did not have the capacity to assess and support their institutional sustainability (ownership, location strength, etc.) to maintain their function over time.



FIGURE 11.4. Sale kiosk at the University of Ghana, Legon, Accra (left) and a crop cleaning and packaging shed at the Plant Pool site, Dzorwulu, Accra (right). (Photos: IWMI)

### 11.5 Lessons Learned and Conclusions

Ensuring the sustainable intensification of urban agriculture means converting to best practices from IPM to safe irrigation. Farmer Field Schools offer a well-established approach for the introduction of innovations. The most promising innovations included micro-enterprise development and helping farmers with direct marketing of their produce (farm sales, farmers’/producers’ kiosks, direct sales to shops, restaurants and supermarkets).

The first step required to strengthen urban producer groups is to develop concrete and specific visions and objectives for the groups that should be reviewed periodically. Joining forces with other groups or organizations with similar objectives to establish strategic alliances or umbrella associations helped to improve group ability to influence decision making and access resources. Major support was however needed to strengthen group formation and cohesion, leadership and conflict management capacities. External facilitation has to be initiated to deal with power struggles, mistrust and conflicting interests within the producer groups, making training of trainers crucial. Irrespective of this, smallholder urban farmers need to be organized or they will lose out to larger commercial farmers, especially in

accessing high-value markets. Similarly, in order to access and compete in the high-value markets, producer organizations should add value and be innovative in their production and marketing strategies.

Some key lessons were:

**Social mobilization potentials:** Trust building among the groups is important. Facilitating structures that build trust, inculcate common group values and a shared vision, goals and rules can improve the social capital of the groups. Farmers' capacity to organize and mobilize for social events (marriages, bereavements, hospitalization, etc.) offers important opportunities for team building. Harnessing such potential for farm activities has the potential to improve the performance of the groups tremendously.

**Strategic networks and alliances:** The farmers' capacity to negotiate and influence policies and attract strategic attention can be improved by forming intra-group alliances and linkages with strategic partners. These alliances could be forged with other agricultural formal and informal associations to form an 'umbrella organization'. In this way they can gain more political weight and recognition to participate in decision making and policy formulation. Through project intervention the three groups supported in Accra started to collaborate and decided to implement joint actions. This initiative could be taken up with other producer groups like the La Farmers Association, Marine Drive Vegetable Farmers and the Korle-Bu Vegetable Group to form a bigger alliance.

**Stakeholder policy platforms:** The multi-stakeholder platforms established earlier through the RUAFA 'Cities Farming for the Future' program (Amerasinghe et al. 2013) appeared to be very instrumental for strengthening the urban producer groups. The farmer groups are members of these platforms which allowed them to interact with governmental, nongovernmental and private sector stakeholders for information sharing on best practices, market information, food safety and regulations. One of the outcomes of this dialogue was the piloting of a sales kiosk directly at the 'Ministries' compound in central Accra.

## 12. Options for Local Financing in Urban Agriculture

Irene S. Egyir, Olufunke O. Cofie and Marielle Dubbeling

*Access to debt financing (credit) is crucial to the development of urban agricultural production, processing and marketing activities. This chapter is based on a 2009 study<sup>1</sup> carried out in Accra to assess the practices of institutions and programs that could finance urban agriculture as well as the existing bottlenecks and opportunities in financing. Information is based on surveys involving 179 respondents sampled from financial institutions; urban farmers (not limited to vegetable farmers), traders and processors; literature reviews, stakeholder mapping; focus group discussions; key informant interviews; and a validation workshop.*

### 12.1 Financing Urban Agriculture – an Overview

Many studies in Ghana and other developing countries have shown that agricultural producers in general have only limited access to credit and finance (Hollinger 2004). The internal factors limiting credit access are lack of collateral due to lack of or poor quality of farm assets, lack of ownership of assets for women farmers, poor financial management, the risky nature of farming and the inability of clients to prepare viable project proposals. External factors are high interest rates, high cost of service delivery to the sector and perceptions that financial farming services providers afford high risk. Following the liberalisation of the financial sector in the early 1990s, the share of agricultural credit in total bank lending initially fell from the mandatory 25% to about 10% before recovering to 12% in 1998. According to the Bank of Ghana Statistical Bulletin, share of agriculture and forestry in the outstanding credit balance of money deposit banks (MDBs) in December 2005 and 2006 were 7% and 5% respectively. This is an indication of a low and deteriorating level of credit supply to the agricultural sector (MoFA, 2007).

The situation is worse in urban areas; this is where all the different types of financing institutions are, yet the available financing products/services are not adapted to the specific conditions of poor urban producers. Moreover, most available loans and subsidies are primarily focused on the production phase of the urban agriculture cycle – growing crops or

---

<sup>1</sup> Egyir, I.S. 2010. Applied study on local finance for poor urban and peri-urban producers in Accra, Ghana. Report submitted to the International Water Management Institute (IWMI/RUAF), Accra [www.ruaf.org/sites/default/files/Applied%20study%20on%20local%20finance%20for%20urban%20producers%20in%20Accra%20Ghana.pdf](http://www.ruaf.org/sites/default/files/Applied%20study%20on%20local%20finance%20for%20urban%20producers%20in%20Accra%20Ghana.pdf)

raising animals – and few instances are found in subsequent phases such as (value-adding) processing and marketing of agro-products (for conventional markets as well as for innovative market niches such as ‘fair-trade’ or ‘biological products or by direct sales to consumers (farmers’ markets, pick-your-own fruit, home delivery schemes).

Several studies carried out in Ghana to understand why people are marginalized in the financial system discuss the case of women and how to improve access (Akudugu et al. 2009; Egyir 2009; CMA 2008; and Onumah 2003). Limited access to credit is a key source of inefficiency that hampers trade and productivity enhancement. All the research mentions lack of collateral as the major contributor to the access problem. Other factors mentioned are lack of efficient storage facilities, poor transport, poorly developed systems of standard grades and measures and unreliable market information systems (Onumah, *ibid*).

Due to the profit maximization goal of formal financial institutions any strategy that will not show a physical gain in the future is likely to be avoided. Lending to the entrepreneurial poor in urban agriculture may not be an option if the producers are not able to demonstrate that they have adequate capacity to mobilize resources for sufficient levels of production. Without support, such people remain under-empowered, both economically and socially. Economically, such people when engaged in agriculture rely mainly on natural resources such as rainfall. In the urban areas where treated water is expensive farmers who cannot afford it use wastewater as the key input for production; they have scant recourse to sophisticated machinery and improved seed; the quality of packaging materials is poor; and efficient postharvest handling and distribution processes are absent. Their sales are low so they have low income generation and cannot accumulate adequate savings, acquire assets or contribute to cooperatives when they join one. As they cannot contribute when they become members of cooperatives (or community-based organizations), they shy away from such groups and thus diminish their social empowerment. If urban producers would join legitimate and functional producer organizations they would improve their social capital and eventually obtain easier access to finance.

## **12.2 The Current Situation of Financial Institutions in Accra**

In Accra, universal banks dominate the operations of the financial system; there are also savings and loans companies, financial NGOs and projects, credit unions and rural/community banks. According to the register of licensed institutions, the Bank of Ghana showed in 2013 that after two decades of the Financial Sector Adjustment Programme

(FINSAP), there are twenty-seven (27) universal banks (also referred to as the traditional commercial/development banks), 135 rural banks, and 58 non-bank financial institutions, which include 25 finance companies, 24 savings and loans companies, 3 credit reference bureau, 2 leasing, 3 finance and leasing and 1 mortgage finance company (<http://www.bog.gov.gh/>).

The Ghana Microfinance Institutions Network (GHAMFIN) was established in 1998 to act as an umbrella organisation for currently about 80 regulated and non-regulated microcredit institutions which is however only a small fraction of the various microfinance institutions in the country. Most financial institutions were established between the 1980s and 2000s, especially after FINSAP was inaugurated in 1987. The vision, mission and objectives of all the financial institutions point to “provision of efficient service and stakeholder satisfaction”. However, the financial NGOs and rural banks specify that their core business is to contribute to the development of the marginalized<sup>2</sup> and poor (Box 12.1) although there is expected economic return on any loan offered. "Institutions with microfinance products are not charities; the funds they operate belong to share holders who expect returns on their investments" (Bank Manager, La Community Bank).

*Box 12.1: Generally, microfinance encompasses the provision of financial services and the management of small amounts of money through a range of products and a system of intermediary functions that are targeted at low income clients. It includes loans, savings, insurance, transfer services and other financial products and services. Microcredit is thus one of the critical dimensions of the broad range of financial tools for the poor (Asiama and Osei 2007).*

Clearly, the major objective of the banking institution is to minimize risk as much as possible. Rawlinson and Fehr (2002) observed that there is conflict between achieving maximum development impact and attaining profit. “As with any company, the bottom line of sustainability through profit comes first, and development must take second place as a priority” (ibid). It is noted that many of the institutions do not have any external support in the form of finance or infrastructure development. Funds are obtained from “shareholders, the bigger banks or Bank of Ghana or generated from deposits, savings and interest on loans and

---

<sup>2</sup> An example is ECLOF (Ecumenical Church Loan Fund) with its Ghana office in Accra which is the practical arm of the ecumenical community and reaches out through its network of churches with a focus on financing the development of people who have been economically and socially marginalized, independently of their particular faith ([www.eclof.org](http://www.eclof.org)).

on-lent to clients (Manager, UniCredit)". There are a few (10%) institutions with external support but they also believe that "in order to sustain oneself in the competitive market and improve the life of clients consistently we need to strive to become the preferred 'bank' of choice in future" (Executive Director, ECLOF Ghana).

All the financing institutions are conscious of the riskiness of small businesses; business related to primary agriculture – the cultivation of crops, rearing of livestock and fishing – are deemed the riskiest. Some stakeholders believe that, "our company has suffered greatly by lending funds to pineapple farmers in Nsawam. A large percentage of that loan remained unpaid for a long time and was written off. The farmers claimed the weather failed, they had poor yield, their buyers failed to pay back and they just will not make any effort to also pay the bank" (Manager, Women's World Banking, Madina, Accra).

Agriculture in Ghana is perceived to be the highest-risk business because the management of water, soil fertility, pests and diseases is rarely dependent on improved technology. Dependence on natural rainfall and climatic elements makes production seasonal and the fresh produce highly perishable. Without effective soil fertility, weed, insect, disease and other pest control management, yields and the quality of produce remain low. This situation results in low farm income, particularly when the market prices cannot be controlled by farmers themselves and the amounts offered are low. In the survey, although all the microfinance institution (MFIs) (i.e. the savings and loans companies, credit unions and financial NGOs) agreed that they do not discriminate against farmers, they also added that farmers were not their preferred choice. They give loans to farmers who have title to land and can show regular flow of income. Indeed, about 90% of the universal banks (Agricultural Development Bank, Ghana Commercial Bank, Barclays Bank, etc.) located in and around Accra admitted that they have never given any loans to smallholder farmers in the area. Most microfunds have been lent to traders of food commodities – retailers of eggs, vegetables and grains.

Many of the firms preferred to finance urban agricultural commerce – sale of vegetables, foodstuffs and eggs under their 'microfinance schemes'. They avoid primary agriculture. Only three out of the 37 financial institutions surveyed had special loan products for agricultural activities in the city (Table 12.1). The three institutions that offered credit to urban producers included ECLOF Ghana, ProCredit Ltd. and the Micro Finance and Consultancy Services (MFCS) project. The producers were vegetable and livestock farmers and fish processors. Two of the three provided figures for the 2009 financial year. The total

value of credit provided by them was about USD49 643 (GHC<sup>3</sup> 69,500) and served only 46 farmers.

**TABLE 12.1.** Agroloan products of financial institutions.

Financial institution	Name of product	Value of loans in 2009 (GHC)	Value of loans in 2009 (GHC)	Type of producer	Number of producers
ECLOF Ghana	Akuapa	10,714	15,000	Poultry farmers and fish processors	20
MFCS project	Multi-agro loan	13,929	19,500	Vegetable and poultry farmers	26
Total		24,643	34,500		46

Source: Survey data, 2009 (USD1.00 = GHC 1.40 at time of survey).

### **ECLOF's Akuapa loan**

The Akuapa loan was created in 2009 and it served next to many other farmers and traders also 20 urban farmers in Accra. The lowest loan offered was GHC200 and the highest was GHC800 (USD 570). All the clients were given seven months to pay back the loan, they paid 4% per month as interest and another 3% per month as insurance. Each of them belonged to a group of five. At the time of discussion, 60% of the loan had been paid, about 30% had defaulted on repayment for one month; as the period of repayment was not up delinquency was not anticipated. Part of the principal loan amount and interest was collected each fortnight (range = GHC20-80). About 50% of the clients did not keep to the scheduled payment dates but paid at their own convenience.

### **The MFCS Multiple Agroloan**

The MFCS agroloan was offered to two groups of farmers in 2009 – the Dzorwulu Vegetable Farmers Cooperative Society and Sowutuom Poultry Farmers Group. The project specified a loan ceiling of GHC500 (USD 357) per person, therefore members could not apply for any higher amount. However, if a member applied for an amount lower than the ceiling figure the balance could be given to a group member who had requested more. Each of the group

<sup>3</sup> The Ghana cedi (currency sign: GHC; currency code: GHS is the unit of currency of Ghana. The new Ghana cedi was introduced on 1 July 2007 at a rate equal to 10,000 old cedis. In the literature both abbreviations (GHC and GHS) can be found.

members was given a one-month moratorium, six-month repayment period, one-month default deferment after the six months and reprieve for 'within-period defaults'. The latter means that if one did not make payments on due dates, no penalties were considered. The project required group guarantee, individual guarantors and records of key activities (production volume and expenditure, sale, key purchasers, key market centers) of the past year.

A special product was developed for poultry farmers because the GHC500 was deemed inadequate in the context of the procurement cost anticipated for the end-of-year season. In October 2009, they were granted GHC1,000 each for a three-month (no moratorium) period. They were required to show evidence of bank savings or checking accounts apart from the personal guarantors provided. Only two out of the six parties did not default on repayment; two of them defaulted throughout the period and made the total payment a fortnight after the expected final repayment date.

#### **Other Financial Services**

Savings, insurance and remittance finance services are available; savings is well-known and critical to micro-entrepreneurs, including urban agricultural producers. There is no indication of the practice among urban producers. There is minimum barrier to savings in both the formal and informal sectors. Apart from financing NGOs, all the financial institutions surveyed offered savings, insurance and money transfer services.

### **12.3 Bottlenecks in Financing Poor Urban Farmers**

There are three constraints that slow down or stop urban farmers from easy access to financial services, especially loans from the formal financial sector: farmer characteristics, organizational capacity of financial institutions and the macro-environment. The study found that irrespective of whether short- or longer-term financial support was required, farmer characteristics are the primary constraint to financing.

#### **Personal Characteristics of Urban Farmers**

Urban vegetable farming in Accra is dominated by adults of between 24 and 68 years of age. Men (95%) dominated farming and women (99%) dominated commerce. Many have religious affiliations (Christianity or Islam) and many are migrants (Table 12.2). With respect to residential location, many urban producers are tenants in low-income areas of city suburbs.

A few who claim they live in their own accommodation described incomplete buildings or makeshift (wooden) structures on parcels of land that belong to the government or families in the diaspora; some of the structures are on lands under dispute.

**TABLE 12.2.** Summary of specific conditions of poor urban farmers.

Characteristics	General situation		Remark
	Frequency	Percentage	
Residential status			Diverse
Migrant	76	65	
Indigenous	41	35	
Major occupation			Urban agricultural producer
Agriculture only	105	90	
Agriculture plus other	12	10	
Technologies employed			Mixed technology
Traditional inputs	117	100	
Modern inputs	97	83	
Mobile phone	117	100	
Both traditional/modern	97	83	
Scale of operation			Micro-enterprise
Micro	116	99	
Small	1	1	
Type of business (%)			Business depends solely on one person
Sole owner	116	99	
Partnership	1	1	
Membership of formal producer organization (%)			Weak networking / interdependencies
Yes	20	17	
No	97	83	
Gross income/month (USD)			Low to moderate compared to the minimum wage of USD 470 per month
140-400	88	75	
400-500	25	22	
>500	4	3	
Access to finance (2008/2009)			Informal finance
% Formal savings	6	5	
% Informal savings	12	10	
% Received formal credit	6	5	
% Received informal credit	70	60	
% Engaged in insurance	0	0	
% Received remittance	6	5	

Source: Survey data, 2009 (Egyir, 2010).

Even though many of them owned mobile phones, indicating that they could be reached at any time, there is a growing phenomenon that can be described as *if you do not want to be*

*disturbed by those you owe, change your mobile phone chip.* It is very easy to do this in Ghana; chips are not registered and it costs less than USD1.00 to replace one.

In short, the urban agricultural producers, like many urban poor workers, have no permanent address. Agricultural production was the full-time occupation of a significant share of the respondents, while others had small side jobs, depending on traditional technologies with few associated benefits. Although exotic vegetables can lift them out of poverty (see chapter 4) others earn less than the minimum daily wage of USD2.91 (May 2013). Such low earnings are partly because many urban agricultural producers are not involved in wholesale trade. Many of the farmers sell on farm and depend on prices offered by their client traders (see chapter 3).

This implies that urban agricultural producers are high-risk cases. They have no permanent address, inconsistent flow of income and operate in weak networks. Aryeetey (2005) observed that projects with high repayment rates often include an appropriate sociocultural environment, that is, the population is not transient, which helps to reduce default as social sanctions are strongest in a stable population.

Urban farmers mostly associate with the informal financial sector. In 2008/2009, many (60%) respondents received credit from informal sources, usually, friends, relatives and trading partners. Danso and Drechsel (2003) observed that “while many agricultural activities in Ghana are financed either by the government or by external aid, the urban farmers producing for the market usually have to rely on self-financing (own funds) to start their businesses, or rely on credit from market women for the purchase of inputs (especially seeds and agrochemicals; see chapter 3).

In the 2009 study only six (5% of) respondents confirmed that they received credit from formal sources of finance such as savings and loans companies and microfinance NGOs. They obtained GHC500; about 30% required more than 50% of the amounts they obtained but they were rationed. Lenders of credit are cautious about default so apart from sharing only what is available, some borrowers are denied the total amount applied for to minimize risks.

The precautionary measures that lenders adopt in order to minimize the risks of default include screening of borrowers to ensure that those who cannot repay are excluded; creating incentives for successful borrowers to be able to repay; and developing various enforcement strategies to ensure that those who are able to repay do so (Nathan et al. 2004). Indeed, the

six producers mentioned earlier were successful because they were prepared to save before the credit offer; they showed evidence of permanent business premises and provided guarantors whose income-generating capacity was high. In communities where micro-entrepreneurs have shown a high level of discipline and credit worthiness a higher access rate has been recorded. Akudugu et al. (2009) reported that about 81% of rural women farmers who applied for or demanded credit from rural banks in the Upper East region of Ghana were successful in their credit applications or demand.

When producers were asked to list obstacles to formal credit access, they listed elements that showed that improvement in the system lies primarily with the producers themselves: poor business management skills and returns, inadequate knowledge of the financing system, high number of dependents and expenditure points, illiteracy, wrong perceptions about financial institutions and compulsory participation in producer organizations (Table 12.3). The ‘difficult financing terms’ (long processing period, group membership, short repayment period and in particular high interest rates between 10 and 60% per annum, average 37.6% in 2009) can be attributed to financial institutions. Nonetheless, high-risk borrowers cannot be given easy terms (Arnoud et al. 1991). At other times clients give erroneous information which needs to be clarified before the process is completed.

**TABLE 12.3.** Obstacles to accessing formal credit for poor urban producers.

<b>Obstacle</b>	<b>Rank (perception of researcher)</b>
Poor business management skills and returns	1
High number of dependents and expenditure points	2
Inadequate knowledge of the financing system	3
Illiteracy of producers	4
Difficult financing terms offered by institutions	5
Wrong perceptions about financial institutions	6
Refusal to join or contribute to group dynamics	7

Source: Survey data, 2009.

The general indication is that even informal units deal with specific groups of people, ensuring that only those who can satisfy distinct selection criteria are able to either deposit with or borrow from them (Aryeetey 2005). Projects with high repayment rates often include many procedures: training programs for participants; nonsubsidized interest rates; integrated formal written membership requirements and screening measures; criteria in their bylaws to ensure discipline among members; a savings program concomitantly accompanies lending; and an appropriate sociocultural environment, for example a fixed population, which helps to reduce default as social sanctions are strongest in a stable population (Aryeetey 2005).

### **Organizational Capacity of Financial Institutions**

Financial institutions are profit-making ventures. This means that they monitor phases such as return on investment, return on equity, turn over, debt, growth, success and sustainability. Projects with high repayment rates will be preferred. If high repayment is to be achieved among poor urban agricultural producers then activities such as training programs for participants and facilitation of producer groups to ensure that they integrate formal written membership requirements and screening measures in their bylaws to ensure discipline among members are introduced.

The default rates recorded by financial institutions that have micro-credit schemes are high at about 29% (Table 12.4); those with high recovery rates (say 75%) use the collateral or cash guarantee system. They follow the principle of high outreach activities and drive towards self-sustainability (Aryeetey 2005). Financial self-sustainability is achieved when the return on equity, net of any subsidy received, equals or exceeds the opportunity costs. Outreach is measured on the basis of the types of clientele served and the variety of financial services offered, including the value and number of loans extended, value and number of savings accounts, type of financial services offered, number of branches and village sub-branches, percentage of the total rural population served, real annual growth of the institution's assets over recent years and participation of women as clients.

Most of the financial institutions have the technical capacity to train and carry out the facilitation processes. However, the cost of sustaining such programs which is expected to be fee-free cannot be sustained by the institutions. Many of the institutions that provide these facilities have grants and other social support for a brief period. If that external support is lacking the only option left is rationing – full or partial. Most of the financial institutions admitted that less than 70% of what clients demand is granted. The reasons are numerous

(also observed by CMA 2008) (see Figure 12.1): that the expected return on clients' investments was lower than declared; low savings capacity of clients; poor repayment history; poor social record; low show of client commitment to financial education and counseling prior to loan supply and refusal to show all necessary documents requested.

**TABLE 12.4.** Distribution of loan recovery and default rates of financial institutions.

Variable	Frequency	Percentage
<b>Loan recovery rate</b>		
40-50	3	8.1
51-60	2	5.4
61-70	1	5.4
71-80	12	32.5
81-90	10	27.0
90-100	8	21.6
Mode		75%
Mean		79.8%
Standard deviation		15.5%
Minimum		40%
Maximum		100%
<b>Default rate</b>		
<21	19	51.4
21-40	7	18.9
41-60	9	24.3
61-80	2	5.4
Mode		10%
Mean		29.0%
Standard deviation		20.6%
Minimum		0%
Maximum		72%

Source: Survey data, 2009.

When clients are not able to show in full all the necessary documents required (pay slip, bank statement, guarantors' identity cards among others), firms reduce the risk of slow pay back by rationing. Formal financial institutions also ration credit when they are overwhelmed by applications. Each bank may lend an amount equal to its excess reserves and not more. When the applications are excessive or the amounts requested are high the bank naturally reduces the amount offered.

**The Macro-environment of Poor Urban Farmers**

Ghana’s macro-economy is characterized by high inflation (over 10% for the past decade), a falling cedi, high unemployment rates, high balance of payments deficits and low economic growth (about 6% in the last decade). The situation though said to be improving in the last few years, constrains financial institutional practice (Acemoglu et al. 2003). The current practices of local financial institutions can be traced to the liberalization of Ghana’s financial sector in 1987.

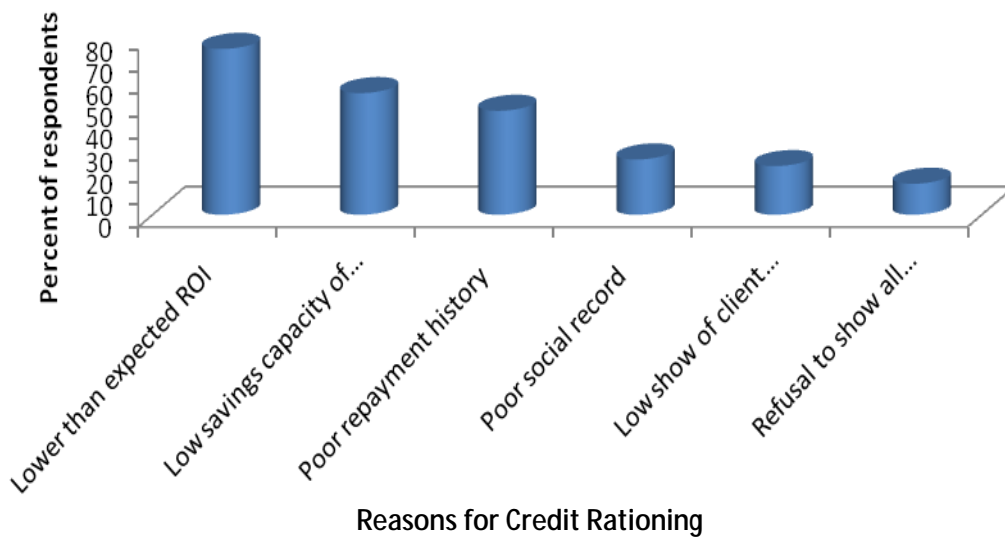


FIGURE 12.1. Reasons why financial institutions refuse full loans.

Source: CMA (2008).

The liberalization strategy was part of the broader FINSAP; it led to the entry of new banks and nonbank financial institutions (NBFIs). As part of FINSAP, controls on bank interest rates were removed; capital bases, management and accounting information systems were also strengthened. In addition a legal and regulatory framework with effective supervision by the central bank, Bank of Ghana (BoG) was put in place. This means that the minimum capital requirements of the bank and NBFIs are reviewed from time to time and this can affect the outreach of financial institutions; banks tend to be protective and minimize risk.

A key macro-environmental factor that serves as a bottleneck in credit access is poor road surface condition and inadequate road networks. This limits branch establishment and

outreach. The mobile phone allows for information and communication technology (ICT)-based transactions but the registration system is not effective. The law stipulated that by July 2011, all individuals should have their phones registered. However, the cost of replacing a chip remains low.

#### **12.4 Opportunities for Financing Urban Agriculture**

The aforesaid factors suggest that there are opportunities for financing urban agricultural producers: financing institutions exist, producers' demand is expressed, political will is there, the macro-economic indicators are improving and the sociological and technological environment can be addressed.

**Presence of financing institutions:** There is a liberal financing system and there are several financing institutions with micro- and small financing schemes: all the financing institutions encountered have small and medium enterprise [SME] banking and microfinance desks (small loans units). A few have specific products for agriculture so with further sensitization and negotiation the special cases of urban agricultural producers can be packaged. The financial institutions recognize that as part of social responsibility well-organized urban producers' associations can be offered certain communal inputs as they often do towards the Farmers Awards Day in December each year.

#### **Producer Financing Needs Can Be Determined**

The financing needs of urban agricultural producers can be determined. The examples of vegetable farmers and poultry farmers are shown in Figures 12.2 and 12.3.

Concerning recent trends in the financing of vulnerable groups in Ghana, since the era of women's empowerment in the early 1980s and that of inclusiveness in the first decade of the twenty-first century, micro-finance for the rural poor and women has increased. Women and the poor who belong to credible groups have benefited from public financing projects with relatively low interest rate such as the Governmental Micro Finance And Small Loans Centre (MASLOC) and the Support Programme For Enterprise Employment And Development (SPEED), NGOs such as Sinapi Aba Trust and savings and loans companies such as ProCredit Ltd.. Urban farming was assumed to be a hobby and insignificant in terms of business activity. With the study's demonstration of the income-generating capacity of the venture, like open-space vegetable farming, nothing should stop these activities from being assisted by financing institutions.

Improvement in the political, economic, sociological and technological environment in the past decade is an opportunity for improved financial systems. Countries pursuing poor macro-economic policies and with weak institutional capacity, including political institutions that do not constrain politicians and political elites, ineffective enforcement of property rights for investors, widespread corruption and a high degree of political instability suffer from slow growth (Acemoglu et al. 2003).

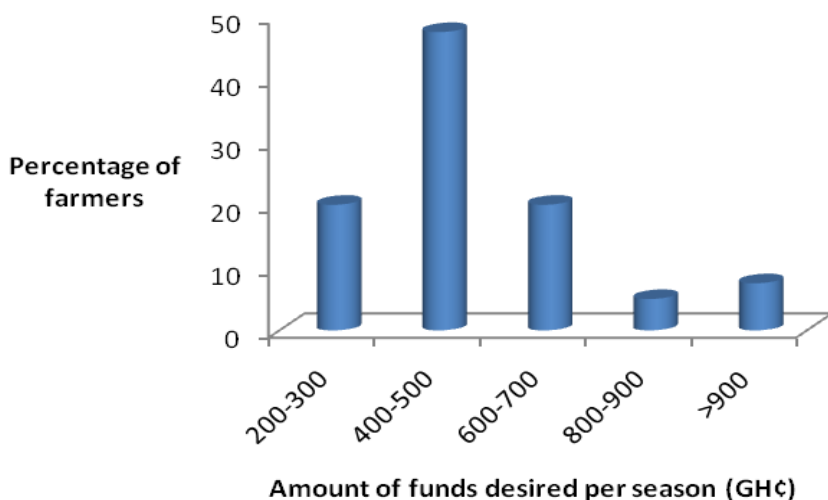


FIGURE 12.2. Seasonal demand for credit by vegetable farmers in Dzorwulu, Accra, in 2009.

Source: Survey data, 2009 (USD1.00 = GH¢1.40).

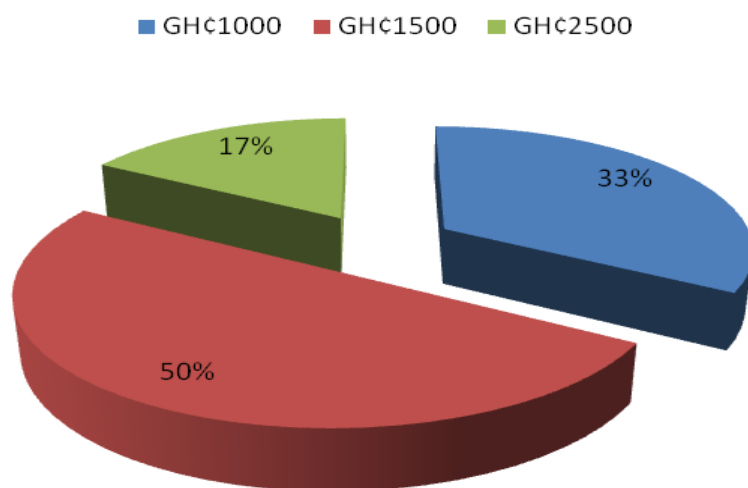


FIGURE 12.3. Demand for credit by poultry farmers in Sowutuom (Ga South District).

Source: Survey data, 2009 (USD1.00 = GH¢1.40).

Accra is the capital of Ghana, and the nation's peace and stability are tied to it. Since 1992, constitutional rule has been maintained and the quality of governance has improved both in the city and all its surrounding districts, assuring peace. The economy is an open one, allowing for innovativeness, importation and exportation of inputs and outputs. Policy guidelines for all key sectors including the financing of businesses (agriculture as well) have

been developed. A special document for micro-finance has been drafted for executive attention. The role of the Ministry of Food and Agriculture (MoFA) in the facilitation of credit for smallholders has been specified in the Food and Agriculture Sector Development Policy (FASDEP) as evidenced by the ministry's effort to establish the Export Development and Agricultural Investment Fund ([www.edaifgh.org](http://www.edaifgh.org)).

The sociological environment is suitable; there are no significant cultural barriers to savings and credit by any group of people. The financing institutions prefer economically active and business-minded clients. Many institutions have branches that are situated fairly close to the communities in which the poor live in and around Accra. This has improved (albeit slightly) the financing culture of the economy; the savings culture of the poor needs more work.

The ICT age allows the use of multimedia and gadgets to simplify the packaging of messages and training of groups and individuals whose literacy level is low. ICT is also improving the effectiveness of linkages of producers to markets. The openness of the economy allows importation of improved machinery, seeds/breeds, pesticides and fertilizers and other technologies to support intensive production.

The only environment that needs critical attention is the macro-economy: as economic indicators such as inflation become unfavorable (double digit), the financial system retards and narrows its credit clientele base to include more secured ones. The inflation rate of the past decade has been between 10 and 18%. It puts the Central Bank prime rate at 20% and commercial bank base rate at 25%.

Urban and peri-urban vegetable growers often use very intensive production systems to receive maximum outputs from small plots of land (FAO 2007, Obuobie et al. 2006). If not properly financed and advised farmers might miss the means needed to shift from improper use of maybe low-cost but harmful chemicals to safer products or invest in on-farm wastewater treatment.

All financial institutions involved in SME banking and/or micro-financing need to participate in the mobilization of such micro- and small enterprises for training in sound business management. Sound business management will ensure that resources – land, labor and capital – are planned and controlled in a sustainable way for consistent profit making. With consistent profit-making saving, excess cash will not be difficult to find; once this prerequisite of many financial institutions is met other areas of discipline can be worked at through the dynamics of the cooperative strategy.

## 12.5 Conclusion

This study has demonstrated that there is opportunity for providing financial support to poor urban farmers. There are different categories of financial institutions available in Accra and its environs. Many of the institutions have financial products that can serve the interest of the entrepreneurial poor so urban farmers can also benefit; much negotiation and learning is necessary. Key bottlenecks can be traced to the characteristics of the farmers, capacity of financial institutions and the macro-environment situation. In order to improve the access of small-scale urban producers to financial support, the following eight steps are recommended: they center on changes in attitudes of poor urban agricultural producers, policy changes of financial institutions and improvement of support by the District Assembly.

1. Agricultural producers should change their attitudes by participating in groups and associations formed to learn more about their trade (see chapter 11). They can then seek for sustainable external support once they obtain legitimization by registering with the Department of Cooperatives or the Registrar General's Department.
2. Urban farmers are squatters; they cannot own land so they should seek to obtain memoranda of understanding from their landlords. Partnering with them can generate confidence in the sustainability of their enterprises.
3. Urban agricultural producers should enrol in adult classes and improve their literacy status; exposure will improve their learning ability and information-seeking skills.
4. Urban farmers should secure permanent addresses to gain trustworthiness.
5. Financial institutions should involve urban agricultural producer groups during their outreach programs. The income-generating capacity of open-space vegetable farming is high enough to deserve any assistance by financing institutions.
6. Financial institutions should pilot urban agro-products. As part of the financial literacy training programs, modules on savings, insurance and money transfer operations should be prioritized.
7. Actions on conditioning of road surfaces by the Department of Feeder Roads should be expedited to make remote areas of urban centers and peri-urban communities more accessible to field officers of microfinance institutions and NGOs.
8. Additional resources should be provided to the statutory institutions of extension and group facilitation (the Ministry of Food and Agriculture, Department of Cooperatives and Community Development) to improve their group facilitation operations.

## 13. Land and Planning for Urban Agriculture in Accra: Sustained Urban Agriculture or Sustainable Urbanization?

Adriana Allen, Alexandre Apsan Frediani and Matthew Wood-Hill

### 13.1 Introduction

The Accra Metropolitan Area (AMA)<sup>1</sup> has undergone rapid and significant changes in recent decades. Liberalization reforms, remittances from abroad and the discovery of oil have caused the real-estate sector to boom, placing a high demand on agricultural land for other purposes. This is not a new story; land in Accra has been contested for generations. The various customary and institutional land tenure systems, the lack of updated urban and spatial planning and poor coordination between planning departments together with weak enforcement have resulted in a situation where market forces have overtaken the land-use planning agenda, favoring real-estate-led development over other land uses such as urban agriculture (Quarcoopome 1992; Larbi 1995; Kasanga et al. 1996; Gough and Yankson 2000; Owusu 2008). This process not only undermines the existence of localized farming systems within the AMA but also and more fundamentally the rights of farmers and the urban poor to the city's land coverage (Allen and Apsan Frediani, 2013).

Another factor influencing the city and its metropolitan region is Accra's recent declaration as a Millennium City by the Earth Institute at Columbia University to aid its progress towards achieving the Millennium Development Goals (MDGs).<sup>2</sup> Despite the presence of an MDG with a focus on environmental sustainability, current plans for its implementation stipulate that urban agriculture (UA) will be pushed to the outskirts, where competition for land is lower. Furthermore, peripheral land within the AMA is to be acquired not for subsistence agriculture but rather large-scale, export-oriented schemes, with reduced prospects for protecting the role of smallholder UA in supporting local livelihoods and contributing to Accra's food security. In addition, plans to create green areas for organic food production within gated communities are emerging in a small number of large-scale real-estate developments. These initiatives,

---

<sup>1</sup>The AMA is the largest urban agglomeration in Ghana, with an estimated year 2000 population of 1.66 million. The area which comprises the AMA (also referred to as the Accra Metropolis District) and the surrounding districts of Ga East, Ga West and Tema (also denominated as the Greater Accra Metropolitan Area – GAMA), has over 2.7 million inhabitants, and has been growing at a rate of 3.4% per year (Obuobie et al., 2006).

<sup>2</sup> For more information on this initiative, visit: [www.urbandesignlab.columbia.edu/?pid=accra\\_ghana](http://www.urbandesignlab.columbia.edu/?pid=accra_ghana) (last accessed on 15 April 2014).

however, appear to be paying lip service to the purported benefits of UA, in that they are unlikely to stop the disappearance of current localized food production systems.

Drawing on the work conducted by the Development Planning Unit (DPU)<sup>3</sup> in collaboration with the International Water Management Institute (IWMI) between 2008 and 2012, this chapter explores the room for UA to remain a living practice in the face of the current development of the AMA.

Initiatives to promote more sustainable agriculture in Accra frequently concentrate on farming and irrigation practices (Asomani-Boateng 2005). Refining and evolving such techniques can contribute greatly to the sustainable development of Accra; however as the available land for UA decreases each year, security of land is itself a vital prerequisite to sustain UA into the future. Land and planning issues related to UA have been underrepresented at the policy level, both locally and nationally, with different groups preaching different attitudes towards it. A common vision for it in Accra is still conspicuously absent, despite the establishment of the Accra Working Group on Urban and Peri-urban Agriculture (AWGUPA) in 2005, a roundtable of key government institutions, research organizations and civil society groups. While setting an important precedent in bringing together various key stakeholders to discuss the future viability of UA in Accra, AWGUPA has faded in influence since funding from the Resource Centres on Urban Agriculture and Food Security (RUAF) 'From Seed to Table' program ended at the end of 2011. As a consequence, pressure on governmental ministries and municipal assemblies to acknowledge the potential contribution of this practice towards the sustainability of the city has been muted by comparison.

Agricultural sites in the AMA and surrounding municipalities exist under different circumstances. Analyzing different spaces reveals the variety of planning and land issues conditioning the potential for urban agriculture to contribute towards an environmentally sustainable and just urbanization process. Located on institutional land in proximity to Accra's city business district the sites of Dzorwulu, Roman Ridge and Plant Pool enjoy a certain degree

---

<sup>3</sup>Between 2008 and 2012, the authors coordinated the work of four groups of postgraduate students from the DPU MSc in Environment and Sustainable Development, who examined a number of sites where UA is currently being practiced within the AMA and Ashaiman. The research undertaken comprised many individual interviews with farmers and key informants, focus group discussions, transects and mapping. While this chapter summarizes some of the main findings related to land and planning under a number of distinctive scenarios, further details can be found by visiting the full reports produced by the students at: <http://www.bartlett.ucl.ac.uk/dpu/programmes/postgraduate/msc-environment-sustainable-development/in-practice/o-f> OR: <http://bit.ly/KXPB3B> (last accessed 15 April 2014).

of land tenure security. Here farming practices are tolerated as a means to protect the land from being encroached in areas where planning regulations prohibit the development of permanent structures. Similarly, on several additional sites across the city informal agreements exist between local farmers and institutional landholders, guaranteeing them a degree of – albeit temporary – land security.

Towards the peri-urban fringe, experiences are different. Once rural farmland is now confronted with a wave of urban expansion, making the area dynamic and volatile both spatially and politically. Traditional farming sites in La,<sup>4</sup> in the east of Accra, are at the center of competing demands. Large tracts of customary land are rapidly entering the real-estate market in the form of gated communities, church and college complexes, and individual structures often built without approval. Signs threatening the latter with demolition pepper the area, but the capacity of the La sub-metropolitan area to enforce local planning regulations is weak. This and other factors helped support the granting of municipal status to the La Dada-Kotpon district in June 2012. It remains to be seen whether greater decentralization of powers will be used to protect agricultural practices or instead further accelerate the commodification of the area and its development as another enclave for luxury housing.

Further afield, the emerging municipality of Ashaiman, some 20 kilometers (km) east from Accra's center, is encountering similar pressures, indicating that it is not just the big city exerting these forces of urban change. The case examined, like La, explores the complex dynamic between different land systems and entitlements, in relation to an area of institutional land that in spite of its status is similarly not immune from the municipality's housing needs and real-estate development pressures. Here a national irrigation scheme constructed in the 1960s is under increasing threat both directly and indirectly from encroachments, while unwarranted developments on a neighboring floodplain, which performs a secondary function as a site for seasonal farming, seemingly puts the municipality as well as the irrigation scheme at risk.

### **13.2 Farming in the Inner City: Contested Claims and Practices**

Irrigated farming within the inner-city area of Accra is practiced mainly on institutional land, where farmers are seen by public authorities as guardians against encroachments from land speculators and/or informal settlements. Details of UA in Accra are presented in chapter 2. The

---

<sup>4</sup> The La people are a subgroup of the Ga-Adangbe ethnic group.

Plant Pool, Dzorwulu and Roman Ridge UA sites have often been associated with relatively secure land tenure conditions for farmers, precisely because of their location under high-tension power cables and next to the railway line and stream. Due to this ‘secure’ condition, these sites have played host to planned interventions to promote sustainable practices orchestrated by the Ministry of Food and Agriculture (MoFA), as well as international programs funded through the RUAF and implemented by IWMI. Meanwhile, the pressures of current urban development trends are opening new questions about the long-term security of these areas for UA.

In spite of their proximity these three sites are affected by urban expansion in different ways, and as a result farmers are generating different coping strategies. Plant Pool and Dzorwulu are located under the high-tension power cables, where permanent structures are not permitted (Beckwith et al. 2009; Al-Khalifa et al. 2010). The institutional landholder in both cases is Ghana Grid Company Limited (GRIDCo), which permits UA as a way of controlling construction on the site. However, both sites are experiencing increasing pressures from encroachments, with the incipient mushrooming of new temporary structures such as containers used for commercial activities and mechanics’ workshops (Bindo et al. 2011; Chan et al. 2011; Bains et al. 2012; Bancheva et al. 2012).

Apart from the loss of farming space, the way in which these changes are taking place in Plant Pool illustrates a complex and unjust set of power relations operating within the land-use and planning systems in Accra. As explained by the an assembly representative,<sup>5</sup> the first containers in the area were allocated with his backing as a response to his electoral supporters. Soon after the opening of a few shops, a member of the local chief’s family argued that permission for construction in the area needed customary approval, and thus started to charge a protection fee from the new shop owners. Farmers of Plant Pool approached the planning department of the AMA arguing that the new constructions in the site were illegal. However, as long as the building material of the constructions falls within the criteria of ‘temporary structures’, the new constructions are not necessarily any less legitimate than farming. Indeed, Public Works, the state department responsible for land-use reinforcement, sent local inspectors to pull down those made from permanent building materials, yet leaving containers and mechanics’ workshops intact. At the time in which the fieldwork was completed in 2012, GRIDCo refused to take an official stand in such contestations. Farmers have occasionally resorted to direct

---

<sup>5</sup>Interview conducted in Nima, Accra, 5 May 2012.

action, bringing down new structures taken place in farming sites. In short, there is considerable conflict and the land ends up being used by those showing greater strength in direct confrontation on the ground.

Similarly in Dzorwulu, land within buffer zones bordering the stream has been encroached by local speculators with the backing of a nephew of the local chief. However these developments differ from those in Plant Pool insofar as they are larger, more permanent and for residential purposes. The deployment of local bodyguards from a member of the local chief's family (known locally as the 'macho-man'), has been intimidating farmers and local Public Works officials. While public authorities recognize the importance of such buffer zones in assuring the permeability of soil and avoiding flooding, they fail to assign an effective mechanism of law enforcement. This has resulted in insecurity among the farmers, who have been actively looking for alternative sites for UA in less contentious areas.

In Roman Ridge, the encroachment issues are similar to Dzorwulu. The land has been acquired from the Osu traditional authority by the Land Commission and Ghana Railway Authority, but as in the case of GRIDCo, these institutions have been reluctant to recognize farmers, fearing that it could complicate potential land-use changes in the future. While areas next to the stream and railway line have been lost to real-estate developments, the inner area of the site has remained free from encroachments.

The processes of encroachment in the aforesaid sites not only put into question the sustainability of these sites for UA, but also illustrate the challenges faced by the state to pursue land policies that are concerned with a sustainable process of urbanization. The cases highlight how spatial characteristics of the site have also contributed to making some areas vulnerable to land pressures due to their desirable location, while others continued to be safeguarded. Nevertheless, if the various state agencies responsible for protecting institutional land are unable to articulate concerted efforts to protect urban farmland, the future of such sites in the inner-city of Accra looks uncertain.

### **13.3 Where Customary Agricultural Practices Meet Market-led Urbanization**

Real-estate development processes are rapidly transforming the face of the AMA through the commodification of customary peri-urban land. This trend is particularly evident in the indigenous area known as 'La', which extends from La Township in the east to Airport Hills on the northeast of the city (Figure 13.1 and Table 13.1).



FIGURE 13.1. Location of the La site in Accra (see also chapter 2).

Source: Christina Semasinghe, IWMI

TABLE 13.1. Basic information on agricultural sites in La.

Criteria	La Urban Farming Area
Numbers and organization	About 200 farmers in 2012, revealing a sharp decrease from previous years. Organized into a Farming Association, most originally from Ga.
Farming practices	Okro, pepper, cassava, maize and watermelon. Irrigation practices are sourced from rainfall, wastewater and stream water by using water pumping machines.
Site	300 to 350 acres (121 to 142 hectares [ha]) under cultivation in 2010, strong seasonality and generally decreasing rapidly.
Tenure status	Land largely controlled by the East Dadekotopon Development Trust, the Burma Military camp and individual traditional families
Challenges	As farming land decreases, farmers shift to more distant areas to the detriment of women, who cannot afford longer distances to travel and the additional costs incurred to prepare the land and to access water for irrigation.

La was once the largest and most prosperous UA site within the AMA, functioning as a significant source of perishable vegetables for the city, and as one of the largest concentrations of urban farmers within Accra, many of them women (Allen et al. 2009). However the past decade has seen the scope for UA dramatically reduced by market forces, which instead favor

a fast process of land conversion led by real-estate development gains (Abiyeva et al. 2010; Bacon et al. 2011; Caradonna et al. 2012).

Urban development in La occurs at various scales and rates, with diverse purposes and common economic motives unifying the drivers behind land-use changes. These range from the development of upmarket gated communities, to the mushrooming of structures built up by individual families, often through slow processes of capitalization fuelled by the remittances sent from Ghanaians living abroad. Grant (2009) describes the former process as the “globalising of Accra from above”, a process by which foreign investors are rapidly penetrating the local real-estate development market. This trend has been fuelled by the restructuring of foreign direct investment, the expansion of international lending and mortgage programs and of ‘global’ residential aspirations and outlooks. In 2004, about 23 gated communities were at varying stages of development in the city, representing an investment of almost USD435 million, but only about 3% of Accra’s total housing stock (ibid).

In the north of the area under study, international companies such as Finali Ltd secured land in 2008, developing over 400 acres of land into a large-scale ‘luxury housing’ compound, Airport Hills. Exclusive developments like this have proliferated towards the northeast of Accra forming a new boundary around one of the sites where farmers have relocated their practices in the last five years, as the land around their traditional farming areas has become encroached by unfinished structures. The latter has been an ongoing trend for more than a decade, driven by what Grant defines as the “globalising in between” forces presently shaping Accra’s development.<sup>6</sup> In the case of La, these forces are partly constituted by returnees and remittance senders who together with numerous traditional families in the area are claiming the land back by building individual houses for their own use, sale or rent. The ‘rush to build’ is indeed characteristic of most areas where land is held under customary rights in Accra and fuelled by multiple attempts to capture land gains before others do so. Figure 13.2 shows the signs populating the area, threatening the demolition of these structures.

Disputes over land led, in recent years, to the creation of the East Dadekotopon Trust (EDDT), a body composed of the main traditional landholding families within La. This is an innovation in the land context, whereby customary rights are being transformed into a new channel to enter

---

<sup>6</sup>For a detailed analysis of the interplay between real-estate and remittances in Accra, see Buckley and Mathema (2007).

the real-estate development game. The EDDT developed a plan to build a mini-gated housing community for approximately 180,000 people. Although the initial plan included a green belt to be dedicated to farming, the area earmarked for this purpose has been almost fully encroached by individual structures, thus making the prospects of sustaining UA fairly slim.<sup>7</sup>



FIGURE 13.2. Demolition threats on unfinished structures peppering the La site (photos courtesy A. Allen).



As a result of these forces, the land under cultivation in the La area has drastically decreased (Figure 13.3) and as result, the number of farmers has declined. Between 2010 and 2011, about 47% of the land under cultivation was lost to residential purposes.

FIGURE 13.3. Cultivated land lost to residential purposes in La between 2010 (light green) and 2011 (dark green).

Source: Bacon et al. (2011).

<sup>7</sup>The East Dadekotopon Development Trust, made up of the Stool and two landholding families, has been entrusted with about 80% of the land in La. Its community plan originally earmarked approximately 100 acres for farmland, approved by Town and Country Planning. There is the perception among farmers, however, that land encroachment will continue until most land is used for building purposes, especially as the green belt continues to be developed.

Farmers in the area have lost 3 to 4 acres on average over the last five years with those who can afford to do so dispersing to available land in the north of the site (Table 13.2). However, farmers' movements, especially for women, are restricted in terms of access to water, distance and increased amount of time and money towards land clearing and preparation, thus forcing many women to withdraw from UA. Whereas farming for men is either a part-time or full-time livelihood, it is a primary source of income and activity for women.

**TABLE 13.2.** Average loss of land for farmers in La.

Farmers	Full-time/part-time	Average /loss of land
Men (21)	15/6	3-4 acres lost on average over five years
Women (35)	28/7	

Source: Adapted from Caradonna et al. (2012), page 22.

The uncertainty of land use has also seen fewer members of the younger generation practicing farming, opening a few casual work opportunities for migrant laborers. The La Farmers Association (FA) has been weakened in recent years due to the contentious politics underlying this process: while the FA leaders have focused their action on securing land for UA within current developments, they have not been heard. This has eroded the hope and collective action of associated farmers, thus reducing the number of active associated farmers.

An additional dimension to be considered in the case of La is the role that farming plays as a place and identity-making practice. Figure 13.4 shows the multiple meanings of the land for the Ga community and the close links between the local classifications of the area and its value as a place for farming, social, spiritual and religious practices. Fighting for the recognition of such values embodied in the land, a local civil society organization – the La Citizens Network – is lobbying for the creation of a green belt in the area of Kordojoor (50 acres) – mainly for agricultural purposes – in order to preserve Ga heritage and culture (Caradonna et al. 2012).

La tells us a story of an agrarian society, where the statutory and customary systems coexist side by side; where confusion prevails as to who owns and controls the land; where farming is being engulfed through hazardous development and land speculation, pushing UA to less fertile lands; and where farmers face increasing vulnerability. La helps us to appreciate the spatial and social transformations fuelled by neoliberal policies which brought forth rapid economic growth and pressing urban development. The phasing out of UA not only impacts many

people's livelihoods, but also reduces the likelihood that Accra can be a self-sufficient, resilient or sustainable city that ensures food sovereignty for its people.



FIGURE 13.4. Place-naming and identity-making in La.

Source: Adapted from Caradonna et al. (2012), page 26.

### 13.4 Putting Unsuitable Land to Productive Use

Lying originally on the outskirts of Tema, approximately 20 km east from Accra's center, Ashaiman is today part of the urban complex of the GAMA and was granted municipal status in 2008. Two of the farming sites on the western edge of Ashaiman, situated on institutional land (managed by the Ghana Irrigation Development Authority, GIDA), are technically protected by local planning regulations and agreements. In spite of this, they too encounter increasing pressures as once rural farming plots contend with the threat of encroachment onto unscrupulously sold plots of land steadily creeping outwards from the municipality.

Conflict arises due to the confused nature of landownership and tenureship in the area. Family members of the Ashaiman Stool<sup>8</sup> still act as freehold owners of the land, often actively selling portions of land to developers for profit, in spite of leasehold agreements made many years ago with state institutions. A brief summary of the land agreements can help to better understand how these tensions have emerged.

<sup>8</sup> The term 'Stool' refers to a customary landholding group or kinship. Customary tenure is a legally recognized form of tenure in Ghana according to the National Land Policy of 1999 and the Land Title Registration Law (PNDCL 152) (Flynn-Dapaah 2002).

In 1952 the Tema Development Corporation (TDC), a governmental body responsible for overseeing the transformation and development of Tema into the country's predominant industrial hub, signed a 126-year leasehold agreement with numerous local Stools in the region, the traditional custodians of the land, for 69 square miles of land to the East of Accra (Boakye 2008). The fledging municipality of Ashaiman (then part of the Tema Municipality) is located within this boundary. One reason for continued disagreement and disregard of formal statutory planning regulations by members of the Stools is remarked upon as being down to whether or not all of the traditional councils were adequately compensated in this process, a recurrent contestation over institutional land to be found throughout the AMA and surrounding municipalities.

The Ashaiman scheme, otherwise known as the Adjei Kojo Mobi Irrigation Scheme (AKMIS), was launched in 1968 by the Ghana Irrigation Development Agency (GIDA), who obtained a 90-year leasehold from the TDC in order to construct the dam and irrigation infrastructure feeding the site (Figure 13.5) (Adams et al. 2009; Abatemi-Usman 2010; Iino et al. 2011).

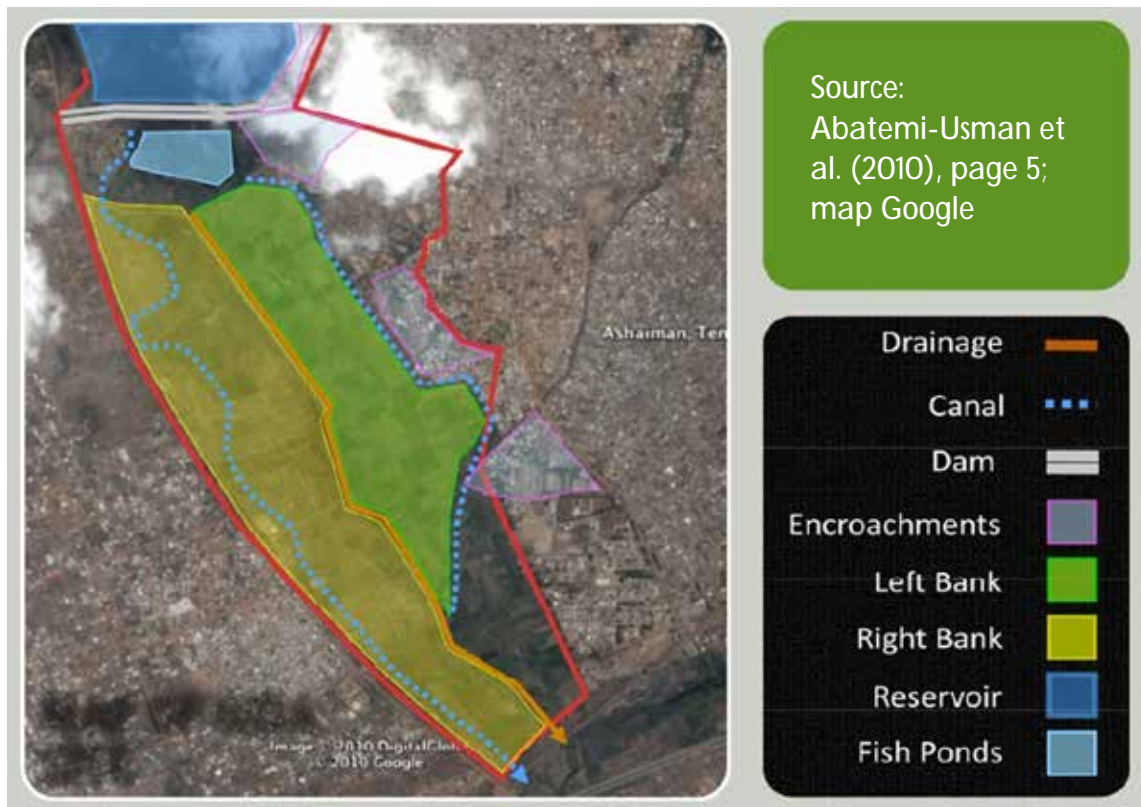


FIGURE 13.5. Ashaiman Irrigation Scheme site with the dam and reservoir in the upper part of the map.

Coupled with the creation of the Irrigation Development Centre (IDC), the purpose of the scheme was to provide a place for agricultural innovation and experimentation that could potentially be scaled up to larger commercial farms. The present condition of formalized agriculture owes its existence to the Japanese International Cooperation Agency (JICA), who conceived a pilot scheme in the late 1990s to revive the ailing scheme which lay neglected following budget and personnel cuts to GIDA during the Structural Adjustment Programme of the 1980s (JICA 2006).

This farmland receives different volumes of water depending on the season; crucial to its functionality therefore, is a second farming site immediately to the south called Roman Down, also on GIDA land. There has been no infrastructural investment on this site, though the farmers do have informal usufruct<sup>9</sup> rights and form an organized unit through their cooperative. Water is received from the comparatively uncontaminated drain flowing downstream through the irrigation scheme as an alternative to extracting wastewater from the municipality's drainage channel on the western edge of the site, which is frequently clogged with plastic waste (Doron et al. 2010; Belkow et al. 2011). The irrigation scheme similarly benefits from its proximity to Roman Down, which serves as a natural buffer zone to contain flooding and prevent it backwashing upstream and swamping the irrigation scheme or putting nearby homes further downstream at risk (see Table 13.3 for basic information on the two sites).

Constructions spreading outwards from Ashaiman have been identified as being predominantly driven by individual middle-class families, often through local entrepreneurs acting as brokers between the buyers and members of the Ashaiman Stool. These encroachments are occurring in three distinct places and affecting the sites in different ways.

First, constructions on the banks of the reservoir are adding to levels of pollution of solid and liquid waste, negatively impacting the quality of water received from the dam. Evidence for this is anecdotal: farmers have remarked how the color and consistency of the water has changed over the years.

Second, debris in the water coming from the reservoir and resultant siltation and blockages have rendered ineffective the irrigation channel serving the western half of the irrigation site, known locally as the 'right bank'. This channel was made of earth instead of concrete and around 99 ha of productive land have been rendered unworkable.

---

<sup>9</sup> The legal right of using and enjoying the fruits or profits of something belonging to another as long as the property is not damaged or destroyed.

**TABLE 13.3.** Basic information on agricultural sites immediately west of Ashaiman Municipality.

Sites	Ashaiman Irrigation Scheme	Roman Down
Numbers and organization	94 farmers approximately, organized into a cooperative	About 40 farmers, almost all members of the farmers' cooperative
Farming practices	Maize, rice, okro, onion, tomato, pepper	Maize, okro, tomato
Site	155 ha	22 ha
Tenure status	Land is owned by GIDA, which recognizes the farmers rights to the land.	Land is owned by GIDA, the farmers are not formally recognized but have informal permission to farm the land.
Challenges	The Right Bank is inactive after the irrigation channel became blocked by debris from the reservoir. The other (concrete) drainage channels face similar problems with siltation. Water quality has worsened over time.	Encroachment is occurring in the northern part of the site, and some farming plots have been destroyed. Siltation and solid waste in the drainage channels that feed the site are increasing the frequency of flooding.

Third, the Roman Down site has been experiencing the knock-on effects of this and similarly suffers from siltation in the drainage channels and diminished water quality. The Ashaiman drain is heavily polluted with plastic waste from the municipality; encroaching buildings constructed on the very edge of the drain have been blamed for this contamination, and many were bulldozed at the behest of the Ashaiman Municipal Assembly in early 2010. Nevertheless the problem has persisted, indicating that the municipality's solid waste management services are not yet doing enough to cater for the behavior of local residents.

The two farming sites share a high degree of interdependency. Figure 13.6 illustrates the spatiality of pressures concerning land, water and waste. As the carrying capacities of the channels are reduced, floodwater can be backed up by debris in the waste stream and lifted on to the farmland, in turn pushing it towards the municipality, increasing the flood risk. Encroaching houses in the northern portion of the site closest to the municipality are reducing the ability of the area to perform its role in the local ecosystem.

Recent legislation on buffer zones produced by the Water Resources Commission outlines clear restrictions on the proximity of buildings to waterbodies, though this appears to be less frequently applied in an urban context. The key question in Ashaiman is one of enforcement, or a lack thereof; with regards to planning regulations, a common vision for the land is currently absent.

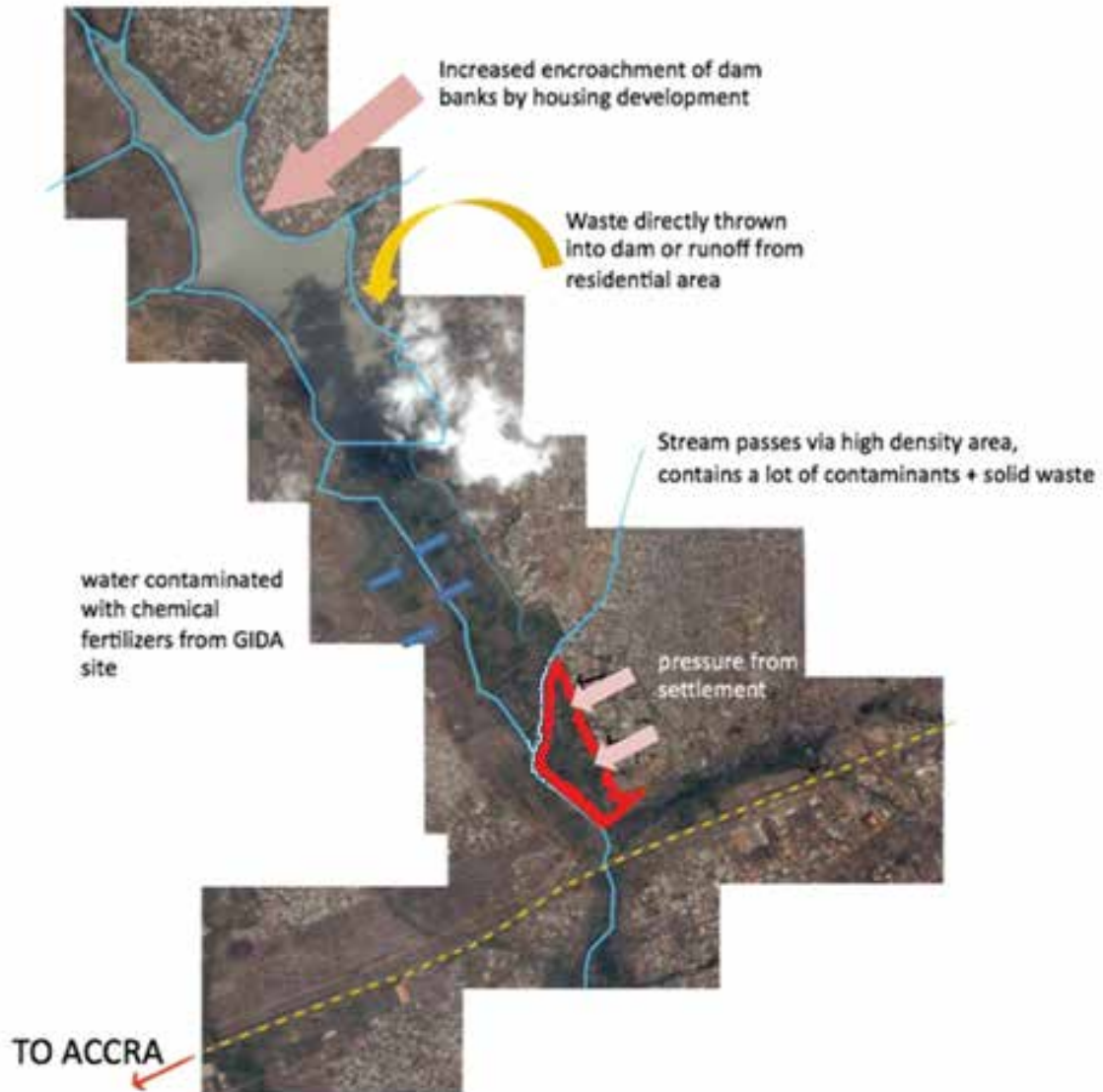


FIGURE 13.6. Encroachment and wastewater flows affecting water quality in Roman Down (red area). Source: Doron et al. (2010, appendix 5).

Three different scenarios appear in juxtaposition: the value of the land in producing food for the city, and as a space for innovation and experimentation; empty land which can be developed to meet the municipality's housing demands; and the natural function of the land as a floodplain and a crucial part of the local ecosystem. Urban agriculture can play an important role in preserving this as a passive space, putting it (seasonally) to productive use in service of the city

and allowing it to serve its natural purpose as a floodplain. Farmers serving as stewards of the land in this way are able to activate through their usufruct rights, their right to the city and sustain their livelihood needs.

A further question might be asked about how such pressures on land and tensions between stakeholders are symptomatic of ‘emerging municipalities’. In Ashaiman, municipal status has given greater authority to local power structures as the statutory has met with the customary, the national with the local and rural with the urban, leading to uncertainty and complex institutional relationships. At the beginning of 2012, GIDA paid the Ghanaian military to patrol the area on several weekends, to the displeasure of the local authorities. However this move succeeded in drawing national media and political attention to the perils of building on floodplains, which appears to have been overlooked somewhat by the municipality and traditional landholders. The interplay between local- and national-level institutions and their attitudes towards enforcement and land rights is a key area of tension. As discussed in the previous section, La is likely to face similar challenges as it effectively becomes a new independent municipality. The question remains as to whether newly formed municipal assemblies will actively engage in preserving buffer zones serving the dual purposes of supporting the local ecosystems and hosting harmonious urban farming practices.

### **13.5 Pathways for Change**

The different cases researched have illustrated a series of common issues across agricultural sites in the GAMA, as well as suggesting that there is room for maneuver in pursuit of a series of pathways for change, briefly outlined below.

#### **Locking Vacant Land through Existing Planning Mechanisms**

In describing the multiplicity of threats facing UA sites in AMA and Ashaiman it may be deduced that the systems of land management and planning are not conducive to a city with urban farming at its core. This might be true; farming is generally seen by city planners and municipal assemblies as an outdated use of land gradually being phased out, with attention focused more heavily on the rural hinterlands providing for the city. Nevertheless there are certain niches within local planning structures that can be used by planners and farmers to make productive use of land upon which restrictions have been imposed in order to protect it from development. In the cases of farming sites in the inner city and emerging municipality, formally designating portions of land unsuitable for construction as buffer zones can aid this process. Areas of land serving as floodplains, for example, can concurrently offer fertile soil for farming,

whereas the protected corridors along the main municipal wastewater drains could make productive use of these open spaces and take advantage of the close proximity to water sources. Another example is better use of the protected land beneath high tension electricity cables.

Precedents exist where land agreements have included guarantees to preserve green space as a wedge or greenbelt, or designating it specifically for agricultural purposes. An example of this is found in Tema, where the TDC's initial agreement included setting aside 9 km<sup>2</sup> of land for agriculture (Boakye 2008). Similarly in La, the EDDT-approved masterplan initially designated some areas for urban farming and therefore as a greenbelt which existing farmers could relocate to as a partial compensation for the loss of their livelihood sources. However, this area has been encroached by structures rendering this compensatory measure ineffective in practice.

While existing land-use planning mechanisms do not explicitly cater for the designation of land for UA, they do make a useful distinction between 'active' and 'passive' spaces or land uses. The former defines areas that can be built upon, whereas the latter can potentially 'lock' certain areas away from development, regardless of the tenure status of the land in question. Through this, it is possible for different stakeholders to request the reclassification of specific tracts of land as passive areas. Though it is less likely that those with vested interests in the commodification of land would activate this process, it is possible for the city authorities and institutional landholders to redesignate those areas deemed unsuitable for residential or commercial development, hence preserving vital ecosystem services for the city. In short, without effecting changes in complex land-titling procedures, it is possible to form a 'land bank' of passive spaces, whereby land unsuitable for development could be protected and used for farming.

### **Activating Land Usufruct Security**

Farmers have been appropriating land for agricultural purposes for many years and as such can justly assume that permission to do so has been tacitly granted. Nevertheless this is not enough. Through self-organization and strong cooperative structures they are able to restrict, manage and incorporate newcomers into the farming systems operating on particular sites, but they are powerless in the face of physical encroachments onto farmland. Even when land is deliberately ring-fenced as unsuitable for development farmers must rely on institutional support to enforce land laws. As illegal encroachments and attempts to take over land usually occur at night, crops and entire plots can still be lost.

Institutional land without a specified purpose provides a way in which farmers can be guaranteed a basic level of land tenure security. Redefining land in this way could provide mutual benefits for farmers and landowners. Some institutions in the more heavily built up inner city area of Accra are happy to permit and actively encourage farmers to turn parts of their surrounding land to productive use (two examples are the farming sites at the Council for Scientific and Industrial Research and at the National Broadcast Centre) (Bancheva et al. 2012). The presence of farmers on their land serves as a means of protecting and policing the land against physical encroachment or development. The cultivation of the land performs a pragmatic function in keeping the area managed and tidy and preventing it from becoming overgrown.

The benefit to the institutions is therefore both in the protection and beautification of the area. Farmers may have a formal registration with the institution whose land they are farming, but this only translates as informal usufruct rights, as they are not formally registered with the MoFA or the Department of Cooperatives. They still only possess a degree of land security for as long as the landholding institution is willing to grant it. Nevertheless this allows farmers to plan year-to-year in the knowledge that they will not be threatened with immediate eviction. In this way institutions and farmers are working towards a mutually beneficial end, even if a long-term vision is absent. In spite of these opportunities a key challenge remains: enforcing planning regulations which are frequently flaunted by encroaching structures not only threatening the livelihoods of farmers, but potentially resulting in unsafe use of land.

It is imperative therefore that the informal agreements with landholders that prevail across numerous agricultural sites in Accra are developed into formal recognition of the right of the farmers to work on the land. Usufruct rights can be secured without the need to transfer land titles and ownership, which might be considered by some landholders as a barrier to granting more stability to urban farmers.

### **Socializing Benefits through Zoning and Land Value Capture**

Internationally there are currently many initiatives enhancing the state's ability to intervene in urban land markets to protect land from speculation and/or to ensure that the benefits brought about by market-led interventions are socially captured and distributed. The first step consists of recognizing the social value of land, which implies that urban land must not be seen merely as a commodity, but as a right where the state has a crucial role in assuring that any benefits accruing from it are distributed equitably (du Plessis 2005). As illustrated in the case of the AMA and Ashaiman, the market itself cannot ensure that the use of land will

automatically generate sustainable and equitable outcomes. Urban agriculture can potentially be recognized and protected due to its social and environmental contribution to the city, even though it might not involve the most profitable use of land. Various mechanisms have been designed to support governments in intervening in land markets and contestations. For example, the Brazilian Ministry of Cities has passed a law which allows informal settlements to be designated as areas of special social and economic interest (Allen and You 2002). Such law has allowed tenure regularization to take place in ways that have protected the rights of dwellers to remain in such locations, avoiding forced eviction or gentrification.

The second set of instruments is concerned with the distribution of the benefits brought about by land speculation. Land value capture is one such instrument that focuses on activating the ability of the state to capture part of the benefits on land value generated by state-led interventions (Gregory and Hong 2012). If the state changes the zoning regulations of a particular area which ends up making properties and land more desirable, it is argued that such benefits should not be absorbed only by private land and property owners, but also captured by the state to be distributed to the rest of society. It is important to reflect on such international experiences to assess their potential to be implemented in the context of the AMA, Ashaiman and elsewhere as a means to enhance the state's ability to interfere in land markets, not merely as an enabler or facilitator, but rather as a distributor of benefits and protector of rights.

### **13.6 Conclusions**

The processes examined in this chapter are not confined to Accra and its wider metropolitan area but are indeed characteristic of most large cities in Sub-Saharan Africa, where urban change is being shaped by burgeoning market forces and abetted by outdated planning mechanisms, weak enforcement and contested land tenure systems. Unless the land question is tackled, the future of urban farming systems remains dynamic and uncertain.

A no-change scenario will see UA increasingly evicted (at least in current locations) from the urban fabric in the medium to long term and with it many opportunities and potential benefits that urban farming offers for the environmentally sustainable and just urbanization of the region will be lost. Such benefits have been discussed in previous chapters and include its capacity to break the vicious cycle of perpetuated malnutrition and poverty. Whether for self-consumption or for marketing aims, UA can play a vital role in enhancing food security. In the context of particularly marginalized groups, including migrants, UA can also contribute to long-term

livelihood diversification and to supporting the right to farm in the city, thus increasing the resilience of such groups to cope with shocks and to strengthening their voice.

Urban agriculture can also bring major environmental benefits not just for the areas in which it is practiced but also the wider city environment (Vázquez et al. 2002; Lee-Smith 2010). Nutrient cycles can potentially be closed through the use of organic solid and liquid waste as an input into farming practices and can reduce the amount of urban waste that needs to be disposed. There are additional benefits in locating farming sites within the urban fabric. By producing food close to where it is consumed the food footprint can be reduced substantially. This is particularly important in the context of the peak oil crisis and the efforts to combat climate change. Moreover, cities require green open spaces, not only to regulate temperature and reduce water runoff but also to contribute to the well-being of citizens. Urban agriculture can play a role in all of these crucial functions.

A second scenario might lead to the preservation of some of the above benefits at the expense of others. This is likely to be the case if land is preserved for agricultural purposes but at the cost of excluding urban farmers and also of providing prime quality vegetables only for those who can afford them.

A third scenario requires pursuing environmental and socioeconomic benefits in tandem with each other and not just for a few but for the well-being of all citizens, in particular those for whom UA constitutes a full-time livelihood or income-complementary activity, a place-making and deeply engrained cultural practice and a food security safeguard. Farming in the city is not a new or occasional activity. Over the years women and men in the GAMA have adapted their farming practices to respond to the limitations and opportunities of the urban context. Their experiences constitute a rich and diverse reservoir that should be recognized and supported through the consolidation and cross-fertilization of their knowledge, practices and collective action across farming associations and other typically disenfranchised communities. Despite the perception that there is no available land in the AMA and surrounding municipalities, over 20% of the area remains vacant. A combination of the strategies discussed above could still make a substantial difference in sustaining UA as a means of promoting sustainable urbanization.

*The documentary related to this chapter can be found on the CD attached to this book or on this Youtube link in the internet: <http://youtu.be/m-6EURne8RU>*

## 14. Health Risk Management for Safe Vegetable Irrigation

Pay Drechsel, Bernard Keraita, Philip Amoah and Hanna Karg

*This chapter presents approaches tested in Ghana to mitigate wastewater irrigation-related risks for consumers and farmers from microbial contamination. The recommended interventions follow the WHO approach concerning multiple barriers along the food chain. Factors that could support the uptake of safety measures are discussed.*

### 14.1 Health Risk Management in Wastewater Irrigation

Different approaches have been proposed for risk mitigation. For a long time, conventional wastewater treatment was regarded as the ultimate risk mitigation measure (Asano and Levine 1998). This approach puts a strong emphasis on the use of water quality standards in wastewater irrigation systems and strict regulations as done in most high-income countries. However, the most recent World Health Organization (WHO) guidelines for wastewater irrigation recommend a shift from water quality standards to so-called ‘health-based’ targets which can be achieved along a chain of multiple risk reduction measures from wastewater treatment to safer irrigation to hygienic marketing and food preparation in the kitchen. The health-based targets thus describe the allowed risk level at the moment of consumption (WHO 2006). This new approach shifts the emphasis across the food chain from the farm and water to actual exposure. There are good reasons for this:

- a) In most low-income countries with insufficient wastewater collection and treatment it is unrealistic to achieve and maintain theoretical water quality standards, while weak regulations cannot prevent hundreds or thousands of farmers from using water from polluted streams.
- b) There can be significant food contamination on and off farm, even where clean irrigation water is used, thus a multiple risk barrier from ‘farm to fork’ is generally recommended and a standard practice around the globe (the Hazard Analysis and Critical Control Points [HACCP] approach).

WHO is thus suggesting that risk barriers are placed at critical control points from wastewater treatment (if available) to food consumption, aiming at maximum risk reduction. A generic example of these barriers is shown in Figure 14.1.

The WHO (2006) guidelines use the DALY<sup>1</sup> approach to define the health-based target. This is currently a tolerable additional disease burden of  $\leq 10^{-6}$  DALY loss per person per year, which translates in areas where high contamination is expected roughly into 6-7 log units of pathogen reduction, which the barriers have to achieve before food intake. This new approach of health-based targets offers authorities more options and flexibility for reducing risks especially where conventional water treatment is not possible. However, as the multiple barrier approach is more complex to implement and understand than setting up water quality thresholds, thresholds remain globally the predominant thrust of wastewater re-use guidelines, especially in those countries which can afford high treatment standards and have no challenges in using water quality criteria as a monitoring tool.

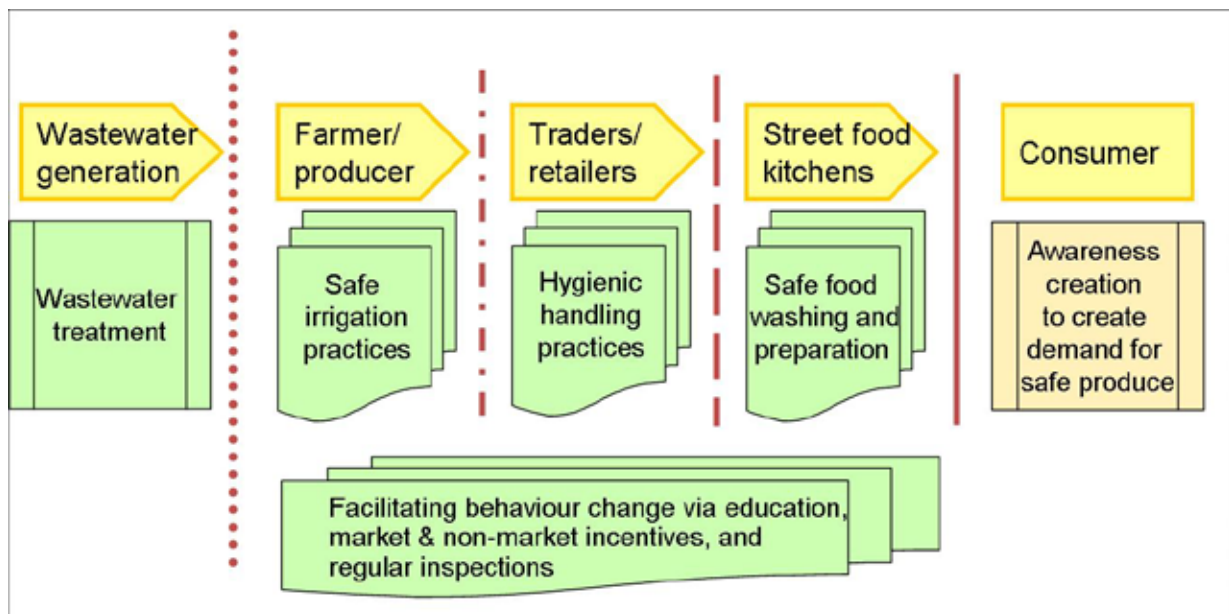


FIGURE 14.1. The multi-barrier approach for consumption-related risks along the food chain as applied in wastewater irrigation (Amoah et al. 2011).

## 14.2 Risk Management Strategies – An Overview

As mentioned above, the ideal option is to increase the coverage of safe wastewater collection (on site via septic tanks and of off site through sewerage) and to have the collected **wastewater appropriately treated** before it enters streams and other waterbodies used for vegetable irrigation.

<sup>1</sup> The disability-adjusted life year (DALY) is a measure of overall disease burden, expressed as the number of years lost due to ill-health, disability or early death. The  $10^{-6}$  threshold is based on the United States Environmental Protection Agency's acceptance level of an annual cancer risk, and is probably conservative, i.e. stricter than appropriate (Mara 2011).

However, as outlined in chapter 6, it will still take considerable time and investments for this to happen in most parts of Africa at a relevant scale. However, depending on the location, there are options where new or rehabilitated treatment plants could directly improve water quality for farming sites nearby.

Another strategy for farmers and extension officers is to explore access to **safer water sources**, which could mean tap water or groundwater, or change of the current plots to others where safer water is available. In Cotonou, Benin, for example, the authorities recognized the contribution of urban agriculture and allocated new parcels of land to urban farmers outside the city with unpolluted shallow groundwater. In Accra, the Ministry of Food and Agriculture was exploring options for groundwater use in urban agriculture areas irrigating with water from city drains. Both efforts had mixed success. In Benin, farmers did not appreciate the longer distance to the urban markets and tried to keep their current sites, while in Accra, most groundwater appeared to be too saline for most crops (Drechsel et al. 2006).

When irrigation projects are either well organized, or where laws are strongly enforced, the classical risk mitigation measures are **crop restrictions** to ensure that wastewater is not used to irrigate high-risk crops, such as leafy vegetables that are eaten raw. Research in Mexico, Chile and Peru has shown that this is possible but it is only a viable proposition for farmers when the crops allowed under the restrictions are of similar profitability, i.e. in higher demand than the banned ones, and for public health if restrictions can actually be enforced (Drechsel et al. 2002). It is doubtful that such an approach would be successful in the context of Ghana where leafy salad greens achieve the best revenues. However, public awareness campaigns (such as through the media) might steer consumers' demand for safer crops and influence farmers' decision making.

WHO's **multiple barrier approach** supports an array of further options for the management of risks from pathogens on farm, in markets and in kitchens (Table 14.1). For example, combining (i) a minimal (low-cost) wastewater treatment (1-2 units pathogen reduction), (ii) drip irrigation (2-4 log units pathogen reduction) and (iii) washing vegetables after harvesting (1 log units pathogen reduction) can achieve 4-7 log<sub>10</sub> unit pathogen reduction. Most of these estimates however need:

- Field testing and implementation of the suggested measures;
- The actual verification of the cumulative risk response;
- A strategy for monitoring the acceptance and effectiveness of such practices.

The verification of the cumulative risk reduction of subsequent pathogen barriers is important as in theory different barriers might affect the same group or size of pathogens and not those remaining.

**TABLE 14.1.** Health-protection control measures and associated pathogen reductions

Control measure	Pathogen reduction (log units)	Notes
<b>A. Wastewater treatment</b>	6-7	Pathogen reduction depends on type and degree of treatment selected.
<b>B. On-farm options</b>		
Crop restriction (i.e., no food crops eaten uncooked)	6-7	Depends on (a) effectiveness of local enforcement of crop restriction, and (b) comparative profit margin of the alternative crop(s).
<i>On-farm treatment:</i>		
(a) Three-tank system	1-2	One pond is being filled by the farmer, one is settling and the settled water from the third is being used for irrigation
(b) Simple sedimentation	0.5-1	Sedimentation for ~18 hours.
(c) Simple filtration	1-3	Value depends on filtration system used
<i>Method of wastewater application:</i>		
(a) Furrow irrigation	1-2	Crop density and yield may be reduced.
(b) Low-cost drip irrigation	2-4	2-log unit reduction for low-growing crops, and 4-log unit reduction for high-growing crops.
(c) Reduction of splashing	1-2	Farmers trained to reduce splashing when watering cans used (splashing adds contaminated soil particles to crop surfaces which can be minimized).
Pathogen die-off (cessation)	0.5-2 per day	Die-off between last irrigation and harvest (value depends on climate, crop type, etc.).
<b>C. Postharvest options at local markets</b>		
Overnight storage in baskets	0.5-1	Selling produce after overnight storage in baskets (rather than overnight storage in sacks or selling fresh produce without overnight storage).
Produce preparation prior to sale	1-2	(a) Washing salad crops, vegetables and fruit with clean water.
	2-3	(b) Washing salad crops, vegetables and fruit with running tap water.
	1-3	(c) Removing the outer leaves on cabbages, lettuces, etc.
<b>D. In-kitchen produce preparation options</b>		
Produce disinfection	2-3	Washing salad crops, vegetables and fruit with an appropriate disinfectant solution and rinsing with clean water.
Produce peeling	2	Fruits, root crops.
Produce cooking	5-6	Option depends on local diet and preference for cooked food.

Sources: EPHC/NRMMC/AHMC (2006); WHO (2006); Amoah et al. (2011).

Reductions expressed in percent or as log units are however only meaningful if used in combination with start and end concentrations. Box 14.1 tries to illustrate this.

**BOX 14.1. Log reductions and percentages (Amoah et al. 2011)**

- A reduction of 1 log unit from  $10^7$  to  $10^6$  (or from 7 to 6 logs) for example, removes 90% of the original coliform count. Two log reductions represent 99% and 3 logs 99.9%. This appears to be an impressive result, but from the initial  $10^7$  perspective the remaining coliform counts in the example are with  $10^4$  (10,000 coli bacteria) still 10 times above the level of 1,000 counts ( $10^3$ ) per 100 ml of irrigation water which is the common upper limit for unrestricted irrigation (WHO 1989).
- A reduction of 6 helminth eggs from— on average — 6.8 to 0.8 eggs represents a reduction by less than 1 log unit or 88% of the original count and although 88% looks less impressive than 99.9% in the example above, a final count of 0.8 eggs matches the WHO (1989) recommended egg count in irrigation water (less than one viable egg per liter).

### **14.3 Options to Improve Urban Sanitation and Wastewater Treatment**

In general, improved urban sanitation and wastewater treatment will lead to cleaner urban water streams; hence farmers will have safer water to use in their farms. While current statistics on wastewater management are gloomy, there are many efforts to improve the situation. For example, in Accra, the Accra Sewerage Improvement Project (ASIP), which is supported by the African Development Bank (AfDB) was approved in 2006. The project is building two waste stabilization pond-based sewage treatment plants at the Densu Delta (about 5,900 m<sup>3</sup>/day) and Legon (about 6,400 m<sup>3</sup>/day) accompanied by extension of sewer network coverage. The existing household connections will be rehabilitated while more than 4,000 new houses will be connected. The project will also build more than 140 new public toilets and 37 septage/night soil reception holding tanks (AfDB 2005). It is however likely that population growth will outpace these efforts. Moreover, Ghana has not the best track record in maintaining its wastewater treatment capacity as shown in chapter 6.

To support the sustainability of treatment plants, Murray and Drechsel (2011) analyzed the conditions of the existing plants in Ghana and posed key questions that could lead to improving the wastewater treatment sector (Table 14.2). These questions are intended to raise awareness among stakeholders about key drivers of the viability of treatment plants in a

context like Ghana's, and to foster informed decisions – including their impacts on environmental and public health – related to the rehabilitation and new design of treatment plants.

**TABLE 14.2.** Proposed guiding questions to improve sanitation infrastructure design, policy and management.

Question	Rationale
<b>Governance</b>	
Is there 'political will' to give waste treatment and safe disposal appropriate priority?	While recognizing that financial limitations do not give governments in low-income countries the flexibility needed to support all development goals equally, and that sanitation especially is often the largest cost factor in municipal budgets, there should be a clear commitment to keep treatment plants (TPs) under all circumstances operational and to prevent untreated sewage being redirected into waterbodies.
Do the institutions in charge have the capacity and positive track record of maintaining TPs? If not, what could be done to enhance and sustain their capacity?	Decentralization efforts in Ghana shifted the responsibility of many TPs to the municipal and metropolitan authorities that had no qualified staff and budget resources to cope with the new responsibility. Despite the fact that also most other operators have extremely poor track records, donor agencies are starting new projects.
<b>Technology selection</b>	
What is the (actual/expected) frequency of electrical power cuts? (This includes cuts due to inadequate power supply and inability to pay electricity bills in time)	If electricity supply proves to be, or is expected to be, sporadic, technology choices must be capable of providing waste treatment also in the absence of power. Ideally, treatment technologies should have no electricity demand, like waste stabilization ponds (WSP), but at the very least should be adaptable. A trickling filter is an example of a technology that is <i>not</i> adaptable. Aerobic systems (e.g. activated sludge systems) will only provide suboptimal treatment when aerators are off. Critical pumps should be connected to stand-by generators.
<b>Operation and maintenance</b>	
How many people must a maintenance request pass through? What is the average response time for a repair to be made? Are there shortcuts depending on the required budget and (emergency) situation?	Repairs or other maintenance needs at treatment facilities were often found to be prolonged due to inefficiencies in the protocol for authorizing such requests. There should be sound justification for each individual or entity involved in the authorization process such that the system is as streamlined and responsive as needed. For ad hoc or emergency requests there should be simplified procedures or step-wise financial authorization limits.  This also requires a related budget and environmental laws with sufficient power to give this budget and repairs highest priority.
Based on the existing or intended treatment scheme, what is the recommended number of person hours per day for an operator at a facility?	All wastewater and fecal sludge treatment technologies require some form of active operation and maintenance (O&M) for optimal function as they face permanent and continuous inflow. Treatment plant staffing decisions should be informed by the demands of the technologies in place.

What is the expected sludge accumulation and recommended removal frequency for the treatment scheme?	Excessive sludge accumulation has a debilitating effect on the performance of treatment technologies. Importantly, accumulation rates differ for wastewater versus fecal sludge treatment, and also vary among technologies. Conventional aerobic treatment tends to generate more sludge than anaerobic treatment and WSPs. A sludge management protocol that is commensurate with the requirements of the technology and sewage source is critical for treatment efficacy.
What is the annual investment in maintenance compared to the replacement value of the wastewater treatment plant and environmental damage?	As a rule of thumb, a minimum of 3% (and up to 6%) of the replacement value of infrastructure should be invested in annual maintenance. Deferred maintenance can significantly decrease the lifetime of a facility and inhibit treatment efficacy. Donors of treatment plants should set up contractual securities or support if they expect that national partners will provide the required maintenance. The observed provision of spare part support over two years after TP commissioning might be too short.
<b>Financial scheme</b>	
What is the user fee collection in comparison to O&M costs?	Complete O&M cost recovery may not be possible from user fees alone; however, fees can be an important component of a sustainable operating budget. The user fees that can be realistically charged and collected should inform the selection of technologies.
What is the percent of users who pay for service compared to the percent of users who receive a formal bill?	The importance of an institutionalized billing process in the sanitation sector must not be underestimated. User fee collection can only be as reliable as the billing scheme, and willingness to pay is shown to be correlated with the professionalism and transparency of the billing process.
<b>Incentives and accountability</b>	
What is the market demand for productive end-use options of wastewater, fecal sludge and treatment byproducts?	It is possible that designing or rehabilitating sanitation facilities for re-use of wastewater, fecal sludge and treatment byproducts can provide further leverage contributing to cost recovery at the facilities by creating economic demand for the treated products. Further, incorporating re-use into the treatment process can lower costs by decreasing treatment and/or disposal requirements.
What are the environmental and health trade-offs of an underperforming or defunct treatment plant?	Environmental and/or public health concerns were not given any weight in the observed cases of treatment failure, despite open discharge of wastewater or fecal sludge in densely populated urban areas. This common 'plan B' of open discharge if the designed system fails should no longer be the convenient option, but should result in disciplinary action and punitive fees above what is required to actually solve the problem.
<b>Monitoring and control</b>	
Which independent agency in charge of human or environmental health could regularly monitor the system? Does this agency have an enforced anticorruption code?	In most observed cases, the operating agencies and in particular the local 'caretakers' did not reveal that their TPs had any problems. Divergence of raw sewage flows into rivers occurred on company premises largely invisible to the public. Control systems with regular (unannounced) field visits are required as part of any risk management plan.

Source: Murray and Drechsel (2011).

Indeed, if all wastewater generated is adequately treated before it reaches farms, then the quality of irrigation water for direct and indirect agricultural re-use would meet standards and health risks would only be limited to postharvest practices. Several reviews show various wastewater treatment options which can meet quality standards needed for crop irrigation (Norton-Brandão et al. 2013; WHO 2006). Table 14.3 shows various wastewater treatment practices and the ranges of pathogen removal. In low-income countries, where pathogens are the main concern, low-rate process technologies such as pond systems are well suited for pathogen reduction (Scheierling et al. 2010). For the control of **chemical contaminants** more sophisticated treatment is required, but this should ideally happen at the source, like an industrial plant.

**TABLE 14.3.** Log unit reduction or inactivation of excreted pathogens achieved by selected wastewater treatment processes.

Treatment process	Log unit pathogen removal			
	Viruses	Bacteria	Protozoan (oo)cysts	Helminth eggs
<b>Low-rate biological processes</b>				
Waste stabilization ponds	1-4	1-6	1-4	1-3 <sup>b</sup>
Wastewater storage and treatment reservoirs	1-4	1-6	1-4	1-3 <sup>b</sup>
Constructed wetlands	1-2	0.5-3	0.5-2	1-3
<b>High-rate processes</b>				
<i>Primary treatment</i>				
Primary sedimentation	0-1	0-1	0-1	0-<1
Chemically-enhanced primary treatment	1-2	1-3	1-2	1-3
Anaerobic up-flow sludge blanket reactors	0-1	0.5-1.5	0-1	0.5-1
<i>Secondary treatment</i>				
Activated sludge + secondary sedimentation	0-2	1-2	0-1	1-<2
Trickling filters + secondary sedimentation	0-2	1-2	0-1	1-2
Aerated lagoon + settling pond	1-2	1-2	0-1	1-3
<i>Tertiary treatment</i>				
Coagulation flocculation	1-3	0-1	1-3	2
High-rate granular or slow-rate sand filtration	1-3	0-3	0-3	1-3
Dual-media filtration	1-3	0-1	1-3	2-3
Membranes	2.5->6	3.5->6	>6	>3
<i>Disinfection</i>				
Chlorination	1-3	2-6	0-1.5	0-<1
Ozonation	3-6	2-6	1-2	0-2
Ultraviolet radiation	1->3	2->4	>3	0

Adapted from WHO (2006).

## 14.4 Farm-based Risk Management Measures for Pathogens

### Low-cost Water Treatment Technologies for Pathogen Removal

In Ghana, shallow dugout ponds (usually less than 1-meter (m) deep and 2-m wide) are widely used in irrigated urban vegetable farming sites. In most cases, shallow dugout ponds are used as storage reservoirs into which surface runoff and wastewater effluents are channeled. Refilling frequency of drums and reservoirs depends on their volume and daily water needs. During the storage of water and gradual use in irrigation, sedimentation takes place, like in water storage and treatment reservoirs (WSTRs), although the extent of pathogen removal will be lower depending on the length of the undisturbed retention time. Studies conducted in Ghana showed that these ponds are very effective in removing helminths (reduced to less than 1 egg l<sup>-1</sup>) when sedimentation is allowed for two to three days (Keraita et al. 2008c; Keraita et al. 2014).

Reductions can be achieved with better pond designs (deeper, wedge-shaped pond beds) and training farmers on how to collect water without stirring up sediment in the pond (Keraita et al. 2008c; see Figure 14.2). In addition, measures that can enhance sedimentation, for example, using natural flocculants such as *Moringa oleifera* seed extracts in the ponds, seem to be promising in Ghana (Sengupta et al. 2012). Furthermore, use of additional measures that influence pathogen die-off such as sunlight intensity, temperature and crop type can help in lessening the pathogen load in irrigation water (Silverman et al. 2014).



FIGURE 14.2. Water fetching without stepping in the pond and whirling up sediment.

In addition to the sedimentation ponds, slow sand filtration systems are ideal in treating irrigation water. Sand filters remove pathogenic microorganisms from polluted water by first retaining them in the filtration media before they are eliminated (Stevik et al. 2004). The typical pathogen removal range reported by WHO is 0-3 log reduction units and 1-3 log

reduction units for bacteria and helminths, respectively (WHO 2006). Our research in Ghana using column slow sand filters achieved between 98.2 to 99.8% of bacteria removal, equivalent to an average of 2 log reduction units  $100 \text{ ml}^{-1}$ . In addition, 71 to 96% of helminths were removed (Keraita et al. 2008b). This removal was significant but not adequate as irrigation water had very high levels of indicator organisms.

In Ghana, farmers use different forms of sieves, but mostly use folded mosquito nets over watering cans to prevent particles like algae, gravel and organic particles from entering the watering cans. Studies of this kind of simple filter systems show about 1 log unit removal for bacteria and 12 to 62% for helminths when a nylon textile as a sieve is used (Keraita et al. 2008b, 2010). Further modifications could be done to increase removal rates, because these are the systems that many farmers find easier to adopt. Clogging is a limitation when using sand filters, however proper choice of filtration media (i.e. right uniformity coefficient and effective size configurations) can reduce the problem.

### **Irrigation Methods**

Based on health impacts from wastewater, WHO has classified irrigation methods into three distinct categories: flood and furrow, spray and sprinkler, and localized irrigation methods, such as drip kits (WHO 2006). Flood and furrow irrigation methods apply water on the surface and pose the highest risks to field workers, especially when protective clothing is not used (Blumenthal et al. 2000). Spray and sprinkler are overhead irrigation methods and have the highest potential to transfer pathogens to crop surfaces, as water is applied on the edible parts of most crops. They also promote wide movement of pathogens through aerosols. Localized techniques such as drip and trickle irrigation offer farm workers the best possible health protection and also ensure minimal pathogen transfer to crop surfaces because water is directly applied to the root (Pescod 1992).

However, localized techniques are comparatively the most expensive and are also prone to clogging as polluted water has high particulate levels. They can reduce contamination on crops by 2-4 log units (WHO 2006). Nevertheless, recently introduced low-cost drip irrigation techniques (Figure 14.3), like bucket drip kits from Chapin Watermatics, USA and International Development Enterprises (IDE-India), have more potential for use and adoption in low-income countries (Kay 2001). Studies done in Ghana using bucket drip kits show massive reduction in contamination (up to 6 log units), especially during the dry season (Keraita et al. 2007a). These studies from Ghana also demonstrated that the traditional watering can system could be modified with a 'rose' at the spout of the can so as to diminish splashing of contaminated soils to the crops, which in turn would reduce crop contamination.



FIGURE 14.3. Low-head drip irrigation kit (Note: crop spacing in this experiment is not according to farmers' needs).

### **Withholding Irrigation Prior to Harvesting**

In West Africa, IWMI tested the effectiveness of withholding irrigation (cessation) a few days before harvest to allow pathogen die-off on crop surfaces due to exposure to sunlight and drying-out of surfaces as recommended by Shuval et al. (1986). The results from the field trials in Ghana in the sunny dry season showed an average daily reduction of 0.65 log<sub>10</sub> units of thermotolerant coliforms and 0.4 helminth eggs 100 g<sup>-1</sup> of lettuce (Keraita et al. 2007b). While the lower coliform counts can be attributed to die-off, lower egg counts could be attributed to fewer additions over the days without irrigation. The studies showed that cessation was not appropriate during the wet season due to lower temperatures and soil (and bacteria) splashing from rainfall. On the other hand, the die-off studies were limited to farms, while natural die-off after harvesting can add a further reduction of 0.5-2 log units day<sup>-1</sup> unless new contamination is added (WHO 2006). The greatest limitation of this measure at the farm level is the loss of crop yield under the hot conditions in Ghana. In the Ghana studies, for the daily pathogen reduction obtained, the corresponding losses were 1.4 t ha<sup>-1</sup> of fresh weight (Keraita et al. 2007b). Assuming a yield of 10-15 t ha<sup>-1</sup>, three days without water can result in a 30 to 40% income loss which is a major adoption deterrent for farmers. In cooler climates, such as Addis Ababa, irrigation frequency is much lower and it is possible to plan for several days minus water without any significant loss of yield.

## **14.5 Postharvest Risk Management Measures for Pathogens**

### **Washing and Peeling of Vegetables at Markets**

While studies on internalization of pathogens from wastewater irrigation are very limited, there is a general consensus from a wide range of literature that most pathogenic contamination occurs on the surface of crops (Ilic et al. 2010).

Only few crops (such as carrots and cucumber) grown in our study locations in West Africa could be peeled to reduce the attached pathogen load, at kitchens or in markets. Most of the irrigated crops are leafy vegetables like lettuce, cabbage and spring onions, or 'fruity' vegetables like green pepper and tomatoes. In the risk reduction studies, we adapted produce 'peeling' to the removal of outer leaves for vegetables like cabbage and lettuce. Akple (2009) showed that the simple removal of ('bad-looking') outer vegetable leaves in markets reduced the coliform counts by 0.5 log units (lettuce) to 1 unit (cabbage) without exceeding a weight loss of the crop of 10%. Further peeling would significantly increase safety but also reduce the size of the crop and its market value unless the peeling is carried out at home. Studies on the impact of peeling on crops such as onions, carrots and cucumber are encouraged.

At markets in warm climates, produce sellers sprinkle water or wash vegetables periodically to keep them looking fresh, so that they can sell them at a higher price. However, many markets in low-income countries have no running water and produce sellers have to rely on water that they buy from tankers. Due to costs, and in some cases unavailability, the same water (usually in buckets and bowls) is used to wash or refresh vegetables for the whole day. In Kumasi, few studies have been carried out to assess the effects of this practice on crop (de)contamination (Owusu 2009; Akple 2009). Owusu (2009) assessed levels of fecal coliforms on spring onions over five washing cycles (1 kilogram [kg] of onions in each washing cycle) in a bucket of water as commonly done by vegetable sellers in Kumasi. The study showed a sharp decrease in fecal coliform levels after the first washing, from about 5 log<sub>10</sub> units 100 g<sup>-1</sup> to less than 1 log<sub>10</sub> unit/100 g<sup>-1</sup>. However, subsequent washing cycles (cycle 2-5) recorded again an increase in contamination, with the fifth cycle showing similar fecal coliform levels as those recorded on unwashed spring onions (about 5 log<sub>10</sub> units). In essence, produce sellers should change the water more often or stop washing after the first cycle; however, this will affect the physical appearance of the produce, resulting in a lower price. Alternatively, washing with the same water should be done only once, but this depends on local water availability and might have cost implications.

### **Produce Disinfection in Kitchens**

Amoah et al. (2007a) tested some popular disinfection practices in laboratory conditions to assess their effectiveness in reducing fecal coliform levels. Lettuce, the most commonly grown urban vegetable in Ghana, was used. Results are presented in Table 14.4.

TABLE 14.4. Effect of selected disinfection methods on fecal coliform levels on lettuce in West Africa.

Method	Log reductions	Comments
Dipping in a bowl of water	1.0-1.4	<ul style="list-style-type: none"> <li>- Increased contact time from a few seconds to 2 minutes improves the efficacy from 1 to 1.4 logs.</li> <li>- Not very efficient compared to washing with other sanitizers.</li> <li>- Not very effective for helminth eggs if washing has to be done in the same bowl of water.</li> <li>- Warming the water did not result in different counts.</li> </ul>
Running tap water	0.3-2.2	<ul style="list-style-type: none"> <li>- Comparatively effective compared with washing in a bowl, also for helminth egg removal.</li> <li>- Increased efficacy only with increased contact time from a few seconds to 2 minutes.</li> <li>- Limited application potential due to absence of tap water in poor households.</li> </ul>
Dipping in a bowl with a salt solution	0.5-2.1	<ul style="list-style-type: none"> <li>- Salt solution is a better sanitizer compared to dipping in water if the contact time is long enough (1-2 minutes).</li> <li>- Efficacy improves with increasing temperature and increasing concentration, however, high concentrations have an aging effect on the appearance of some crops like lettuce.</li> </ul>
Dipping in a bowl with a vinegar solution	0.2-4.7	<ul style="list-style-type: none"> <li>- Very effective at high concentrations (<math>&gt;20 \text{ ml l}^{-1}</math>) but this could have possible negative effects on taste and palatability of the washed vegetables and will also be too expensive.</li> <li>- To achieve best efficacy and keep the sensory quality of the product the contact time should be increased to 5-10 minutes.</li> <li>- Efficacy is improved even at low concentration if carried out with a temperature over <math>30^\circ\text{C}</math>.</li> </ul>
Dipping in a bowl with purple potassium permanganate solution	0.6-3.0	<ul style="list-style-type: none"> <li>- Most effective at higher concentrations (200 ppm), a temperature of <math>30^\circ\text{C}</math> or higher and a contact time of 5-10 minutes.</li> <li>- Higher concentration dyes washed vegetables purple which requires more water for rinsing or may raise questions of a negative health impact.</li> </ul>
Dipping in a bowl with a solution containing a washing detergent (OMO <sup>TM</sup> )	1.6-2.6	<ul style="list-style-type: none"> <li>- Significant reductions could be achieved with 5-10 minute contact time.</li> <li>- Residual perfumes and soap taste might affect the consumer's sensory perception</li> <li>- As OMO contains surfactants which could affect health, thorough rinsing is required.</li> </ul>
Dipping in a bowl of water with added household bleach	2.2-3.0	<ul style="list-style-type: none"> <li>- Tested dosages (commercial bleach) resulted in <math>165\text{-}248 \mu\text{S cm}^{-1}</math> salinity (= concentration indicator).</li> <li>- Effective with 5-10 minute contact time, and widely used in Francophone West Africa.</li> <li>- May pose health risks if dosage is not well explained and too high.</li> </ul>
Dipping in a bowl of water containing chlorine tablets	2.3-2.7	<ul style="list-style-type: none"> <li>- Effective at 100 ppm but tablets not commonly available in some West African countries.</li> <li>- Effect of higher concentrations on efficacy not tested.</li> </ul>

Source: Amoah et al. (2007a), modified.

The assessment showed that, irrespective of the method used, washing vegetables reduced fecal coliform levels in lettuce, however, the levels varied significantly and common concentrations of salt or vinegar, for example, appeared to have little impact. Pathogen removal through disinfection was largely influenced by contact time, concentration and the type of disinfection. Similar results were obtained for related studies done to disinfect cabbage and spring onion (Akple 2009). Table 14.4 shows recommended options like potassium permanganate (available in local pharmacies and markets) or bleach which is a very common vegetable disinfectant in Francophone West Africa (so-called 'Eau de Javel').

Vegetable washing was also recommended in view of pesticides, although some are hydrophobic and can only be removed with soap. For crops that can be peeled, like tomatoes, the removal of the skin was recommended. This was considered the best option as with a melting point over 100°C, even boiling could not remove some pesticides (Obuobi et al. 2006).

#### **14.6 Chemical Contaminants**

There are management options for smallholder farmers in developing countries to address the challenges and risks of exposure to heavy metals or excessive salts through irrigation water. These measures include soil- and water-based interventions as well as changes in crops and crop varieties (Simmons et al. 2010). Compared to interventions suggested for pathogens, the options remain however limited and it is not possible to provide (for most of these measures) details on their general effectiveness in terms of health risk reduction which will largely depend on local contamination levels, current practices and site conditions, as well as spatial and temporal factors; thus careful risk assessment and monitoring are required. This is a challenge as the required analytical capacity to analyze heavy metals, for example, and in particular organic contaminants is seldom adequate in developing countries, like Ghana. It is therefore important to support the enforcement of legislations separating industrial from domestic wastewater streams or other water source potentially used for irrigation, and to treat any chemical effluent at its source.

Where contaminated water is used, the contaminant might not enter the food chain if the affected crop functions as a health risk barrier, which is the case for certain heavy metals (see chapter 9). In other cases, farmer and authorities might have no other choice than to go for nonedible crops (for instance biofuel) or to zone the areas for nonagricultural land use (Simmons et al. 2010).

### 14.7 Options to Support Uptake of Safe Practices

The adoption of safe practices by key actors means that farmers, produce sellers and those who prepare food in households and street restaurants need to change their behavior and routine practices. However, although experience shows that conventional awareness rising and training in improved safety practices is important, both are not a guarantee for any behavior change and practice adoption (Drechsel and Karg 2013). Indeed, for most risk mitigation measure, the related actors will need to make an ‘investment’. The investment can be in different forms such as (i) increased labor, (ii) some capital or operational costs, (iii) loss of space and yield or (iv) other inconveniences from behavior change. To support this investment, it is important to understand what could trigger behavior change and/or which incentive systems are needed to trigger and maintain it (Frewer et al. 1998). This critical area for implementing the multibarrier approach is not addressed in the current WHO (2006) guidelines.

Some specific factors that could enhance adoption of risk mitigation measures are given below.

**Economic incentives:** Studies show that people are more likely to adopt innovations for direct economic returns on investments (Frewer et al. 1998). The adoption of safer irrigation practices should then potentially help farmers and traders to sell more or sell at higher prices. However this will only happen if consumers show risk awareness and are willing to pay more for safer produce. Where this is the case, producer groups should be encouraged to sell their products outside the existing marketing channels to avoid mixing-up with unsafe produce. This could be done by linking farmers directly to large consumers like hotels and demarcating specific selling points in markets and supermarkets (see chapter 11).

Economic incentives can also come from the public sector, for example through subsidies or soft loans for key actors to adopt safer practices or rewards for those that have already adopted them. For this to happen, local authorities need to understand the overall benefits of safer practices to society, as well as the overall costs. A quantification of such costs and benefits and demonstration that benefits are higher than costs will help to justify this public support. A supporting measure can be economic disincentives, such as taxes or fines for noncompliance with mutually-agreed on safety measures.

**Enabling farmers to visualize the risk:** To encourage behavior change, key actors need to be aware of the risks of wastewater irrigation and the benefits of adopting safer practices. This awareness concerns consumers like traders and producers (Amoah et al. 2009). The importance of awareness to increase demand and willingness to pay for safer products has been discussed in the previous section. A particular challenge of pathogenic risks is their invisible nature which makes it difficult for the key actors to (i) be aware of the risks and (ii) to assess the effectiveness and quantify the impacts of suggested risk mitigation measures. Risk visibility would greatly facilitate risk perceptions and encourage adoption of safer practices. While many actors like farmers and produce sellers in low-income countries use physical indicators such as color, dirt and odor to assess the cleanliness of the produce, these physical indicators do not always correspond with microbiological indicators<sup>2</sup>. Scientists need to work with farmers to validate physical indicators or combinations of physical indicators that can indicate levels of microbiological contamination at the farm level (Keraita et al. 2008a; Amoah et al. 2009). Key actors will also like to ‘see the impacts’ of the risk mitigation measures before changing from their original practices to new ones. In this regard, participatory approaches as used in many farming experiments could help key actors to compare new practices with old practices in their own environments before making choices.

**Social marketing:** Social marketing seeks to induce a target audience to voluntarily accept, modify or abandon behavior for the benefit of individuals, groups or society as a whole (Siegel and Doner-Lotenberg 2007). This could be an important tool for adopting risk mitigation measures in low-income settings where economic (market) incentives are limited by low-risk perceptions among customers (Drechsel and Karg 2013).

Even if health considerations are not valued highly in the target group, social-marketing studies can help to identify valuable related benefits, including indirect business advantages (such as attracting tourists), improved self-esteem and a feeling of comfort or respect for others. Studies must look for supportive core values that trigger the adoption of innovative approaches. For example, if a feeling of being ‘advanced’ can be associated with using vinegar rather than salt for vegetable washing, or drip kits compared to watering cans, then the social-marketing messages and communication strategies should re-inforce these existing positive associations (Karg and Drechsel 2011).

---

<sup>2</sup> An innovative tool for visualizing ‘invisible’ threats is the Glitterbug™ ([www.glitterbug.com](http://www.glitterbug.com)).

**Land tenure security:** Concentration of population and economic activities in cities results in very limited land availability and intense competition for its use in and around urban areas. Besides, and especially in Ghana, there is often uncertainty regarding the ownership of land (see chapter 13). In general, market forces push up land price and landowners will seek maximum revenue (rent) from their plots which makes farming noncompetitive. That we still see many hectares under agriculture is the result of informal farming on plots with low housing value (flood-prone zones and so forth) or where agriculture is tolerated as a transitional occupancy, especially on so far unused governmental or institutional land. Both forms have in common a very weak land tenure security which was often mentioned by farmers as a key risk factor for their livelihoods (see chapter 10). An incentive such as better tenure security could facilitate farmers' interest in investments in structures that have positive health impacts, such as small-scale wastewater treatment ponds. Municipalities may adopt a variety of approaches to securing land for horticulture, including regularization of informal titles, or promoting urban farming on public land (such as terraces along urban rivers). Similar incentives are possible for street food restaurants, which are often more informal than formal.

**Training and extension:** Another key factor for the correct application of safer practices and compliance over time is having trained and qualified actors. Extension services and research-extension linkages will have a significant role to play. The current curriculum of urban extension officers is not much different from the one for rural extension and modules on exotic vegetable production or irrigation with polluted water sources are needed. Training materials (also for trainers) supporting food safety on and off farm have been prepared for example by IWMI and FAO (Box 14.2) and can be used within larger training programs like farmer field schools (see chapter 11) for urban and peri-urban producers (e.g. FAO 2007).

**Laws and regulations:** Karg and Drechsel (2011) identified regulations as an important external factor to institutionalize new food-safety recommendations so as to provide the legal framework for compliance monitoring via both incentives (e.g. certificates) and disincentives (e.g. fees). To integrate improved food-handling practices into institutional structures, inspection forms can be updated, inspectors and extension officers can be trained and pressure can be applied to farmers and caterers to enhance compliance. However, regulations should not be based on imported (theoretical) standards, but rather on locally feasible standards that are viewed as practical and are not prone to corruption. In this way, regulation

and institutionalization may contribute to ensuring the long-term sustainability of behavior change, whereas promotional and educational activities are usually limited to a specific time frame.

**BOX 14.2.** Training and awareness materials on wastewater irrigation and food safety developed by IWMI and FAO in Ghana.

On-farm practices for the safe use of wastewater in urban and peri-urban horticulture. A FAO training handbook for farmer field schools. [www.fao.org/docrep/016/i3041e/i3041e.pdf](http://www.fao.org/docrep/016/i3041e/i3041e.pdf)

Low cost options for health risk reduction where crops are irrigated with polluted water in West Africa. IWMI Research Report  
[www.iwmi.cgiar.org/Publications/IWMI\\_Research\\_Reports/PDF/PUB141/RR141.pdf](http://www.iwmi.cgiar.org/Publications/IWMI_Research_Reports/PDF/PUB141/RR141.pdf)

On-farm treatment options for wastewater, greywater and fecal sludge with special reference to West Africa. IWMI Resource Recovery and Reuse Report.  
[www.iwmi.cgiar.org/Publications/wle/rrr/resource\\_recovery\\_and\\_reuse-series\\_1.pdf](http://www.iwmi.cgiar.org/Publications/wle/rrr/resource_recovery_and_reuse-series_1.pdf)

Safer irrigation practices for reducing vegetable contamination in urban sub-Saharan Africa: An illustrated guide for farmers and extension officers.  
[www.iwmi.cgiar.org/Publications/Books/PDF/Farmers\\_Guide-Low\\_res-Final2.pdf](http://www.iwmi.cgiar.org/Publications/Books/PDF/Farmers_Guide-Low_res-Final2.pdf)

Improving food safety in Africa where vegetables are irrigated with polluted water. Awareness and training video for staff of street restaurants. [http://youtu.be/DXHkQE\\_hFg4](http://youtu.be/DXHkQE_hFg4) \*

Good farming practices to reduce vegetable contamination. Awareness and training video for wastewater farmers and extension officers. [http://youtu.be/Aa4u1\\_RblfM](http://youtu.be/Aa4u1_RblfM) \*

\* The two films listed here also on the CD which is part of this publication.

**Effective communication:** To be useful, knowledge (whether it is farmers' innovations, latest research findings or pressing policy issues) must be effectively shared amongst people and institutions. It is important to understand the information pathways (like media) used by key actors, such as farmers, produce sellers and those who prepare foods in households and street restaurants, who should adopt risk mitigation measures, so that effective communication channels are selected to reach the target groups. For example, a pilot social marketing study in Ghana showed that it is more likely that innovations spread from farmer to farmer through social networks than through any external facilitation (Keraita et al. 2010). Farmers prefer field demonstration and/or learning-by-doing. This also verifies the importance of encouraging actors' own experimentation because it promotes knowledge generation, as well as self-monitoring and evaluation. However, it is pertinent for the implementation process to recognize the wider system within which key actors operate. The wider system, made up of institutions, regulatory bodies and in- and output markets can have

a significant positive or negative influence on key actors' decision making, while this is often ignored by scientists.

### **14.8 Conclusions**

Developing risk mitigation measures in line with the WHO-recommended multi-barrier approach offers a variety of options to achieve a realistic chance for the management of pathogenic risk along the food chain deriving from informal wastewater irrigation in low-income countries. Improving urban sanitation and wastewater treatment remains however central to address also chemical contaminants and to safeguard the natural environment.

Where treatment capacity is weak, this chapter has demonstrated the potential of additional pathogen barriers tested in actual field studies in Ghana. The studies have shown that farm and postharvest risk mitigation measures can contribute to preventing contamination and supporting decontamination of vegetables grown with highly-polluted water. Although the effectiveness of *individual* measures may not be sufficient to safeguard public health, measures can be used in combination to complement each other (multiple barriers) in order to achieve acceptable risk levels. Combinations can be accomplished within and between operation levels, i.e. farms, markets and households. The measures presented, though not exhaustive, allow for flexibility to adaptation in different locations. Equally important are however the discussed factors, incentives and strategies that could foster adoption of safety practices, as risk awareness per se is still low and thus also market demand for safe produce.

## 15. Governmental and Regulatory Aspects of Irrigated Urban Vegetable Farming in Ghana and Options for its Institutionalization

Pay Drechsel, Emmanuel Obuobie, Andrew Adam-Bradford and Olufunke O. Cofie

*This chapter examines key institutional issues that are important to the recognition and sustainability of irrigated vegetable farming in Ghanaian cities. It assesses the informal nature of the business and examines current roles being played by relevant agencies directly or indirectly linked to urban vegetable farming and urban wastewater management. The chapter also looks at relevant bylaws, strategies and policies that have implications for the recognition of informal irrigation and/or the adoption of safety measures for risk reduction in irrigated vegetable farming. It also suggests options to facilitate the institutionalization of irrigated urban agriculture.*

### 15.1 Informality of Irrigated Urban Farming

Cornish et al. (1999) define *formal* irrigation as being reliant on some type of fixed irrigation infrastructure that was designed and may be operated by a public entity or private sector and which is used by more than one farm household; while *informal* irrigation is practiced by individuals or groups of farmers without reliance on irrigation infrastructure that is planned, constructed or operated through the intervention of a government or donor agency. The development of formal irrigation schemes in Ghana is recent compared to other more water-scarce countries. In 2007, the Ghana Irrigation Development Authority (GIDA) under the Ministry of Food and Agriculture (MoFA) reported 22 irrigation schemes under its jurisdiction with a potential area of about 14,700 hectares (ha) of which about 60% are developed for irrigated farming (JICA-MoFA 2007). The actual land area that is cropped has been changing over the years and seasons and varies among reports from 5,000 to 7,000 ha. Most of the nonfunctioning or underperforming schemes are pump-based (GIDA-JICA 2004). Similar to the definition of Cornish et al. (1999), Namara et al. (2010) classified irrigation systems in Ghana into two broader groups based on their current level of formalization. These are (1) the *conventional* systems, which are mainly initiated and developed by the Government of Ghana or various NGOs; and (2) *emerging* systems initiated and developed by private entrepreneurs and farmers, either autonomously or with little support from the government and/or NGOs. Besides a few – mostly export-oriented – commercial schemes (Agodzo and Blay 2002; Gyamfi 2002), irrigated vegetable farming in urban and peri-urban Ghana clearly falls under the ‘informal’ or ‘emerging’ smallholder category. In the 40

kilometer (km) radius around Kumasi alone, there are estimated to be 12,700 households irrigating at least 11,900 ha in the dry season, which is about twice the area cropped under formal irrigation in the whole of Ghana (Cornish and Lawrence 2001). However, informal irrigation goes beyond urban and peri-urban vegetable production and includes, for example, shallow groundwater use, as in the Upper East and Keta area, irrigation around small reservoirs and along the Volta River (Namara et al. 2010).

In spite of its size and importance, these forms of irrigated vegetable farming do not yet receive the support they need from policy makers and irrigation institutions. For instance, the GIDA, which is the government agency officially responsible for developing irrigation in Ghana focused since its inauguration solely on conventional or formal irrigation schemes, until in 2010 the new National Irrigation Policy, Strategies and Regulatory Measures extended GIDA's mandate. Still, it takes time till official training programs for extension staff and farmers consider the needs of informal irrigators.

## 15.2 Agencies Relevant to Irrigated Urban Farming

At least seven ministries<sup>1</sup> are responsible for the formulation of policies affecting the nexus of irrigated agriculture, food safety and food quality. These are the

- Ministry of Food and Agriculture;
- Ministry of Trade and Industries;
- Ministry of Health;
- Ministry of Local Government and Rural Development;
- Ministry of Environment, Science, Technology and Innovation;
- Ministry of Tourism, Culture and Creative Arts;
- Ministry of Water Resources, Works and Housing.

Due to decentralization, many responsibilities, especially of the Ministry of Food and Agriculture and Ministry of Health have shifted from ministerial departments to district departments and units, which remain linked to the original ministries but report to the local **assemblies**, like the Accra or Kumasi Metropolitan Assemblies (AMA and KMA).

### The Ministry of Food and Agriculture (MoFA)

The MoFA is charged with the development and growth of agriculture in the country. The departments and agencies under the MoFA undertake, for example, the setting of standards

---

<sup>1</sup> Names of ministries differ slightly over the years, also as certain purviews might be moved from one to another ministry. For the current status please see [www.ghana.gov.gh](http://www.ghana.gov.gh).

for Integrated Crop Management (ICM), Integrated Pest Management (IPM) or irrigation water management, to name just a few activities. They are also responsible for providing extension services and specific components of inspection and registration in collaboration with the Ghana Standards Board.

In accordance with government policy of decentralization, the MoFA's current structure comprises a National Secretariat made up of four line directorates, technical directorates, regional and district directorates, and subvented organizations.

Selected subvented organizations and directorates are, for example, the

- Ghana Irrigation Development Authority (GIDA);
- Agricultural Extension Services Directorate;
- Women in Food and Agricultural Development Directorate.

In 2005, the Ministry at the national level officially acknowledged urban and peri-urban agriculture and its water challenge in a vision statement (see chapter 10). Implementing this, the MoFA-AMA **director**ate started working on zoning of lands for farming and tried to assist farmers in accessing safer irrigation water. MoFA-AMA works closely at the implementation level with the **Metropolitan Sub-Committee on Agriculture**, which mainly plans and evaluates agricultural policies, marketing options and so forth. The directorate also works with the **metro-health directorates** to enforce bylaws related to health aspects of urban agriculture (food quality, market cleanliness etc). The national MoFA Extension Services Directorate supports the district directorates, and in 2005 started exploring groundwater availability for urban vegetable farmers in Accra. The **Irrigation Development Authority** is a semi-autonomous subvented government agency under the responsibility of the MoFA. With the recent approval of Ghana's first national irrigation policy, GIDA will support formal, informal and commercial irrigation in the country, including irrigated urban and peri-urban agriculture.

### **The Ministry of Trade and Industry (MoTI)**

The MoTI has overall responsibility for the formulation, implementation and monitoring of Ghana's internal and external trade. Bodies under the MoTI set standards for local and imported fresh and processed foods and drugs. They also ensure chemical safety by monitoring quality and usage. These bodies, in addition, undertake training of staff as well as inspection of products and premises.

The statutory and regulatory agency under the MoTI concerned with the safety of food is the **Ghana Standards Authority** (see below).

### **The Ministry of Health (MoH)**

As a critical sector of the economy, the MoH seeks to improve the health status of all people living in Ghana. The statutory and regulatory agency under the MoH tasked with issues related to food quality and safety is the **Food and Drugs Authority** (see below). Another important body is the decentralized **Ghana Health Service (GHS)** established under Act 525 of 1996 as required by the 1992 constitution. It is an autonomous Executive Agency responsible for implementation of national policies under the control of the Minister of Health. The GHS has eight directorates and under the **Public Health** office there are several units, which all could be linked to health risks from irrigation, like Disease Control, Family Health and Nutrition.

There are regional and district **Directorates of Health**, District Health Management Teams and District Health Committees. Though they work with the assemblies, they report to both the Assembly and the Ministry. According to the Local Government Act of 1993 (Act 462) Section 14, the directorates are the implementing agencies responsible for health and sanitation issues within cities. There are some overlapping functions with the Environmental Health Departments of the local assemblies which, however, address sanitation to prevent unhealthy situations while the MoH outlets work more on the curative part of health care. The health directorates also work closely with the **Metro Subcommittee on Environmental (Health) Management** which is responsible for making policies in areas of health, sanitation, waste management, pollution control and prevention, management of waterbodies and resources among others.

### **The Ministry of Local Government and Rural Development (MLGRD)**

The Ministry is the supervisory body of the District Assemblies. Its task is to promote the establishment and development of a vibrant and well-resourced decentralized system of local government. Tasks include among others facilitating the promotion of a clean and healthy environment and of horticultural development. The Ministry developed the National Sanitation Policy (NSP) which was approved by the Cabinet in 2010. In 2008, the **Environmental Health and Sanitation Directorate (EHSD)** was established under the MLGRD which addresses, among others, wastewater treatment and is the single most decentralized institution with presence at national, regional and district levels. The Directorate is supporting Regional Environmental Health and Sanitation Units in support of District Environmental Health (and Sanitation) Departments to provide input on possible health impacts linked to environmental sanitation in district-planning processes. The departments have to prevent communicable diseases, promote health and educate the public on basic

personal hygiene and the rudiments of environmental health through Environmental Health Officers (**EHOs**). The enforcement of the laws regulating food treatment and handling in general and street-food vending in particular is also the task of these departments. They work closely with the respective **Metro Environment Management Sub-Committee** and **Waste Management Departments** where available.

The Ministry also operates the **Department for Parks and Gardens** which takes care of some sites occupied by urban farmers.

### **The Ministry of Environment, Science, Technology and Innovation (MEST)**

The overall objective of the MEST is to ensure accelerated socioeconomic development of the nation through the formulation of sound policies and a regulatory framework to promote the use of appropriate environmentally friendly, scientific and technological practices and techniques. This includes the intensification of the application of safe and sound environmental practices. Under the Ministry, the **Department for Town and Country Planning** has an advisory role to the assemblies in planning and zoning for different land uses. Activities related to food quality and food safety relate to the planning, set up and maintenance of market infrastructure and inspection/licensing of food vendors and caterers which is done in cooperation with the Food and Drugs Board (FDB).

The Ministry is also supervising the **Environmental Protection Agency (EPA)**. The EPA was created in 1994 as a regulatory body for environmental affairs. Included in its mandate is the control and prevention of discharge of waste into the environment, and the protection and improvement of the quality of the environment in addition to ensuring compliance with any laid down environmental impact assessment procedures in the planning and execution of development projects. The EPA is also charged with setting standards (environmental management, chemical management), pesticide regulation and registration of chemicals as well as advice and inspection tasks.

The Ministry is also operating through the **Council for Scientific and Industrial Research (CSIR)** which provides an umbrella for Ghana's research institutions such as the Water Research Institute (WRI).

### **Ministry of Tourism**

The **Ghana Tourism Authority (GTA)** was established by the Tourism Act, 2011 (Act 817) as the main implementing body of the Ministry of Tourism. It replaced the **Ghana Tourist Board** which was established in 1973, and has among others, the mandate to register, supervise and regulate practices and standards of accommodation and catering enterprises,

including restaurants, ‘chop bars’ and fast food establishments, and thus is an important partner for any efforts to improve food safety in this sector (see below).

### **The Ministry of Water Resources, Works and Housing (MWRWH)**

The Ministry is supervising the Ghana Water Company Limited (GWCL), Community Water and Sanitation Agency (CWSA), **Water Resources Commission (WRC)** and the Water Directorate of the Ministry.

While GWCL embarks on water supply development activities in urban areas, the CWSA is responsible for facilitating the provision of potable water and sanitation to rural areas and small towns under the auspices of the District Assemblies. The guiding program is the National Community Water and Sanitation Programme (NCWSP). Sanitation in urban centers falls under the responsibility of the respective assemblies.

Ghana’s **Water Resources Commission (WRC)** was established by an Act of Parliament (Act 522 of 1996) with the mandate to regulate and manage the country’s water resources and coordinate policies relating to them. The WRC coordinated the process of developing Ghana’s National Water Policy and initiated the National Water Quality Monitoring Programme. As a first step, a Raw Water Quality Monitoring Guideline for the Coastal and Western river systems in the country has been developed. Consultations are ongoing between the WRC and the EPA for preparing a memorandum of understanding on wastewater discharges and pollution of waterbodies and the respective roles to be played by each institution. The WRC also facilitated the establishment of a uniform riparian buffer zone policy for riverbanks, reservoirs, lakes, etc. This policy targets agricultural encroachments and therefore small-scale farmers along the major rivers but also along streams in urban and peri-urban areas using stream water for irrigation.

### **Selected National Statutory Bodies:**

With regard to food quality and safety, the following statutory and regulatory bodies play a significant role in Ghana, the Ghana Standards Authority (GSA), the Food and Drugs Authority (FDA) and the Ghana Tourism Authority (GTA).

**The Ghana Standards Authority (GSA)** formerly the Ghana Standards Board (GSB): As an authority under the MoTI, the GSA is tasked with setting standards, including those on food quality in line with relevant international standards, like the FAO-WHO supported ‘Codex Alimentarius’. The application of food standards in products and processes is governed by national standards. The GSA has established over 300 standards on food products that offer

protection, reliability and choice while ensuring safety and quality. Sections of the standards on food safety touch on hygiene, microbiological, packaging and labeling requirements.

An example of such standards is the GS ISO 22000:2005, which specifies requirements for an enterprise in the food supply chain, to plan, implement, operate, maintain and update a Food Safety Management (FSM) system. The FSM combines the Hazard Analysis and Critical Control Points (HACCP) plan (Box 15.1) with basic conditions and activities necessary to maintain hygienic environments suitable for the production, handling and provision of safe end products via *good practices* (cf. Conclusions). The standards require that all hazards expected to occur in the food chain, including those associated with the type of process and facilities used, are identified, assessed and controlled or eliminated, to ensure food safety.

**BOX 15.1. Hazard Analysis Critical Control Point (HACCP)**

The **HACCP** is a systematic **preventative** approach to food safety and quality assurance of food products based on a system of identification, evaluation and control of hazards. It addresses physical, chemical and biological hazards as a means of preventing threats rather than inspection of finished products. The HACCP is recognized by FAO and WHO as a Quality Assurance System that contributes to enhancing food safety and preventing the outbreak of food-borne diseases. Legislators in an increasing number of countries stipulate legal requirements regarding hygiene in the food industry based on the HACCP principles as laid down in the Codex Alimentarius *Code of Practice – General Principles of Food Hygiene*.

Another key operational area of the GSA is quality control and testing: chemical and microbiological analysis of food and drinks and agricultural products for quality evaluation and certification purposes, pesticide residues in food products, product-testing and certification to ensure conformity with specific (export) target markets. However, as the GSA is addressing many sections of life, it is less equipped in terms of staff and resources in individual areas like food quality; here the FDA (see below) is in a better position. On the other hand, the GSA is probably better positioned to steer a policy process to institutionalize the new WHO guidelines in the country through the Codex Alimentarius.

The **Food and Drugs Authority (FDA)** evolved in 2012 from the Food and Drugs Board (FDB) which was established in August 1997. It is the National Regulatory Authority mandated by the public Health Act, 2012 (Act 851) to regulate among others food, drugs and food supplements. The FDA operates under the MoH and is charged to regulate the

manufacture, importation, exportation, distribution, use and advertisement of food, drugs, cosmetics, household chemical substances and medical devices. With special reference to food quality and safety, the FDA is responsible for:

- The registration of food, human and animal drugs, herbal medicines, homeopathic drugs, cosmetics, medical devices and household chemical substances;
- The publication of codes of practice in connection with matters provided for under the food and drugs law for the purpose of giving guidance (such as guidelines for the export of palm oil).

The FDA's activities in the field of food hygiene and food safety are based on the Food and Drugs Law, 1992, PNDCL-305B; and Food and Drugs (Amendment) Act, 1996, Act 523. The FDA's **Food Safety Division** contributes to the attainment of the functions of the authority for safeguarding public health and safety by ensuring that all food products meet the appropriate standards of safety and quality. This is achieved through inspection, analysis as well as ensuring that labeling requirements are met. The division also monitors catering facilities by collaborating with EHOs of district assemblies who carry out inspections and enforce basic rules related to food hygiene on site.

**The Ghana Tourism Authority (GTA)**, formerly the Ghana Tourist Board (GTB), was established by the Tourism Act, 2011 (Act 817) under the Ministry of Tourism. The GTA has the powers to register, supervise and regulate the practices and standards of accommodation and catering enterprises in Ghana. The GTA is also empowered to close until further notice the premises of an enterprise and fine/imprison an owner, where the standards do not meet the minimal criteria, declared in LI 1205. In this context, LI 1205 specifies:

- That all catering enterprises need to be registered and licensed (license renewed each consecutive year) by the GTA, or otherwise to be considered illegal and liable for prosecution;
- The minimum requirements for the staff members of an enterprise and standards of the facilities needed to prepare, serve and store the food, including kitchen and dining area facilities; facilities for customers and staff; garbage disposal; water supply; staff medical examination (every half a year and photocopies submitted to the GTA); staff uniforms and so forth. Street food vendors have to register with the municipal assembly;
- Some of the food hygiene aspects that must be observed by the catering enterprises: clean and tidy premises; "no food exposed to the risk of contamination"; appropriate hand washing facilities for staff and customers with "soap, nail-brushes and clean towels".

In order to avoid overlapping responsibilities, the FDA and GTA agreed some years ago that the FDA (FDB) should carry out inspections in hotels and restaurants and award hygiene permits on behalf of the GTA (GTB).

### **Other Institutions**

Besides various urban farmer associations (see chapter 11) or Ghana's Traditional Caterers' Association, the *Nestlé* supported Maggie Fast Food Association of Ghana (MAFFAG) is very prominent within the fast food sector and has significant outreach. The MAFFAG also engages in capacity-building activities with a significant interest in food safety. Other stakeholders are for examples GIDA's irrigation training center, MoFA's training schools for extension officers and the various schools providing training in food catering, food safety and hygiene as well as the Ghana Social Marketing Foundation (GSMF) which could be an important partner for facilitating behavior change towards 'good practices'.

To develop good practices for enhanced food safety, several national research organizations and universities had related projects in the past, such as the CSIR and the Noguchi Memorial Institute at Legon concerning (street) food safety, and the Kwame Nkrumah University of Science and Technology (KNUST) and University of Development Studies (UDS) regarding safer irrigation practices, both in close collaboration with IWMI, Accra. Particular research interest and support for urban agriculture has also been provided over the last years for example by FAO ([www.fao.org/fcit](http://www.fao.org/fcit)), the RUAF Foundation c/o IWMI-Accra, the College of Agriculture and Consumer Sciences (CACS) of the University of Ghana, the Development Planning Unit at the University College London (UCL) and the African-German partnership under UrbanFoodPlus – GlobE ([www.urbanfoodplus.org](http://www.urbanfoodplus.org)).

### **15.3 A Review of Regulatory Bylaws, Policies and Development Plans**

Of over 90 bylaws, policies, regulations and strategies reviewed in 2007 and periodically later, several addressed unsafe water for agricultural production and/or street food safety. There are three legislative documents which directly mention and/or address 'wastewater' irrigation. These are at the district level Accra's bylaws and at the national level the 2010 Medium Term Agriculture Sector Investment Plan and the National Irrigation Policy of 2011. Most others legislations address issues related to food handling and safety (see also Fenteng 2000; Laryea 2002). The most important documents and statements of relevance for irrigated urban vegetable farming and the implementation of the WHO (2006) guidelines and their institutionalization are summarized below.

## Bylaws

The most comprehensive bylaw compilation is available for Accra. In the 1970s, most municipal bylaws referring to urban food production and sale were put in place, however, not to increase food production but to maintain sanitary standards (Obusu-Mensah 1999).

Many bylaws which date back to 1972 were updated in 1976, 1977, 1993 and 1995 (Obosu-Mensah 1999). They support backyard gardening but demand the registration of open-space farmers. Three sections of these bylaws show that the Accra Metropolitan Assembly (AMA) has a clear direction for urban agriculture and food safety. Among these are (i) control of swine, cattle, goats and sheep; (ii) control of poultry in dwelling houses; and (iii) growing and sale of crops (AMA 1995, pp. 171-202). The third states that no person shall grow crops anywhere other than on land within his/her premises unless he/she has registered with the medical officer of health furnishing his/her name and address and the description of the site where the crop is to be grown. It continues strictly that:

*“No crop shall be watered or irrigated by the effluence from a drain from any premises or any surface water from a drain, which is fed by water from a street drainage. Also no crops shall be sold, offered or displayed for sale at any other place than in a market, stall, store, or kiosk. The medical officer of health may where he considers necessary in the interest of public health, declare any crops unfit for human consumption. No crop declared unfit for human consumption shall be sold, offered or displayed for sale as human food. A person who contravenes this bye-law commit an offence and is liable on summarily conviction to a fine not exceeding hundred thousand cedis<sup>2</sup> or in default of the payment of the fine, to a term of imprisonment not exceeding three months or to both” (AMA, 1995).*

In short, the AMA bylaws follow categorically a water standard-based approach, which does not foresee alternative measures to protect public health. These bylaws are however barely enforced and currently under review for possible revision. There are no specific bylaws regulating urban agriculture in other cities, like Kumasi or Tamale.

With increasing attention to farming in the city and knowledge about options for health risk reduction, the MoFA proposed a revision of the AMA bylaws. This process is still ongoing, and was facilitated in the past by IWMI’s Resource Centres on Urban Agriculture and Food Security (RUAF) project resulting in the following proposition for a wastewater irrigation bylaw (Box 15.2).

---

<sup>2</sup> 100,000 (old Ghana) cedis were about USD100 in 1995; USD11 in 2006 and approximately USD2.7 in August 2014.

BOX 15.2. Proposed Changes in Accra Bylaws on Wastewater Irrigation

**Current AMA Bylaw**

“No crop shall be watered or irrigated by the effluence from a drain from any premises or any surface water from a drain, which is fed by water from a street drainage” (AMA, 1995).

**Proposed AMA Bylaw**

“No parts of the crops consumed in the fresh or raw state shall be watered or irrigated directly by the effluent from a drain from any premises or any surface water from a drain which is fed from any water from a street drainage, unless appropriate risk reduction measures such as drip irrigation, furrow irrigation and cessation of irrigation prior to harvesting as outlined in the WHO/FAO guidelines (wastewater reuse) of 2006, or simple water treatment options are put in place”.

**National strategies and policies**

At the national level, especially those policies of younger origin appear progressive and supportive of the WHO (2006) guidelines.

The **Food and Agriculture Sector Development Policy (FASDEP) I and II** (September 2002, August 2007): The first FASDEP edition highlighted that MoFA considers food quality as part of food security and that “the quality of food is determined by the methods of production, harvesting, haulage, processing, storage, packaging and marketing”. The second FASDEP edition (2011-2015) acknowledges in addition that “practitioners of **urban agriculture**, a source of livelihood for migrants in major cities, are confronted with problems of access to land and irrigation water, and access to extension services, particularly on the safe use of agrochemicals. Since the commodities are mainly vegetables that are in most cases consumed fresh, the lack of access to quality extension also has food safety implications for consumers.” The policy also says that “Formal irrigation development has been very much supply-driven. The informal sector on the other hand is not serviced sufficiently to realize its potential. Irrigation support services especially for the private sector have been inadequate due to unclear institutional mandates.” In this sense, FASDEP I supported micro- and small-scale irrigation with the provision of boreholes and dugouts.

The **Medium Term Agriculture Sector Investment Plan** (METASIP) was developed to implement FASDEP II from 2011 to 2015. The plan refers, under component 2.6, explicitly to the support of urban and peri-urban agriculture and mentions the common use of wastewater. It outlines related benefits and potential risks and refers in this context to Section 51, subsection 3 of the **Local Government Act** 462 (1993) which generally allows urban farming activities without prior permission from the District/Metropolitan Planning Authority.

However, METASIP also mentions the AMA bylaws (see above) demanding mandatory registration with the metropolitan officer of health. METASIP mentions that urban farmers face constraints of access to land and quality water for irrigation. Under 2.6.1, METASIP is setting a target of a 20% production increase from peri-urban agriculture and earmarks – among others – the following to increase output generation from urban and peri-urban agriculture:

- Liaise with metropolitan, municipal and district authorities to zone areas within urban and peri-urban areas for agricultural activities;
- Identify owners and potential users of such lands for agricultural purposes and discuss and agree on conditions of use;
- Monitor and enforce the use of the lands according to agreements;
- Train peri-urban producers in good agricultural practices (GAPs).

The **National Water Policy** (2007) and **National Environmental Sanitation Policy** (1999, revised 2010): Both policies list as one of their main principles the quality of water resources, the prevention of pollution and the fundamental right of all people to safe and adequate water. A key objective concerning water for food security in the designated water policy is to ensure availability of water in sufficient quantity and quality for cultivation of crops. This policy gives irrigating farmers a strong position and makes clear that it is the duty of the government to prevent pollution and provide safe water.

**National Irrigation Policy, Strategies and Regulatory Measures (2010):**<sup>3</sup> Ghana's *national irrigation policy* which was approved by cabinet in 2010 acknowledges the importance of the informal irrigation sector, including irrigated urban and peri-urban agriculture. The policy complements the National Water Policy by accepting the reality of polluted waterbodies and corresponding recommendations directly supporting the WHO guidelines. The policy emphasizes the need to:

---

<sup>3</sup> <http://mofa.gov.gh/site/wp-content/uploads/2011/07/GHANA-IRRIGATION-DEVELOPMENT-POLICY1.pdf> (accessed 18 April 2014).

- Support best practices for the safe use of marginal quality water in accordance with the WHO *Guidelines for the Safe Use of Wastewater, Excreta and Greywater in Agriculture* (section 5.1.1);
- Promote access to safer groundwater or safer irrigation practices where only marginal-quality water is available (section 5.3.1);
- Encourage research on safe irrigation practices for irrigated urban and peri-urban agriculture and disseminate these in collaboration with other institutions (Section 5.3.1).

The need for a functional link between research, extension and farmers is also stressed in the **Agricultural Extension Policy** (June, 2003; October 2003 abridged version).

**National Land Policy** (June 1999): The National Land Policy encourages the use of wetlands for farming provided that this supports the sustainable productivity of wetlands, but declares a minimum of 100 meters (m) off the high water mark (of a waterbody) as protected area. This prohibition is targeting on the one hand flood control, i.e. the sealing of natural drainage areas through constructions, and on the other hand aims at the protection of the waterbodies from pollution. Protected land is defined in the National Land Policy as “any land area established by the appropriate bye-law of which social and/or economic activities are permitted only in accordance with the bye-law and under supervision”. This formulation does not categorically exclude farming from protected areas.

### **Riparian Buffer Zone Policy**

The WRC started in 2004 to develop a Riparian Buffer Zone Policy for Managing Freshwater Bodies in Ghana as a harmonized document of all the dormant and fragmented regulations in the country concerning buffers bordering waterbodies or river systems. The November 2011 edition of this policy published by the Ministry of Water Resources, Works and Housing states – among others – that the following practices and activities shall be restricted within the buffer zone, except with the prior approval of the appropriate authorizing agency:

- a. Clearing or grubbing of existing vegetation;
- b. Clear cutting of vegetation or trees;
- c. Soil disturbance by practices such as grading and stripping;
- d. Filling or dumping of waste;
- e. Use, storage, or the application of pesticides, herbicides and fertilizers; and
- f. Conversion of existing vegetation from majority native to majority exotic species.

These restrictions would not permit farming, especially of exotic vegetables, within the buffer zones. However, growing crops further away from the waterbody would be a hardship given the increased transport distance for water. These arguments were shared with the WRC. It was also pointed out that in urban areas farming along streams has a more positive function than any likely alternative, like squatting and illegal waste dumping, and that farm soils have a high water retention capacity in the case of flooding.

However, the policy argues in section 7 (Riparian Buffer Zones in Urban and Peri-Urban Areas) that farming is an ecologically unfriendly activity. The policy refers to harmful contaminants such as pesticides and fertilizer from agricultural farms which can degrade drinking water quality and threaten public health. The policy does not say that this contribution might be negligible compared with the volumes of waste and wastewater which transform urban streams and rivers across the country into unusable waterbodies. The policy encourages, however, *approved edge gardening and flood recession farming for purposes of mitigating erosion and water pollution and for sustenance of livelihoods*.

The recommended buffer widths are for 10-60 m for major perennial rivers/streams; 10-20 m for minor perennial streams; and 10-15 m for important seasonal streams. If the land use involves, for example, intensive chemical-based farming, the buffer zone width shall be adjusted to include an additional 20 m. On the other hand, if the land use involves flood recession farming, a variation to the buffer zone width can be possible. In addition, under 9.3.7 (Legislative Initiatives), the policy acknowledges that controlled farming can provide better waterbody protection in urban areas where natural vegetation no longer provides sufficient protection from indiscriminate waste dumping or vehicle washing.

In the same line of (urban farming supportive) argumentation, the Ghana National Urban Policy Action Plan, published in 2012 by the Ministry of Local Government and Rural Development, recommends under Action Area 4 (Environmental Quality) to “develop and use open spaces, green belts and other ecologically sensitive areas (i) for appropriate recreation and urban farming; (ii) to enhance visual amenity; and (iii) to promote microclimate control as appropriate” in order to support the policy goal “Protect open spaces, green belts, forest reserves, water bodies, wetlands, water catchment areas and other ecologically sensitive areas from physical development and urban encroachment”. The main responsibility for this is with the metropolitan, municipal and district assemblies.

### 15.4 Institutionalizing Safe Vegetable Farming

As the policy review shows, several policies and development plans recognize irrigated urban farming which is crucial for its institutionalization and the development of support programs and mechanism for urban farmers. However, the trajectory from policy to practice takes time, and the integration of urban farming into particular institutional structures, plans and strategies remains a significant challenge (see chapter 14). To support the institutionalization of urban farming multi-stakeholder approaches have been tried with noteworthy success (Amerasinghe et al. 2013). However, several of the initiated processes, like the revision of Accra's bylaws, lost their momentum once the external project came to an end.

Forkuor et al. (2011) suggested the use of GIS for integrating urban and peri-urban agriculture (UPA) into urban and peri-urban planning (Figure 15.1). The authors determined the suitability of areas for irrigated vegetable farming in five districts of southern Ghana based on soil type, access to transportation, market access, available water resources, slope, and tenure security. Results indicate that, out of the five districts, Tema has the highest percentage (44%) of highly suitable lands for market oriented vegetable production followed by AMA (13%), Ga Est (12%), Ga West (7%) and Akuapim South (4%). This type of analysis could allow policy makers and planners to study different scenarios with different criteria and weights in a participatory manner before decisions for example on zoning are made.

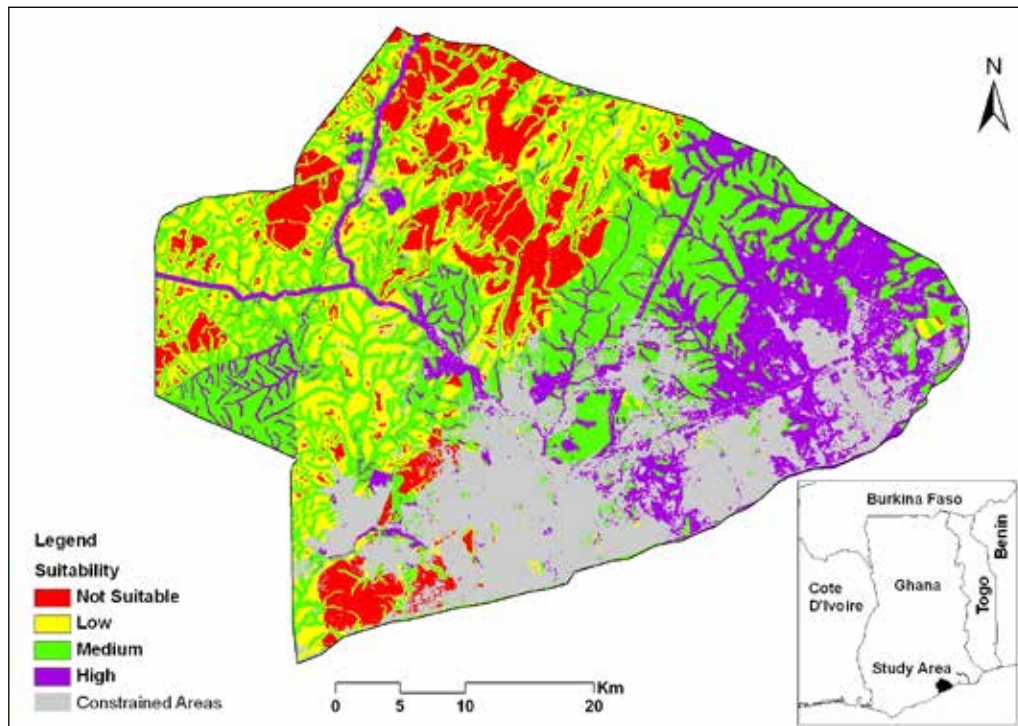


Figure 15.1. Suitability map for urban and peri-urban irrigated vegetable production in the Greater Accra Area. (Source: Modified from Forkuor et al. 2011).

For a successful institutionalization, it might be appropriate to promote urban farming less for its own sake and benefits but as a means to support the existing development agendas of cities and institutions, instead of flagging its ‘classical’ contributions to urban greening, livelihoods and food supply. In other words, to attract sustainable institutional support it will be crucial to analyze and show how urban farming serves the actual challenges of the targeted authorities or institutions, instead of promoting something which is seen as an independent or additional issue not linked to institutional priorities and work plans. An innovative approach would be to show, for example, the actual and possible (cost-saving) contributions of irrigated urban farming to climate change adaptation for instance via urban flood control (Annorbah-Sarpei 1998). Table 15.1 highlights possible contributions of open-space farming to different (urban) development goals.

In order to analyze the impacts of **climate change (CC) adaptation and mitigation** through urban and peri-urban agriculture and forestry (UPAF), an analytical framework was presented by the RUA Foundation (2014). The framework (Table 15.2 shows a small section) can serve as a basis for analyzing potential impact categories for different farming and forestry interventions in the urban context.

Another, frequently discussed contribution of irrigated urban agriculture is its **ability to treat wastewater** (land application, land treatment, soil filtration). This possible benefit applies in particular to the production of fodder crops, biofuel or fuelwood, but can also apply for example to rice systems as long as the water does not contain chemical contaminants, like heavy metals which could accumulate in the food. Given the significant degree of water pollution in the cities, urban farms can only absorb and filter a certain amount of the generated urban wastewater, thus the bulk of all wastewater still pollutes the environment and requires other means of treatment. To assess the magnitude of this contribution Lydecker and Drechsel (2010) estimated that vegetable farmers in Accra use 11,250 m<sup>3</sup> of irrigation water per day; most of this water is urban gray water, raw or mixed with stream or river water, which is often diverted into shallow standing-water dugouts to allow easy storage and fetching, but also allows for pollutants and pathogens to settle out of the water. With an average per capita production of wastewater of approximately 50 l day<sup>-1</sup>, the flow of water from residents to urban vegetable plots informally contributes to the wastewater treatment of 225,000 residents (Figure 15.2). In theory, these 225,000 residents – some 14% of the population – currently have a functioning (‘natural’) wastewater treatment system that is not disposal-oriented, but turns wastewater into an asset. This number is probably larger than the one served through sewerage and existing treatment plants in the city.

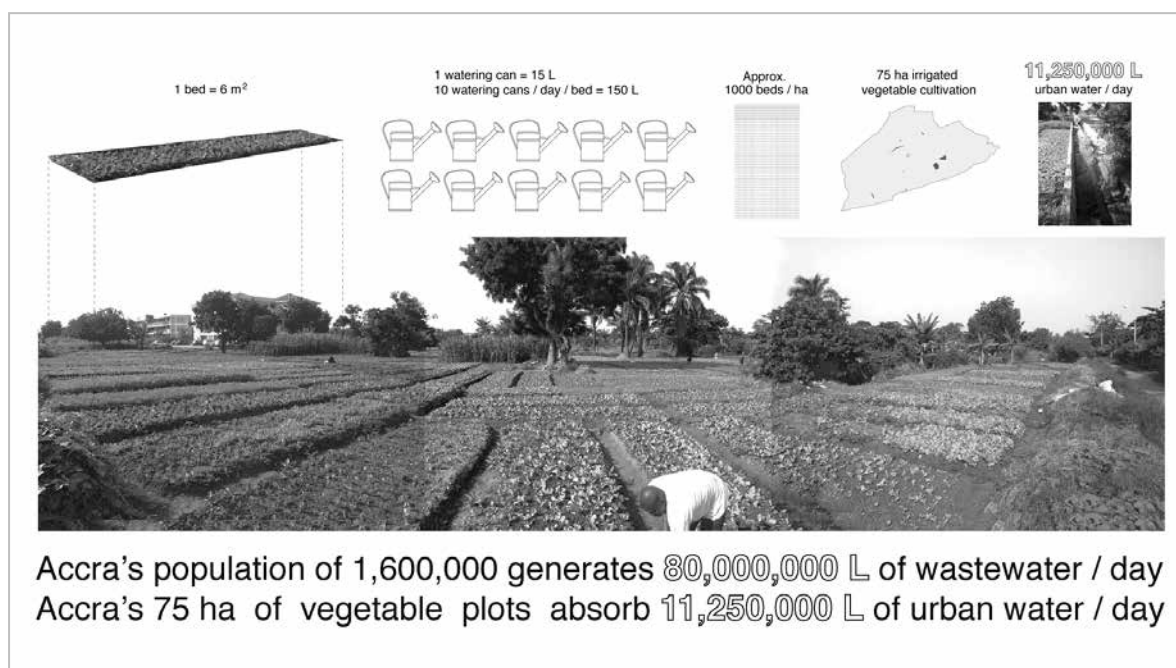
**TABLE 15.1.** Possible replicable benefits of urban open-space vegetable production.

<b>Condition/threat</b>	<b>Innovation/benefit from open-space farming</b>	<b>Transferable aspects to achieve urban development goals</b>
Climate change and flooding	Buffer zones for improved infiltration; slope stabilization and prevention of soil sealing	Climate change adaptation; flood control
Marginalized wasteland along watercourses	Transformation of marginal lands into productive use for general benefit, scenic value and health risk control	Land reclamation; urban greening, urban biodiversity
Storm and wastewater channels entering streams	Wastewater purification through land application, filtration and constructed wetlands	Wastewater filtration, pollution control, reduced treatment costs
Urban demand for fresh produce	Growing of high-value crops for improved diets	Small-scale private sector support
Lack of cold storage facilities in markets	Production of perishable goods in market proximity (reduced urban footprint)	Savings in power, transport and infrastructure investments
Squatters and waste dumping on unused land	Land under permanent agricultural use	Land protection, slum prevention, savings in waste collection
Land eviction (threat) or official support of farmers (opportunities)	Formation of Vegetable Growers Associations for protecting farmers' interests.	Strengthening vulnerable minorities
Flooding	Slope upgrading/stabilization, improved infiltration and human-induced fencing; minimized waste dumping into streams	Flood control; improved drainage
Solid waste accumulation in cities	Need for organic inputs; use of organic waste products; minimized waste dumping into streams	Waste reduction through compost use; resource recovery
Competing claims for urban space by commercial and other conventional city land uses	(i) Incorporation of market gardening in land use of newly developing areas (ii) Enacting municipal bylaws and legislation permitting market gardening	(i) Creating jobs for vulnerable groups (ii) Enacting proactive legislation
Economic crisis; civil war	Urban food supply independent of functional rural-urban linkages and external aid	Emergency food program

Source: Annorbah-Sarpei (1998, modified and extended).

**Table 15.2.** Section of the Framework for Monitoring the Impacts of UPAF on Climate Change (Source: RUAF Foundation 2014).

City zone	UPA type or measure	Impacts of climate change (CC)		Development benefits	Variables that determine the extent to which such impacts on CC can be achieved.		
		Mitigation benefits	Adaptation benefits				
Inner city	Promotion of backyard and community gardening	+ +  +  +  +	Less energy use and GHG emission due to reduce food miles  Reduction of waste volumes due to on-the-spot composting/reuse  Minor carbon storage and sequestration.	+ + +  +  +  +  +	Less vulnerability to an increase in food prices and disturbances in food imports to city due to enhanced local production and diversification of food (and income) sources  Positive effects on urban biodiversity (especially niche species).	Enhanced food security and nutrition (for the urban poor and women) due to improved access to nutritious food close to consumer  Positive effect on urban biodiversity and live-ability  Educational and recreational opportunities.	Food import and consumer transport distances for buying food  Degree of external inputs and materials used in UPA and related energy costs/ GHG emissions (ecological vs. conventional production; degree of waste recycling, use of rainwater harvesting and water saving production techniques, crop choice: use of drought-resistant species).



**FIGURE 15.2.** Contribution of urban agriculture to wastewater re-use in Accra (Lydecker and Drechsel 2010).

To support the acceptance of irrigated vegetable farming, it is crucial to address related health risks. At the national level, informal irrigation practices like in urban and peri-urban areas receive increasing attention which is reflected in the mentioning of urban and peri-urban agriculture in FASDEP II and METASIP. Both documents also mention the challenge of urban and peri-urban farmers with poor irrigation water quality. FASDEP calls directly for the provision of safe irrigation water. The irrigation policy does not denounce the use of marginal quality water but calls for research on safer irrigation practices.

As discussed in previous chapters, the most promising options are a combination of conventional treatment and/or other risk mitigation measures as recommended by the WHO (2006) multi-barrier approach. The possible institutionalization of the WHO (2006) guidelines for safe wastewater irrigation is supported by the National Irrigation Policy, but its implementation at the district level will require support from a number of agencies and stakeholders.

The institutionalization of a multiple barrier approach as suggested in the revised WHO guidelines is in line with the HACCP approach and target of the Ghana Standard Authority to establish Food Safety Management (FSM) systems along the food chain based on Good Practices (Figure 15.3). For vegetables, the system should probably go beyond the current structure of Figure 15.3 by addressing options for risk reduction on farm and at the point of food preparation, for example in canteens or street food restaurants (Amoah et al. 2011).

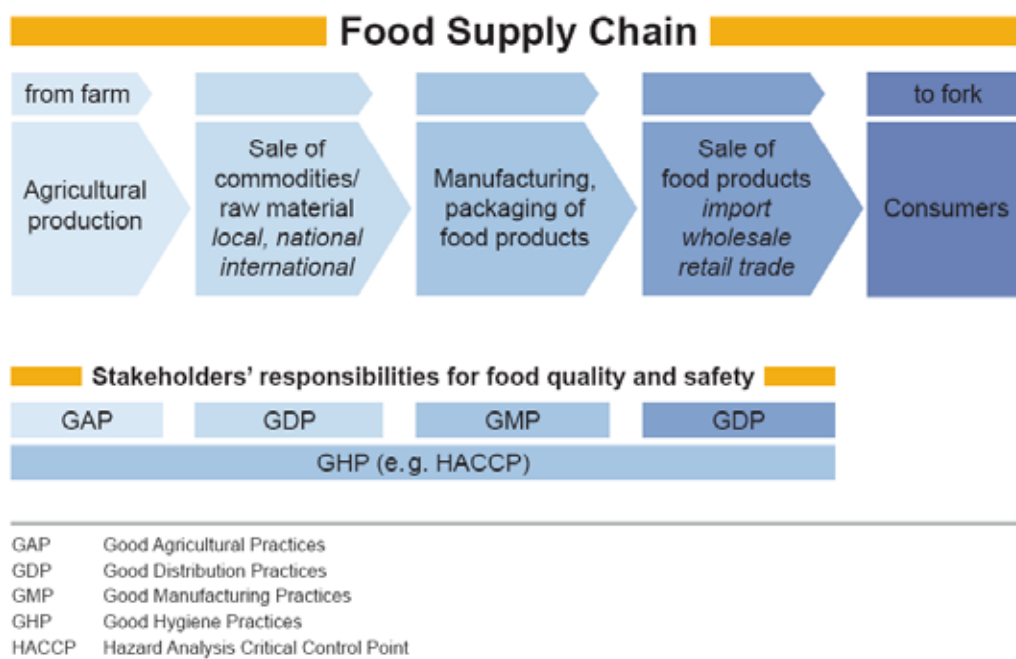


FIGURE 15.3. Ghana Standard Authority guidelines to establish FSM systems along the food chain (Source: Will and Guenther 2007).

However, there are also legislative documents which have reservations against farming close to waterbodies (Riparian Buffer Zone Policy) or prohibit the use of unsafe water (AMA bylaws). It is important to show that *good farming practices* can actually maintain land and water quality without affecting public health. The multiple dimensions of legislations and related institutional stakeholders clearly show that any progress towards the institutionalization of (especially irrigated) urban agriculture will require a multi-stakeholder dialogue with farmers and other actors along the food chain or from the health perspective along the contamination pathway.

WHO is currently working on an operational manual (Sanitation Safety Plan) for its 2006 guidelines on safe wastewater irrigation. Key institutions which should be targeted for the institutionalization of the multi-barrier approach at the national level are the extension service of the MoFA, Ghana Standards Authority, the Food and Drugs Authority and the private sector associations of farmers and restaurants selling raw salads (such as MAFFAG). Particular attention will be needed to understand that farmers and traders will require well-thought out incentives for a lasting behavior change, which requires an approach that goes beyond conventional ‘awareness creation’ and ‘education’ or threatening with fines or disciplinary measures (Drechsel and Karg 2013).



## 16. References

- Abagale F. K., Kyei-Baffour, N., Ofori, E., and Mensah, E. 2013. Types and seasonal diversity of helminth eggs in wastewater used for peri-urban vegetable crop production in Tamale Metropolis, Ghana. *International Journal of Current Research* 5(11): 3354-3359.
- Abaidoo, R.C.; Keraita, B.; Drechsel, P.; Dissanayake, P.; Akple, M.S. 2009. Soil and crop contamination through wastewater irrigation and options for risk reduction in developing countries. In *Soil biology and agriculture in the tropics*, ed. Dion, P., 498-535. Heidelberg, Germany: Springer Verlag.
- Abatemi-Usman, S.; Cheng, V.; Demurtas, A.; Guy, S.; Kaibu, A.; Kunvipusilkul, C.; Pratap, R.; Rassouli, S.; Usman, H. 2010. GIDA Ashaiman report, MSc Environment and Sustainable Development Overseas Fieldwork 2009-10, Development Planning Unit, UCL. [http://www.scribd.com/fullscreen/48167031?access\\_key=key-28s0czutowkbb3qgu46z](http://www.scribd.com/fullscreen/48167031?access_key=key-28s0czutowkbb3qgu46z)
- Abban, C.B. 2003. A comparative study on the economics of formal and informal irrigated urban vegetable production in the Greater Accra Region. Unpublished M. Phil. thesis, Dept of Agr. Economics and Agribusiness, University of Ghana, Legon. 114p.
- Abdul-Raouf, U.M.; Beucht, L.R.; Ammar, M.S. 1993. Survival and growth of E. coli on salad vegetables. *Applied Environmental Microbiology* 59(7): 1999-2006.
- Abiyeva, N.; Cerdas-Calvo, D.; Espinoza, E.; Gogol, D.; Holford, L.; Jaffer, A.; Njinga, L.; Palos Pamplona, B.; Sandhu, N.; Viale, L. 2010. Sustaining urban agriculture in the Greater Accra Metropolitan Region. Case study of La, Accra, Ghana. MSc Environment and Sustainable Development Overseas Fieldwork 2009-10, Development Planning Unit, UCL.
- Abubakari, A.-H.; Hussein, R.; Addi, P.E. 2011. Strategies for minimizing health risks of wastewater for poor farmers in the urban environment. *Acta Hort.* (ISHS) 911: 123-132.
- Acemoglu, D.; Johnson, S.; Robinson, J.A.; Thaicharoen, Y. 2003. Institutional causes, macroeconomic symptoms: volatility, crises and growth. *Journal of Monetary Economics* 50, January 2003: 49-123.
- Adam, M. 2001. Definition and boundaries of the peri-urban interface: patterns in the patchwork. *Waste composting for urban and peri-urban agriculture: Closing the rural-urban nutrient cycle in Sub-Saharan Africa*, ed. Drechsel, P.; Kunze, D., 193-208. Wallingford: CABI Publishing.
- Adams, S.; Athulathmudali, S.; Breyer, E.; Burgess, C.; Burrige, A.; Gaber, B.; Hardy, S.; Odekina, D.; Perry, J.; Rotsztain, E.; Suzuki, R.; Woodward, T. 2009. Towards a model of sustainable urban agriculture: A case study of Ashaiman, Ghana, MSc Environment and Sustainable Development Overseas Fieldwork 2008-09, Development Planning Unit, UCL.
- Adamtey, N.; Cofie, O.; Ofosu-Budu, G.K.; Danso, S.K.A.; Forster, D. 2009. Production and storage of N-enriched co-compost. *Waste Management* 29: 2429-2436.
- Adeoti, A.; Barry, B.; Namara, R.; Kamara, A.; Titiati, A. 2007. *Treadle pump irrigation and poverty in Ghana*. Colombo, Sri Lanka: International Water Management Institute, 24p. (IWMI Research Report 117).

- AfDB (African Development Bank). 2005. Accra Sewerage Improvement Project Appraisal Report. Accra: African Development Bank.
- Affum, H.A.; Oduro-Afriyie, K.; Nartey, V.K.; Adomako, D.; Nyarko, B.J.B. 2008. Bio-monitoring of airborne heavy metals along a major road in Accra, Ghana. *Environ. Monit. Assess.* 137: 15-24.
- Afrane, A.A.; Klinkenberg, E.; Drechsel, P.; Owusu-Daaku, K.; Garms, R.; Kruppa, T. 2004. Does irrigated urban agriculture influence the transmission of malaria in the city of Kumasi, Ghana? *Acta Tropica* 89(2): 125-134.
- Agodzo, S.K.; Huibers, F.P.; Chenini, F.; van Lier, J.B.; Duran, A. 2003. *Use of wastewater in irrigated agriculture. Country studies from Bolivia, Ghana and Tunisia. Vol 2: Ghana.* Wageningen UR: Wageningen.
- Agodzo, S.K.; Blay, A.K. 2002. A case study of the Volta River Estates Limited (VREL), Ghana. In *Private irrigation in sub-Saharan Africa*, ed. Sally, H.; Abernethy, C.L., 157-164. IWMI-FAO-CTA, Proceedings of a regional seminar 22-26 Oct 2001. Accra, Ghana.
- Akpedonu, P. 1997. Microbiology of street foods from a high density community in Accra. Noguchi Memorial Institute for Medical Research, University of Ghana (mimeo).
- Akple, M.S.K. 2009. *Assessment of effectiveness of non-treatment interventions in reducing health risks associated with consumption of wastewater – Irrigated cabbage.* A thesis submitted to the Department of Theoretical and Applied Biology, Kwame Nkrumah University of Science and Technology. MSc thesis (Environmental Science). Faculty of Biosciences, College of Science.
- Akudugu, M.; Egyir, I.S.; Mensah-Bonsu, A. 2009. Women farmers' access to credit from rural banks in Ghana. *Agricultural Finance Review* 69: 284-299.
- Akuffo, S.B. 1998. *Pollution control in a developing economy. A study of the situation in Ghana.* 2nd edition. Accra: Ghana Universities Press. 128p.
- Al-Khalifa, K.; Brinenberg, S.; Chi, X; Egborge, E.; Jeffery, T.; Nwogu, A.; Solomon, V.; Song, J.; Tao, Y. 2010. Promoting sustainable urban agriculture in Accra, Ghana. Case study: Plant Pool and Roman Ridge. MSc Environment and Sustainable Development Overseas Fieldwork 2009-10, Development Planning Unit, UCL.
- Allen, A.; You, N. (eds.). 2002. *Sustainable urbanisation: bridging the green and brown agendas.* London: DPU/UN-Habitat/DFID.
- Allen, A. and Apsan Frediani, A. 2013. Farmers, not gardeners: The making of environmentally just spaces in Accra. City: analysis of urban trends, culture, theory, policy, action, 17(3): 365-381 <http://dx.doi.org/10.1080/13604813.2013.796620>
- Allen, K.; Bushimata, A.; Confalonieri, A.; Elhassan, J.; Escoto Carranza, C.A.; Abdel-Gawad, N.; Gerrard, A.; Henze, J.; Moretti, J.; Morrow, R.; Yanez, K.; Zygmunt, J. 2009. Promoting sustainable urban agriculture in La, Accra Ghana. MSc Environment and Sustainable Development Overseas Fieldwork 2008-09, Development Planning Unit, UCL.
- Amarchey, C.A. 2005. Farmer response to urban pressures on land, the Tamale experience. *Urban Agriculture Magazine* 15: 39-40.
- AMA 1995. *Accra Metropolitan Assembly bye – laws*, Local Government Bulletin 1: 171-202

- Ameko, E.; Achio, S.; Alhassan, S.; Kassim, A. 2012 Microbial safety of raw mixed-vegetable salad sold as an accompaniment to street vended cooked rice in Accra, Ghana. *African Journal of Biotechnology* 11(50): 11078-11085.
- Amerasinghe, P.; Cofie, O.O.; Labri, T.O.; Drechsel, P. 2013. Facilitating outcomes: multi-stakeholder processes for influencing policy change on urban agriculture in selected West African and South Asian cities. Colombo, Sri Lanka: International Water Management Institute (IWMI). 34p. (IWMI Research Report 153).
- Amoah, P.; Drechsel, P.; Abaidoo, R.C. 2005. Irrigated urban vegetable production in Ghana: Sources of pathogen contamination and health risk elimination. *Irrigation and Drainage* 54: 49-61.
- Amoah, P.; Drechsel, P.; Abaidoo, R.C.; Ntow, W.J. 2006. Pesticide and pathogen contamination of vegetables in Ghana's urban markets. *Archives of Environmental Contamination and Toxicology* 50(1): 1-6.
- Amoah, P.; Drechsel, P.; Abaidoo, R.C.; Klutse, A. 2007a. Effectiveness of common and improved sanitary washing methods in selected cities of West Africa for the reduction of coliform bacteria and helminth eggs on vegetables. *Tropical Medicine and International Health* 12(2): 40-50.
- Amoah, P.; Drechsel, P.; Abaidoo, R.C.; Henseler, M. 2007b. Irrigated urban vegetable production in Ghana: Pathogen contamination in farms and markets and the consumer risk group. *Journal of Water and Health* 5(3): 455-466.
- Amoah, P. 2008. *Wastewater irrigated vegetable production: contamination wastewater irrigated vegetable production: contamination pathway for health risk reduction in Accra, Kumasi and Tamale – Ghana*. PhD thesis (Biological Science), Kwame Nkrumah University of Science and Technology (KNUST). 202p.
- Amoah, P.; Drechsel, P.; Schuetz, T.; Kranjac-Berisavjevic, G.; Manning-Thomas N. 2009. From world cafés to road shows: using a mix of knowledge sharing approaches to improve wastewater use in urban agriculture. *Knowledge Management for Development Journal* 5(3): 246–262
- Amoah, P.; Keraita, B.; Akple, M.; Drechsel, P.; Abaidoo, R.C.; Konradsen, F. 2011. *Low cost options for health risk reduction where crops are irrigated with polluted water in West Africa*. IWMI Research Report Series 141. Colombo.
- Anku, S.; Doe, B.; Tetteh, D. 1998. Environmental assessment of urban agriculture in Accra. In *Urban agriculture in Greater Accra Metropolitan Area*, ed. Armar-Klemesu, M.; Maxwell, D. Final report to IDRC. Centre file: 003149. Noguchi Memorial Institute for Medical Research, University of Ghana.
- Annang, L.; Drechsel, P. 2005. Nana Kwaku Saiw: A success story. *Urban Agriculture Magazine* 14: 40.
- Annorbah-Sarpei, A.J. 1998. Urban market gardens. Accra, Ghana. The Mega Cities Project MCP-018C. 26p.
- Anyane, S. La. 1963. Vegetable gardening in Accra. *The Ghana Farmer* 1(6): 228-230.
- Armar-Klemesu, M.; Maxwell, D. (eds.). 1998. *Urban agriculture in Greater Accra Metropolitan Area*. Project: 003149. Final report to IDRC. Noguchi Memorial Institute for Medical Research, University of Ghana.

- Armar-Klemesu, M.; Akpedonu, P.; Egbi, G.; Maxwell, D. 1998. Food contamination in urban agriculture: vegetable production using wastewater. In *Urban agriculture in Greater Accra Metropolitan Area*, ed. Armar-Klemesu, M.; Maxwell, D. Final report to IDRC. Centre file: 003149. Noguchi Memorial Institute for Medical Research, University of Ghana.
- Armon, R.; Dosoretz, C.G.; Azov, Y.; Shelef, G. 1994: Residual contamination of crops irrigated with effluent of different qualities: a field study. *Water Science and Technology* 30: 239-248.
- Arnoud W. A. Boot, Anjan V. Thakor and Gregory F. Udell. 1991. Secured Lending and Default Risk: Equilibrium Analysis, Policy Implications and Empirical Results Vol. 101, No. 406 pp. 458-472.
- Aryeetey, E. 2005. Informal finance for private sector development in Sub-Saharan Africa. *Journal of Micro Finance*, 7(1): 13-38.
- Asano, T.; Levine, A. 1998. Wastewater reclamation, recycling, and reuse: an introduction. In *Wastewater reclamation and reuse*, Vol 10, ed. Asano, T., 1-56. Boca Raton, FL: CRC Press.
- Asem-Hiablie, S.; Church, C.D.; Elliott, H.A.; Shappell, N.W.; Schoenfuss, H.L.; Drechsel, P.; Williams, C.F.; Knopf, A.L.; Dabie, M.Y. 2013. Serum estrogenicity and biological responses in African catfish raised in wastewater ponds in Ghana. *Science of the Total Environment* 463/4: 1182-1191.
- Asiama, J.P.; Osei, V. 2007. A Note on Microfinance in Ghana. Bank of Ghana. Working Paper WP/BOG-07/01  
[www.bog.gov.gh/privatecontent/Research/Working%20Papers/Microfinancing\(1\).pdf](http://www.bog.gov.gh/privatecontent/Research/Working%20Papers/Microfinancing(1).pdf)  
(accessed 16 August 2014)
- Asomani-Boateng, R. 2002. Urban cultivation in Accra: an examination of the nature, practices, problems, potentials and urban planning implications. *Habitat International* 26: 591-607
- Atmar, R.L.; Estes, M.K. 2006. The epidemiology and clinical importance of norovirus infection. *Gastroenter. Clinics. N. Amer.* 352: 275-290.
- ATSDR (Agency for Toxic Substances and Disease Registry). 2013. *Minimal risk levels*, December 2010, July 2013 Accessed from: <http://www.atsdr.cdc.gov/mrls/mrllist.asp> on 15 Aug 2014
- Avila, M.; Jabbar, M.A. 1992. Socio-economic assessment of alley farming. In *The AFNETA alley farming training manual - Volume 1: Core course in alley farming. Alley Farming Network for Tropical Africa*, ed. Tripathi, B.R.; Psychas, P.J. Available at: <http://www.fao.org/Wairdocs/ILRI/x5545E/x5545e09.htm> (accessed 9 April 2014).
- AWWA 1999. *Waterborne pathogens*, First Edition, ed. AWWA. Denver, Colorado, USA.
- Bacon, R.; Charrasse, F.; Francis, K.; Gulhane, J.; Isbasaran, N.E.; Kanchwala, R.; Kaur, D.; Matabuena, R.; Sun, W. 2011. Farmers, not gardeners: urban and peri-urban Agriculture in La, Accra. MSc Environment and Sustainable Development Overseas Fieldwork 2010-11, Development Planning Unit, UCL.
- Bains, G.; Berberyan, A.; Calisesi, F.; Gadi, K.; Overas, J.; Veronesi, M.; Wong, J. 2012. Environmentally just urbanisation: rethinking space through the lens of social relations: a new dimension of urban agriculture. MSc Environment and Sustainable Development Overseas Fieldwork 2011-12, Development Planning Unit, UCL.

- Bancheva, S.; Brandt, F.; Crawshay Jones, C.; Doria, N.; Ferro, P.; Ordoñez, A.; Segura, C.; 2012. Environmentally just urbanisation: Legon, Accra, MSc Environment and Sustainable Development Overseas Fieldwork 2011-12, Development Planning Unit, UCL.
- Barker, S.F.; Amoah, P.; Drechsel, P. 2014. A probabilistic model of gastroenteritis risks associated with consumption of street food salads in Kumasi, Ghana: Evaluation of methods to estimate pathogen dose from water, produce or food quality. *Science of the Total Environment* 487 (2014) 130–142.
- Beckwith, L.; Chaware, K.; Coll, F.; Cowan, E.; Egeh, B.; Gitonga, K.; Guilbert-Billetedoux, A.; Musi, S.; Salazar, D.; Valerio, A.; Ziegler, T. 2009. Promoting sustainable urban livelihoods through sustainable urban agriculture. Case study: Dzorwulu, Ghana. MSc Environment and Sustainable Development Overseas Fieldwork 2008-09, Development Planning Unit, UCL.
- Belkow, T.; Li, Z.; Mason, A.; Morris, R.; Narayanan, B.; Oehlkers, K.; Smith, C.; Spagakou, F.; Threpsiades, A. 2011. Sustainable urban and peri-urban agriculture in Accra. “Urban agriculture and beyond”. MSc Environment and Sustainable Development Overseas Fieldwork 2010-11, Development Planning Unit, UCL.
- Bindo, M.; Eriksson, A.; Fujiyama, Y.; Hampl, A.; Perrin, L.; Predusel, P.; Sternberg, H.; Stonehouse, A. 2011. Promoting sustainable urban and peri-urban agriculture in Greater Accra, Ghana. Plant Pool case study. MSc Environment and Sustainable Development Overseas Fieldwork 2010-11, Development Planning Unit, UCL.
- Biney, C.A. 1998. The threat of pollution to the coastal zone of the Greater Accra Metropolitan Area, Ghana. *Ghana Journal of Science* 31-36: 47-54.
- Blake, B.; Kasanga, K. 1997. Kumasi Natural Resource Management Research project, Inception report; NRI, Natural Resource Institute, The University of Greenwich, UK and University of Science and Technology, Kumasi, Ghana.
- Blumenthal, U.J.; Peasey, A. 2002. Critical reviews of epidemiological evidence of health effects of wastewater and excreta in agriculture. Background paper for WHO guidelines for the safe use of wastewater and excreta in agriculture. Geneva: WHO.
- Blumenthal, U.J.; Peasey, A.; Ruiz-Palacios, G.; Mara, D.D. 2000. *Guidelines for wastewater reuse in agriculture and aquaculture: recommended revisions based on new research evidence*. WELL study, Task No: 68 Part 1.
- Boakye, S. 2008. Sustaining Urban Farming: Explaining why farmers make investment with the absence of secure tenure with new evidence from Ghana, DSA conference paper.
- Bowyer-Bower, T.A.S.; Tengbeh, G. 1995. *The environmental implications of illegal UA in Harare, Zimbabwe*. Working Paper No. 4 of ODA Research Project R5946.
- Bowyer-Bower, T.A.S.; Mapaure, I.; Drummond, R.B. 1996. Ecological degradation in cities: Impact of urban agriculture in Harare, Zimbabwe. *Journal of Applied Science in Southern Africa* 22: 53-68.
- Brook, R.; Dávila, J. (eds.). 2000. *The peri-urban interface: a tale of two cities*. School of Agricultural and Forest Sciences, University of Wales, Bangor and Development Planning Unit, University College London. 251+vii pp.
- Buckley, R.M.; Mathema, A.S. 2007. Real estate and remittances in Accra, Ghana: A case of the winner’s curse? Background paper for a PPIAF study (April) [<http://www.worldbank.org/urban/symposium2007/papers/buckley.pdf>]

- Campilan, D.; Drechsel, P.; Joecker, D. 2001. Monitoring and evaluation and its adaptation to urban and peri-urban agriculture. *Urban Agriculture Magazine* 5: 40-42.
- Caradonna, F.; Cheng, S.L.; El-Aama, D.; Bello, H.; Isaacson, J.; Pretell, M.; Reinig, M. 2012. Environmentally just urbanisation: La, Accra. MSc Environment and Sustainable Development Overseas Fieldwork 2011-12, Development Planning Unit, UCL.
- Card, M.L and C. Yu-Ping. 2011. Uptake and degradation of natural and synthetic estrogens by maize seedlings. American Chemical Society Conference, Denver, CO: August 28 - September 01, 2011. Available at: <http://hdl.handle.net/1811/48534> Accessed 23 August 2012.
- CENCOSAD (Centre for Community Studies, Action and Development) 1994. *Urban market gardens in Accra*. Accra, Ghana: Centre for Community Studies, Action and Development and the Mega Cities Project.
- Chan, F.; Haddad, C.; Haji Hamidon, W.; Mpigi G.; Mistry, I.J.; Saeed, O.; Tassinari, D.; Wong, M.C., 2011. A case study for analyzing wellbeing through sustainable urban agriculture: Plant Pool, Accra, Ghana. MSc Environment and Sustainable Development Overseas Fieldwork 2010-11, Development Planning Unit, UCL.
- Chancellor, F. 2004. Gender, water and urban agriculture. *Urban Agriculture Magazine* 12: 18-19.
- Chinery, W.A. 1984. Effects of ecological changes on the malaria vectors *Anopheles funestus* and the *Anopheles gambiae* complex of mosquitoes in Accra, Ghana. *J. Trop Med. Hyg.* 87: 75-81.
- CMA (Christian Mothers Association). 2008. *Improving microfinance services for the rural women in Ghana*. Final report submitted to the Christian Mothers Association of Ghana, Accra by AIDEC International Ltd.
- Cofie, O.O.; Kranjac-Berisavljevic, G.; Drechsel, P. 2005. The use of human waste for peri-urban agriculture in northern Ghana. *Renewable Agriculture and Food Systems* 202: 73-80.
- Cofie, O.O.; van Veenhuizen, R.; Drechsel, P. 2003. Contribution of urban and peri-urban agriculture to food security in Sub-Saharan Africa. Paper presented at the Africa Day of the 3rd WWF in Kyoto, 17-3-2003.
- Cofie, O.; Danso, G.; Larbi, T.; Kufogbe, S.K.; Obiri-Opareh, N.; Abraham, E.; Schuetz, T. and Forkuor, G. 2008. Livelihood Support Potentials and Policy Issues for Urban Agriculture in Accra, Ghana. Accessed 11 Aug 2014 on <http://ruaf.iwmi.org/Data/Sites/4/PDFs/Accra%20UPA%20paper%20-%200309.pdf>
- Cornish, G A.; Lawrence, P. 2001. *Informal irrigation in peri-urban areas: A summary of findings and recommendations*. DFID's Water KAR Project R7132, Report OD 144. Wallingford, UK: HR Wallingford. 54p.
- Cofie, O.O, Adeoti, A., Nkansah-Boadu, F. and Awuah E. 2010. Farmers Perception and Benefits of Excreta Use in Southern Ghana. *Resources, Conservation and Recycling* 55:161–166.
- Cornish, G.A.; Mensah, E.; Ghesquière, P. 1999. *Water quality and peri-urban irrigation. an assessment of surface water quality for irrigation and its implications for human health in the peri-urban zone of Kumasi, Ghana*. Report OD/TN 95. Wallingford, UK: HR Wallingford.

- Cornish, G.A.; Aidoo, J.B. 2000. *Informal irrigation in the peri-urban zone of Kumasi, Ghana. Findings from an initial questionnaire survey*. Report OD/TN 97 March 2000. HR Wallingford, UK. 41p.
- Cornish, G.A.; Aidoo, J.B.; Ayamba, I. 2001. *Informal irrigation in the peri-urban zone of Kumasi, Ghana. An analysis of farmer activity and productivity*. Report OD/TN 103, February 2001. DFID's Water KAR Project R7132, HR Wallingford, UK. 39p.
- Critchley, W. 2007. *Working with farmer innovators: a practical guide*. Wageningen: CTA and Centre for International Development, Vrije Universiteit Amsterdam.
- Cui, Y.J.; Zhu, Y.G.; Zhai, R.H.; Chen, D.Y.; Huang, Y.Z.; Qui, Y.; Liang, J.Z. 2004. Transfer of metals from near a smelter in Nanning, China. *Environ. Int.* 30:785-791.
- Da Silva, A.K.; Le Saux, J.C.; Parnaudeau, S.; Pommepuy, M.; Elimelech, M.; Le Guyader, F.S. 2007. Evaluation of removal of Noroviruses during wastewater treatment, using real-time reverse transcription PCR: different behaviors of genotypes I and II. *Appl. Environ. Microbiol.* 73(24): 7891-7897.
- Danso, G.; Drechsel, P. 2003. The marketing manager in Ghana. *Urban Agricultural Magazine* 9: 7.
- Danso, G., Drechsel, P.; Wiafe-Antwi, T.; Gyiele, L. 2002a. Income of farming systems around Kumasi, Ghana. *Urban Agriculture Magazine* 7: 5-6.
- Danso, G.; Fialor, S.C.; Drechsel, P. 2002b. Perceptions of organic agriculture by urban vegetable farmers and consumers in Ghana. *Urban Agricultural Magazine* 6: 23-24.
- Danso, G., P. Drechsel, S. Fialor and M. Giordano. 2006. Estimating the demand for municipal waste compost via farmers' willingness-to-pay in Ghana. *Waste Management* 26: 1400–1409
- De Lardemelle, L. 1996. *The role of local authorities in the food supply and distribution systems in Ghana*. Food into Cities Collection, Rome: FAO.
- Dietz, A.; Schnoor, J. 2001. Advances in phytoremediation. *Environmental Health Perspectives* 109(22): 163-168.
- Dinham, B. 2003. Growing vegetables in developing countries for local urban populations and export markets: problems confronting small-scale producers. *Pest Manag Sci.* 59: 575-582.
- Donkor, E.S.; Lanyo, R.; Kayang, B.B.; Quaye, J.; Edoh, D.A. 2010. Internalisation of microbes in vegetables: microbial load of Ghanaian vegetables and the relationship with different water sources of irrigation. *Pak. J. Biol. Sci.* 13(17): 857-61.
- Doron, N.; Henriques, R.; Henry, S.; Lambert, R.; Mittal, N.; Roberts, M.; Rodrigues, T.; Sahara, J.; Vargas, D.; Wood-Hill, M. 2010. Sustainable urban and peri-urban agriculture in Accra: Roman Down. MSc Environment and Sustainable Development Overseas Fieldwork 2009-10, Development Planning Unit, UCL.
- Drechsel, P.; Seidu, R. 2011. Cost-effectiveness of options for reducing health risks in areas where food crops are irrigated with wastewater. *Water International* 36(4): 535-548.
- Drechsel, P.; Dongus, S. 2010. Dynamics and sustainability of urban agriculture; examples from sub-Saharan Africa. *Sustainability Science* 5(1): 69-78. Available at <http://www.springerlink.com/content/a1060622842356q0/fulltext.pdf>

- Drechsel, P.; U. Zimmermann, P. 2005. Factors influencing the intensification of farming systems and soil nutrient management in the rural - urban continuum of SW Ghana. *Journal of Plant Nutrition and Soil Science* 168(5): 694-702.
- Drechsel, P.; Graefe, S.; Sonou, M.; Cofie, O.O. 2006. *Informal irrigation in urban West Africa: An overview*. Colombo, Sri Lanka: International Water Management Institute (IWMI Research Report Series 102).
- Drechsel, P.; Abaidoo, R.C.; Amoah, P.; Cofie, O.O. 2000. Increasing use of poultry manure in and around Kumasi, Ghana: Is farmers' race consumers' fate? *Urban Agricultural Magazine* 2: 25-27.
- Drechsel, P.; Sarpong, E.O.; Hope, L. 2009. Urban farming and household food security. *Urban Agriculture Magazine* 22: 6.
- Drechsel, P.; Hope, L.; Cofie, O. 2013. Gender mainstreaming: Who wins? Gender and irrigated urban vegetable production in West Africa. *Journal of Gender and Water (wH<sub>2</sub>O)* 2: 15-17.
- Drechsel, P.; Giordano, M.; Gyiele, L.A. 2004. *Valuing nutrients in soil and water: concepts and techniques with examples from IWMI studies in the developing world*. Colombo: International Water Management Institute. (IWMI Research Report Series 82).
- Drechsel, P.; Giordano, M.; Enters, T. 2005. Valuing soil fertility change: selected methods and case studies. In *Natural resources management in agriculture: methods for assessing economic and environmental impacts*, ed. Shiferaw, B.; Freeman, H.A.; Swinton, S.M., 199-221. Wallingford: ICRISAT-CABI Publishing.
- Drechsel, P.; Blumenthal, U.J.; Keraita, B. 2002. Balancing health and livelihoods: Adjusting wastewater irrigation guidelines for resource-poor countries. *Urban Agriculture Magazine* 8: 7-9.
- Drechsel, P.; Blumenthal, U.J.; Keraita, B. 2002. Balancing health and livelihoods: Adjusting wastewater irrigation guidelines for resource-poor countries. *Urban Agriculture Magazine* 8: 7-9.
- Drechsel, P.; Graefe, S.; Fink, M. 2007. *Rural-urban food, nutrient and virtual water flows in selected West African cities*. Colombo, Sri Lanka: International Water Management Institute (IWMI Research Report Series 115).
- Drechsel, P.; Karg, H. 2013. Motivating behaviour change for safe wastewater irrigation in urban and peri-urban Ghana. *Sustainable Sanitation Practice* 16: 10-20.
- du Plessis, Jean. 2005. The growing problem of forced evictions and the crucial importance of community-based, locally appropriate alternatives. *Environment and Urbanization*, April, 17: 123-134.
- Egyir, I.S. 2009. *Rural women and microfinance in Ghana: Challenges and prospects*. Proceedings of a conference organized by the International Labour Organization, Accra, Ghana on Financing Local Economic Development in Ghana: Old Problems, New Strategies, 26-27 March, 2009, Volta Hotel, Akosombo.
- Egyir, I.S. 2010. *Applied study on local finance for poor urban and peri-urban producers in Accra, Ghana*. Report submitted to the International Water Management Institute (IWMI/RUAF), Accra  
[www.ruaf.org/sites/default/files/Applied%20study%20on%20local%20finance%20for%20urban%20producers%20in%20Accra%20Ghana.pdf](http://www.ruaf.org/sites/default/files/Applied%20study%20on%20local%20finance%20for%20urban%20producers%20in%20Accra%20Ghana.pdf)

- Ensink, J.H.J.; Mahamood, T.; Dalsgaard, A. 2007. Wastewater irrigated vegetables: market handling versus irrigation water quality. *Tropical Medicine and International Health* 12 (December, 12): 2-7.
- EPA (Environmental Protection Agency). 2001. Status of sewage treatment plants: internal monitoring report. Accra: EPA.
- EPA-USAID (United States Agency for International Development). 2004. *Guidelines for water reuse*. Washington, DC: US Environmental Protection Agency. EPA/625/R-04/108. p246.
- EPHC (Environment Protection and Heritage Council -NRMCC (Natural Resource Management Ministerial Council -AHMC (Australian Health Ministers' Conference). 2006. *Australian guidelines for water recycling: Managing health and environmental risks (Phase I)*. Natural Resource Management Ministerial Council, Environment Protection and Heritage Council and Australian Health Ministers' Conference. Available at [www.ephc.gov.au](http://www.ephc.gov.au)
- Erni, M.; Drechsel, P.; Bader, H.-P.; Scheidegger, R.; Zurbrugg, C.; Kipfer, R. 2010. Bad for the environment, good for the farmer? Urban sanitation and nutrient flows. *Irrigation and Drainage Systems, Special Issue on Wastewater Reuse* 24(1-2): 113-125.
- Essamuah, E.; Tonah, S. 2004. Coping with urban poverty in Ghana: An analysis of household and individual livelihood strategies in Nima/Accra. *Legon Journal of Sociology* 1(2): 79-96.
- European Commission (EC) (2006) Standards for lead, cadmium and mercury. Commission Regulation (EC) No 1881/2006. Accessed on 11/8/2014 at: <http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2006R1881:20100701:EN:PDF>
- FAO (Food and Agriculture Organization of the United Nations). 2007. *The urban producer's resource book. A practical guide for working with low income urban and peri-urban producers organization*. Rome, Italy: FAO.
- FAO/WHO 2010. Evaluations of the joint FAO/WHO expert committee on food additives (JECFA). Accessed 18/7/2012. <http://apps.who.int/ipsc/database/evaluations/chemical.aspx?chemID=3511>
- Feglo, P.; Sakyi, K. 2012. Bacterial contamination of street vending food in Kumasi, Ghana. *Journal of Medical and Biomedical Sciences* 1(1): 1-8.
- Fenteng, S. 2000. AMA bye-laws and policies on street-food vending in Accra. In *Enhancing the food security of the peri-urban and urban poor through improvements to the quality, safety and economics of street-vended foods*, ed. Johnson, P.-N. T.; Yawson, R.M., 46-52. Workshop Report, 25-26 September 2000. Accra. DFID/NRI/FRI PROJECT R No 7493 (ZB0199).
- Ferguson, J.E. 1990. *The heavy metals elements: Chemistry, environmental impact and health effects*. Oxford, UK: Pergamon Press.
- Fewtrell, L.; Prüss-Üstün, A.; Bos, R.; Gore, F.; Bartram, J. 2007. *Water, sanitation and hygiene: quantifying the health impact at national and local levels in countries with incomplete water supply and sanitation coverage*. Geneva: World Health Organization, Geneva (WHO Environmental Burden of Disease Series No. 15).

- Flynn-Dapaah, K. 2002. *Land negotiations and tenure relationships: Accessing land for urban and peri-urban agriculture in Sub-Saharan Africa*. CFP Report Series 36. Ottawa: IDRC.
- Forkuor, G., P. Drechsel and O. Cofie. 2011. A GIS-based approach for integrating agriculture into urban and peri-urban planning. *West Africa Review* 19: 136-154
- Frewer, L. 2003. Societal issues and public attitudes towards genetically modified foods. *Trends in Food Science and Technology* 14: 319-32.
- Frewer, L.J.; Howard, C.; Shepherd, R. 1998. Understanding public attitudes to technology. *Journal of Risk Research* 1(3): 221-235.
- Fung, J.; Keraita, B.; Konradsen, F.; Moe, C.; Akple, M. 2011. Microbiological quality of urban-vended salad and its association with gastrointestinal diseases in Kumasi, Ghana. *Int. J. Food Safety, Nutrition and Public Health* 4:152-166.
- Gbewonyo, K. 2007. Wastewater irrigation and the farmer: investigating the relation between irrigation water source, farming practices, and farmer health in Accra, Ghana. Harvard College, Cambridge, Massachusetts (unpublished thesis).
- Gbireh, Z.A. 1999. Development of urban and peri-urban irrigation for food security within and around Accra Metropolitan Area. FAO Technical Report. (unpublished)
- Gerstl, S. 2001. *The economic costs and impact of home gardening in Ouagadougou, Burkina Faso*. PhD dissertation. University of Basel, Switzerland. Available at [www.sti.unibas.ch](http://www.sti.unibas.ch)
- Ghana Statistical Services (GSS). 2002. *2000 population and housing census; summary report of final results, Accra, Ghana*.
- GIDA-JICA. 2004. *Strategies for effective utilization of existing irrigation projects*. SSIAPP-FU, March 2004, 328pp.
- Gilbert, R.J. ; de Louvois, J. ; Donovan, T. 2000. Guidelines for the microbiological quality of some ready-to-eat foods sampled at the point of sale. *Communicable Disease and Public Health* 3(3): 163-167.
- Giweta, M.H. 2011. *Mainstreaming wastewater management in urban planning. A case study of Tamale Metropolis, Ghana*. MSc thesis, Wageningen University, The Netherlands.
- Gough, K.V; Yankson, P.W.K. 2000. Land markets in African cities: The case of peri-urban Accra, Ghana. *Urban Studies* 37(13): 2485-2500.
- Grant, R. 2009. *Globalizing city: The urban and economic transformation of Accra, Ghana*. Syracuse NY: Syracuse University Press.
- Gregory, I.K.; Hong, Y. 2012. *Value capture and land policies*. Proceedings of the 2011 Land Policy Conference, Lincoln Institute of Land Policy.
- GSS. 2004. *Ghana demographic and health survey 2003*. GSS, Noguchi Institute, ORC Macro. Calverton, Maryland.
- GSS. 2012a. *2010 population and housing census*. Accra: Ghana Statistical Service.
- GSS. 2012b. *Revised gross domestic product 2011*. Accra.
- Gupta, U.C.; Gupta S.C. 1998. Trace element toxicity relationships to crop production and livestock and human health: Implication for management. *Common. Soil Sci. Plant Anal.* 29: 1491-1522.

- Gyamfi, A.A. 2002. Commercial irrigation farming. In *Private irrigation in sub-Saharan Africa*, ed. Sally, H.; Abernethy, C.L., 151-155. IWMI-FAO-CTA, proceedings of a regional seminar 22-26 October 2001, Accra, Ghana.
- Gyiele, L. 2002a. *Integrated economic and environmental impact assessment of urban and peri-urban agriculture in and around Kumasi. Vol. 1: Financial analysis*. Final report submitted to FAO (Project PR 17951). Kumasi, Ghana: IWMI-IBSRAM-KNUST.
- Gyiele, L. 2002b. *Integrated economic and environmental impact assessment of urban and peri-urban agriculture in and around Kumasi. Vol. 2: Economic analysis*. Final report submitted to FAO (Project PR 17951). Kumasi, Ghana: IWMI-IBSRAM-KNUST.
- Hamilton, A.J.; Boland, A.-M.; Stevens, D.; Kelly, J.; Radcliffe, J.; Ziehl, A.; Dillon, P.J.; Paulin, R. 2005. Position of the Australian horticultural industry with respect to the use of reclaimed water. *Agricultural Water Management* 71: 181-209.
- Harris, L.J.; Farber, J.M.; Beuchat, L.R.; Parish, M.E.; Suslow, T.V.; Garrett, E.H.; Busta, F.F. 2003. Outbreaks associated with fresh produce: incidence, growth, and survival of pathogens in fresh and fresh-cut produce. *Compr. Rev. Food Sci. F* 2: 78-141.
- Henseler, M.; Danso, G.; Annang, L. 2005. Lettuce survey. Project Report. Lettuce Survey Component of CP51, CGIAR CPWF Project 51. Unpublished report, IWMI, Ghana.
- Hodgson, I.; Larmie, S.A. 1999. Sewage, septage and faecal sludge management in Tamale Municipality of Ghana. *Journal of Applied Science and Technology* 4(1/2): 67-71.
- Hofny-Collins, A. 2006. *The potential of using composited municipal waste in agriculture: The case of Accra, Ghana*. PhD thesis. Uppsala: Swedish University of Agricultural Sciences.
- Hollinger F. 2004. *Financing agricultural term investments*. Agricultural Finance Revisited 7. Rome: Food and Agriculture Organization of the United Nations (FAO), Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ).
- Hope, L.; Cofie, O.; Keraita, B.; Drechsel, P. 2009. Gender and urban agriculture: the case of Accra, Ghana. In Chapter 4 of *Women feeding cities –mainstreaming gender in urban agriculture and food security*, ed. Hovorka, A.; de Zeeuw, H.; Njenga, M., 65-78. Warwickshire: PRACTICAL ACTION.
- Hope, L.; Keraita, B.; Akple, M.S.K. 2008. Washing of vegetables grown in urban farms in irrigation water in Kumasi, Ghana. *Urban Agriculture Magazine* 20: 29-30.
- ICMSF (International Commission on Microbiological Specifications for Food). 1974. *Microorganisms in foods 2. Sampling for microbiological analysis: Principles and specific applications*. Toronto: University of Toronto Press.
- Iino, S.; Groves, L.; Khan, N.; Iglesia, H.; Malik, M.; Seelam, S.; van Asseldonk, E.; Chirapaisarnkul, A.; Wesselowsky, V. 2011. Environmental justice in urban and peri-urban agriculture: Case study of Ashaiman Irrigation Scheme, MSc Environment and Sustainable Development Overseas Fieldwork 2010-11, Development Planning Unit, UCL.
- Ilic, S.; Drechsel, P.; Amoah, P.; LeJeune, J. 2010. Applying the multiple-barrier approach for microbial risk reduction in the post-harvest sector of wastewater irrigated vegetables. In *Wastewater irrigation and health: Assessing and mitigation risks in low-income countries*, ed. Drechsel, P., Scott, C.A.; Raschid-Sally, L.; Redwood, M.; Bahri, A., 239-259. UK: Earthscan-IDRC-IWMI.

- IPCS (International Programme on Chemical Safety). 2002. *Global assessment of the state-of-the-science of endocrine disruptors*. WHO/PCS/EDC/02.2. Ed. Damstra, T.; Barlow, S.; Bergman, A.; Kavlock, R.; Van Der Kraak, G. Geneva, Switzerland: World Health Organization.
- Ismail, B.S.; Farihah, A.K.; Khairiah, J. 2005. Bioaccumulation of heavy metals in vegetables from selected agricultural areas. *Bull. Environ. Contamin. Toxicol.* 74: 320-327.
- Jassir, M.S.; Shaker, A.; Khalip, M.A. 2005. Deposition of heavy metals on green leafy vegetables sold on roadsides of Riyadh city, Saudi Arabia. *Bull. Environ. Contam. Toxicol.* 75: 1020-1027.
- JICA (Japan International Cooperation Agency) - MoFA (Ministry of Food and Agriculture). 2007. *The study on the promotion of domestic rice in the republic of Ghana*. Progress Report 2. Nippon Koe Co. Ltd.
- JICA. 2006. Historical changes in technical cooperation provided to Ghana's irrigated agriculture sector. In *A study of the effectiveness and problems of JICA's technical cooperation from a capacity development perspective*. Available at [www.jica.go.jp/english/publications/reports/study/capacity/200609/pdf/200609\\_04e.pdf](http://www.jica.go.jp/english/publications/reports/study/capacity/200609/pdf/200609_04e.pdf) (last accessed: 31 May 2012).
- Jobling, S.; Williams, R.; Johnson, A.; Taylor, A.; Gross-Sorokin, M.; Nolan, M.; Tyler, C.R.; van Aerle, R.; Santos, E.; Brighty, G. 2005. Predicted exposures to steroid estrogens in u.k. rivers correlate with widespread sexual disruption in wild fish populations. *Environ. Health Perspect.* 114: 32-39.
- Johnson, P.N.T. 2002. Overview of a recent DFID/NRI/FRI project on street-vended food in Accra. In SADAOC (2002) *Street food in Ghana: Types, environment, patronage, laws and regulations*, 41-51. Proceedings of a roundtable conference on 6 September 2001. ISSER, University of Ghana, Legon, Accra, Ghana.
- Jothikumar, N.; Cromeans, T.L.; Hill, V.R.; Lu, X.; Sobsey, M.D.; Erdman, D.D. 2005. Quantitative real-time PCR assays for detection of human adenoviruses and identification of serotypes 40 and 41. *Appl. Environ. Microbiol.* 71(6): 3131-3136.
- Karg, H.; Drechsel, P. 2011. Financial and non-financial incentives and triggers to enhance the adoption of safer irrigation and post-harvest practices in West Africa. *Water International* 36(4): 476-49.
- Kasanga, R.K.; Cochrane, J.; King, R.; Roth, M. 1996. Land market and legal contradictions in the peri-urban areas of Accra, Ghana: informant interviews and secondary data investigations. Land Tenure Centre, University of Wisconsin-Madison; LARC, UST, Ghana.
- Kay, M. 2001. *Smallholder irrigation technology: prospects for Sub Sahara Africa*. Rome: IPTRID, FAO.
- Keraita, B. 2002. Wastewater use in urban and peri-urban vegetable farming in Kumasi, Ghana. Unpublished MSc thesis. Wageningen University, The Netherlands.
- Keraita, B., Drechsel, P.; Huibers, F.; Raschid-Sally, L. 2002. Wastewater use in informal irrigation in urban and peri-urban areas of Kumasi, Ghana. *Urban Agriculture Magazine* 8: 11-13.
- Keraita, B.; Drechsel, P.; Amoah, P. 2003. Influence of urban wastewater on stream water quality and agriculture in and around Kumasi, Ghana. *Environment and Urbanization* 15(2): 171-178.

- Keraita, B.; Konradsen, F.; Drechsel, P.; Abaidoo, R. 2007a. Effects of low-cost irrigation methods on microbial contamination of lettuce irrigated with wastewater. *Tropical Medicine and International Health* 12: 15-22.
- Keraita, B.; Konradsen, F.; Drechsel, P.; Abaidoo, R.C. 2007b. Reducing microbial contamination on lettuce by cessation of irrigation before harvesting. *Tropical Medicine & International Health* 12 suppl. 2: 8-14.
- Keraita, B.; Drechsel, P.; Konradsen, F. 2008a Perceptions of farmers on health risks and risk reduction measures in wastewater-irrigated urban vegetable farming in Ghana. *Journal of Risk Research* 11(8): 1047-1061.
- Keraita, B.; Drechsel, P.; Konradsen, F.; Vreugdenhil, R.C. 2008b. Potential of simple filters to improve microbial quality of irrigation water used in urban vegetable farming in Ghana. *Journal of Environmental Science and Health, Part A*, 43(7): 749-755.
- Keraita, B.; Drechsel, P.; Konradsen, F. 2008c. Using on-farm sedimentation ponds to improve microbial quality of irrigation water in urban vegetable farming in Ghana. *Water Science & Technology* 57 (4): 519-525.
- Keraita, B., Drechsel, P.; Seidu, R.; Amerasinghe, P.; Cofie, O.; Konradsen, F. 2010. Harnessing farmers' knowledge and perceptions for health risk reduction in wastewater irrigated agriculture. In *Wastewater irrigation and health: Assessing and mitigation risks in low-income countries*, ed. Drechsel, P.; Scott, C.A.; Raschid-Sally, L.; Redwood, M.; Bahri, A., 337-554. UK: Earthscan-IDRC-IWMI.
- Keraita, B.; Drechsel, P.; Klutse, A.; Cofie, O. 2014. *On-farm treatment options for wastewater, greywater and fecal sludge with special reference to West Africa*. Colombo, Sri Lanka: International Water Management Institute (IWMI).CGIAR Research Program on Water, Land and Ecosystems (WLE). 32p. (Resource Recovery and Reuse Series 1).
- Klinkenberg, E.; McCall, P.J.; Hastings, I.M.; Wilson, M.D.; Amerasinghe, F.P.; Donnelly, M.J. 2005. Malaria and irrigated crops, Accra, Ghana. *Emerging Infectious Diseases* 11(8): 1290-1293.
- Knudsen, L.G.; Phuc, P.D.; Hiep, N.T.; Samuelsen, H.; Jensen, P.K.; Dalsgaard, A.; Raschid-Sally, L.; Konradsen, F. 2008. The fear of awful smell: risk perceptions among farmers in Vietnam using waster and huma excreta in agriculture. *Southeast Asian J. Trop. Med. Public Health* 392: 341-52.
- Kylander, M.E.; Rauch, S.; Morrison, G.M.; Andam, K. 2003. Impact of automobile emissions on the levels of platinum and lead in Accra, Ghana. *J. Environ. Monit.* 5: 91-95.
- Labite, H. 2008. *Analysis of Health benefits versus costs of interventions in the urban water system in Accra, using Quantitative Microbial Risk Assessment*. MSc thesis. Delft, the Netherlands: UNESCO-IHE Institute for Water Education.
- Lai, K.; Scrimshaw, M.; Lester, J. 2002. Biotransformation and bioconcentration of steroid 29 ethinylestradiol, and 17 $\beta$ -estradiol in algae and duckweed-based wastewater treatment systems. *Environmental Science and Pollution Research* 17(4): 824-833.
- Larbi, W.O. 1995. *The urban land development process and urban land policies in Ghana. Our common estate*. London: Royal Institute of Chartered Surveyors.

- Laryea, J.A. 2002. *AMA, Accra; rules, regulations, enforcement and sanction on street vended food in the Accra Metropolis; in street foods in Ghana: Types, environment, patronage, laws and regulations*. Proceeding of a Roundtable Conference (6 September 2001). Ghana, Accra: ISSER.
- Lazo, J.K.; Kinnell, J.C.; Fisher, A. 2000. Expert and lay person perceptions of ecosystem risks. *Risk Analysis* 20: 179-93.
- Lee-Smith, D. 2010. Cities feeding people: an update on urban agriculture in equatorial Africa. *Environment and Urbanization* 22(2): 483-499.
- Leitzinger, C. 2000. Ist eine Co-Kompostierung aus stofflicher Sicht in Kumasi/Ghana sinnvoll? Unpublished MSc thesis, SANDEC, Eidgenössische Technische Hochschule (ETH), Zurich.
- Lente, I.; Keraita, B.; Drechsel, P.; Ofosu-Anim, J.; Brimah, A.K. 2012. Risk assessment of heavy metal contamination on vegetables grown in long-term wastewater irrigated urban farming sites in Accra, Ghana. *Journal of Water Quality, Exposure and Health*, 4: 179-186.
- Lunani, I. 2007. *Analysis of the public health risks of the urban water system to Accra by microbial risk assessment*. MSc Thesis. Delft, the Netherlands: UNESCO-IHE Institute for Water Education.
- Lydecker, M.; Drechsel, P. 2010. Urban agriculture and sanitation services in Accra, Ghana: The overlooked contribution. *International Journal of Agricultural Sustainability* 8(1): 94-103.
- Mackay Niittylä, H. 2013. *Mapping and theorising the spatiality, scale and functionality of urban agriculture in Ghana*. MSc thesis. Sweden: Umeå University.
- Mapanda, F.; Mangwayana, E.N.; Nyamangara, J.; Giller, K.E. 2007. Uptake of heavy metals by vegetables irrigated using wastewater and the subsequent risks in Harare, Zimbabwe. *Phys. Chem. Earth. Parts A/B/C* 32(15-18):1399-1405.
- Mara, D.D. 2011. Water- and wastewater-related disease and infection risks: what is an appropriate value for the maximum tolerable additional burden of disease? *J. Water Health* 9(2): 217-24.
- Marenya, P.P.; Barrett, C.B. 2007. Household-level determinants of adoption of improved natural resources management practices among smallholder farmers in western Kenya. *Food Policy* 32: 515-536.
- Mawoneke, S.; King, B. 1999. *Impact of urban agriculture research in Zimbabwe*. CFP Report 29D. Ottawa: IDRC.
- Maxwell, D.; Armar-Klemesu, M. 1999. *Urban agriculture in Greater Accra: Reviewing research impacts for livelihoods, food and nutrition security*. CFP Report 29F. Ottawa: IDRC.
- Maxwell, D.; Levin, C.; Armar-Klemesu, M.; Ruel, M.; Morris, S.; Ahiadeke, C. 2000. *Urban livelihoods and food and nutrition security in Greater Accra, Ghana*. IFPRI Research Report 112. IFPRI, Noguchi Memorial Institute for Medical Research, WHO. Washington: IFPRI (International Food Policy Research Institute). 172pp.

- Mbaye, A.; Moustier, P. 2000. Market-oriented urban agricultural production in Dakar. In *Growing cities, growing food: urban agriculture on the policy agenda*, ed. Bakker, N.; Dubbeling, M.; Gündel, S.; Sabel-Koschella, U.; de Zeeuw, H., 235-256. Feldafing/Germany: DSE/ZEL.
- McGregor, D.; Simon, D.; Thompson, D. 2002. *Peri-urban natural resources management at the watershed level: Kumasi, Ghana*. Final Technical Report for DFID project R7330. CEDAR-IRNR, Royal Holloway University of London: London.
- Mensah, E.; Amoah, P.; Abaidoo, R.C.; Drechsel, P. 2001. Environmental concerns of (peri-urban vegetable production – Case studies from Kumasi and Accra. In *Waste composting for urban and peri-urban agriculture - closing the rural-urban nutrient cycle in sub-Saharan Africa*, ed. Drechsel, P.; Kunze, D., 55-68. Wallingford: IWMI/FAO/CABI.
- Mensah, P.; Yeboah-Manu, D.; Owusu-Darko, K.; Ablordey, A. 2002. Street foods in Accra, Ghana: how safe are they? *Bulletin of WHO* 80: 546-554.
- Miah, Z. 2004. *Mortalities of immature stages of Culex quinquefasciatus at various breeding sites in Accra, Ghana*. MSc thesis. Liverpool: Liverpool School of Tropical Medicine.
- Miyoshi, T.; Nagayo, N. 2006. *A study of the effectiveness and problems of JICA's technical cooperation from a capacity development perspective: Case study of support for the advancement of Ghana's irrigated agriculture. Case study report on capacity development*. Tokyo, Japan: Institute for International Cooperation, Japan International Cooperation Agency.
- MoFA (Ministry of Food and Agriculture) 2007. *Food and Agriculture Sector Development Policy (FASDEP II)*. MoFA, Government of Ghana.
- MLGRD (Ministry of Local Government and Rural Development). 2010. *National Environmental Sanitation Strategy and Action Plan (NESSAP) 2010-2015*. MLGRD, Government of Ghana.
- Mougeot, L.J.A. 2000. Urban agriculture: definition, presence, potentials and risks. In *Growing cities, growing food: urban agriculture on the policy agenda*, ed. Bakker, N.; Dubbeling, M.; Gündel, S.; Sabel-Koschella, U.; de Zeeuw, H., 1-42. Deutsche Stiftung für Internationale Entwicklung (DSE). Feldafing, Germany: Zentralstelle für Ernährung und Landwirtschaft.
- Muchuweti, M.; Birkett, J.W.; Chinyanga, E.; Zvauya, R.; Scrimshaw, M.D.; Lester, J.N. 2006. Heavy metal content of vegetables irrigated with mixtures of wastewater and sewage sludge in Zimbabwe: implications for human health. *Agric. Ecosyst. Environ.* 112:41-48.
- Murray, A.; Drechsel, P. 2011. Why do some wastewater treatment facilities work when the majority fail? Case study from the sanitation sector in Ghana. *Waterlines* 302: 135-149.
- Namara, R. E.; Hope, L.; Sarpong, E.O.; de Fraiture, C.; Owusu, D. 2014. Adoption patterns and constraints pertaining to small-scale water lifting technologies in Ghana. *Agricultural Water Management* 131: 194-203.
- Namara, R. E.; Horowitz, L.; Nyamadi, B., Barry, B. 2011. Irrigation Development in Ghana: Past experiences, emerging opportunities, and future directions. IFPRI GSSP Working Paper 27.

- Namara, R.; E.; Horowitz, L.; Kolavalli, S.; Kranjac-Berisavljevic, G.; Dawuni, B.N.; Barry, B.; Giordano, M. 2010. *Typology of irrigation systems in Ghana*. Colombo, Sri Lanka: International Water Management Institute (IWMI Working Paper 142).
- Nathan, O.; Andrie, S.; van der Berg, S. 2004. Credit demand and credit rationing in the informal financial sector in Uganda. African Development and Poverty Reduction: the macro-micro linkage. Forum Paper, 13-15 October, Lord Charles Hotel, South Africa.
- Nichols, D.; Daniel, T.; Edwards, D.; Moore, P.; Pote, D. 1998. Use of grass filter strips to reduce 17 $\beta$ -estradiol in runoff from fescue-applied poultry litter. *Journal of Soil and Water Conservation* 53(1): 74-77.
- Nikiema, J.; Cofie, O.; Impraim, R.; Drechsel, P. 2012. Fortified excreta pellets for agriculture. Paper presented at the Second International Faecal Sludge Management Conference in Durban, 29-31 October 2012. Available at: <http://susana.org/lang-en/library>
- Norton-Brandão, D.; Scherrenberg, S.M.; van Lier, J.B. 2013. Reclamation of used urban waters for irrigation purposes: A review of treatment technologies. *Journal of Environmental Management* 122: 85-98.
- NRI/DFID/FRI. 2000. *Enhancing the food security of the peri-urban and urban poor through improvements to the quality, safety and economics of street-vended foods*. Report on workshop for stakeholders, policy makers and regulators of street-food vending in Accra, 25-26, September 2000.
- Ntow, W.J. 2001. Organochlorine pesticides in water, sediment, crops, and human fluids in a farming community in Ghana. *Arch. Environ. Contam. Toxicol.* 40: 557-563.
- Ntow, W.J.; Gijzen, H.J.; Kelderman, P.; Drechsel, P. 2006. Farmer perception and pesticide use practices in vegetable production in Ghana. *Pest Management Science* 62: 356-365.
- Nugent, R.A. 2000. The impact of urban agriculture on the household and local economies. In *Growing cities, growing food: urban agriculture on the policy agenda*, ed. Bakker, N.; Dubbeling, M.; Gündel, S.; Sabel-Koschella, U.; de Zeeuw, H., 67-97. Deutsche Stiftung für Internationale Entwicklung (DSE). Feldafing, Germany: Zentralstelle für Ernährung und Landwirtschaft.
- Nyanteng, V.K. 1998. Draft summary report on food markets and marketing in the Accra Metropolis. In AMA-FAO. *Food supply and distribution to Accra and its metropolis*. Workshop - Proceedings, Accra, Ghana, 13-16 April 1998.
- Obiri-Danso, K.; Weobong, C.A.A.; Jones, K. 2005. Aspects of health-related microbiology of the Subin, an urban river in Kumasi, Ghana. *Journal of Water and Health* 3(1): 69-76.
- Obosu-Mensah, K. 1999. *Food production in urban areas. A study of urban agriculture in Accra, Ghana*. Aldershot, UK: Ashgate Publishing. 227pp.
- Obuobie, E.; Drechsel, P.; Danso, G.; L. Raschid-Sally. L. 2004. Gender in open-space irrigated urban vegetable farming in Ghana. *Urban Agriculture Magazine* 12: 13-15.
- Obuobie, E.; Keraita, B.; Danso, G.; Amoah, P.; Olufunke, O.C.; Raschid-Sally, L.; Drechsel, P. 2006. *Irrigated urban vegetable production in Ghana: Characteristics, benefits and risks*. Accra, Ghana: IWMI-RUAF-CPWF. (first edition of this book)

- Odai, S.N.; Mensah, E.; Sipitey, D.; Ryo, S.; Awuah, E. 2008. Heavy metals uptake by vegetables cultivated on urban waste dumpsites: case study of Kumasi, Ghana. *Res. J. Environ. Toxicol.* 2: 92-99.
- Okorley, E.L.; Kwarteng, J.A. 2002. Current status of the use of pesticides in urban and peri-urban vegetable production in the central region of Ghana. Paper presented at RESEAU Ghaneen/SADOAC Workshop on Sustainable Food Security in Southern West Africa. 30-31 January 2002, Miklin Hotel, Accra, Ghana.
- Olsen, M. 2006. Risk awareness of street food handlers and consumers. Lettuce survey. Project report. Lettuce Survey Component of CP51, CGIAR CPWF Project 51. Unpublished report, University of Copenhagen, Denmark.
- Onumah, G. 2003. Improving Access to rural finance through warehouse receipt systems in Africa. Paper presented at 'Paving the Way Forward for Rural Finance: An International Conference on Best Practices', Washington 2-4 June 2003.
- Ouedraogo, B. 2002. Perceptions of Ouagadougou market gardeners on water, hygiene and disease. *Urban Agriculture Magazine* 8: 24-25.
- Overcash, M.; Sims, R.C.; Sims, J.L.; Nieman, J.K.C. 2005. Beneficial reuse and sustainability: The fate of organic compounds in land-applied waste. *Journal of Environmental Quality* 34: 29-41.
- Owusu, G. 2008. Indigenes' and migrants' access to land in peri-urban areas of Accra, Ghana. *International Development Planning Review* 30(2): 177-198.
- Owusu, I. 2009. *Evaluation of non-treatment interventions for reducing health risks with wastewater irrigated spring onions*. Department of Theoretical and Applied Biology, Kwame Nkrumah University of Science and Technology. MSc thesis (Environmental Science). Faculty of Biosciences, College of Science.
- Owusu, V.; Bakang, J-E; Abaidoo, R.; Kinane, M. 2012. Perception on untreated wastewater irrigation for vegetable production in Ghana. *Environment, Development and Sustainability* 14(1): 135-150.
- Peasey, A. 2000. *Human exposure to Ascaris infection through wastewater reuse in irrigation and its public health significance*. PhD thesis. University of London, England.
- Peck, M.; Gibson, R.W.; Kortenkamp, A.; Hill, E.M. 2004. Sediments are major sinks of steroidal estrogens in two United Kingdom rivers. *Environmental Toxicology and Chemistry* 23(4): 945-952.
- Pescod, M.B. 1992. *Wastewater treatment and use in agriculture*. FAO Irrigation and Drainage Paper 47. Rome: FAO. Available at: <http://www/fao.org/docrep/T0551E/T0551E00.htm> (accessed 13 June 2004).
- Pesticide Safety Directorate. 2005. Excel Spreadsheet of current MRLs. Department for Environment, Food, and Rural Affairs, London. Available at [www.pesticides.gov.uk/guidance/industries/pesticides](http://www.pesticides.gov.uk/guidance/industries/pesticides) (accessed August 2005).
- Poferl, P.; Keraita, B. 2008. Effects of mulching and poultry manure quality on microbiological contamination of lettuce in urban vegetable farming in Kumasi, Ghana. Unpubl. Internship Report, Horticulture Department, TU Muenchen.
- Prain, G.; de Zeeuw, H. 2007. Enhancing technical, organizational and institutional innovation in urban agriculture. *Urban Agriculture Magazine* 19: 9-14.

- Prüss-Üstün, A.; Bos, R.; Gore, F.; Bartram, J. 2008. *Safer water, better health: costs, benefits and sustainability of interventions to protect and promote health*. Geneva: WHO.
- Prüss-Ustün, A.; Corvalan, C. 2006. *Preventing disease through healthy environments, towards an estimate of the environmental burden of disease*, Geneva: WHO.
- Quansah, C.; P. Drechsel; B.B. Yirenyki and S. Asante-Mensah. 2001. Farmers' perceptions and management of soil organic matter - a case study from West Africa. *Nutrient Cycling in Agroecosystems* 61 (1/2): 205-213
- Quarcoopome, S.S. 1992. Urbanisation, land alienation and politics in Accra. *Research Review NS* 8 (1 and 2): 40-54.
- Rawlinson, H.; Fehr, P. 2002. Creating export markets for Bolivia's dried beans. In *Building businesses with small producers*, ed. Kapiola, S.; Mead, D. Ottawa: IDRC.
- RUAF Foundation. 2014. A first framework for monitoring the impacts of urban agriculture on climate change. *Urban Agriculture Magazine* 27: 44-49. [www.ruaf.org](http://www.ruaf.org)
- Sawidis, T.; Chettri, M.K.; Papaionnou, A.; Zachariadis, G.; Stratis, J. 2001. A study of metal distribution from lignite fuels using trees as biological monitors. *Ecotox. Environ. Saf.* 48: 27-35.
- Scheierling, S.M.; Bartone, C.; Mara, D.D.; Drechsel, P. 2010. *Improving wastewater use in agriculture: An emerging priority*. World Bank. Policy Research Working Paper No. WPS 5412 (<http://go.worldbank.org/UC28EAWNIO>).
- Seidu, R. 2010. *Disentangling the risk factors and health risks of faecal sludge and wastewater reuse*. PhD Thesis. Department of Mathematical Sciences and Technology, Norwegian University of Life Sciences, Ås.
- Seidu, R.; Heistad, A.; Amoah, P.; Drechsel, P.; Jenssen, P.D.; Strenstrom, T.A. 2008. Quantification of the health risk associated with wastewater reuse in Accra, Ghana: a contribution toward local guidelines. *Journal of Water and Health* 6(4):461-471.
- Seidu, R.; Drechsel, P.; Stenstrom, T.A. 2009. *Occupational health risk associated faecal sludge application*. 1st IWA Development Congress. Water and Sanitation Services: What Works for Developing Countries. Mexico City, Mexico. 15-19 November 2009.
- Sengupta, M. E.; Keraita, B.; Olsen, A.; Boateng, O.K.; Thamsborg, S.M.; Palsdottir, G.R.; Dalsgaard, A. 2012. Use of *Moringa oleifera* seed extracts to reduce helminth egg numbers and turbidity in irrigation water. *Water Research* 46(11): 3646-3656.
- Sharma, R.K.; Agrawal, M.; Marshall, F. 2006. Heavy metals contamination in vegetables grown in wastewater irrigated areas of Varanasi, India. *Bull. Environ. Contam. Toxicol.* 77: 312-318.
- Sharma, S.; Prasad, F.M. 2009. Accumulation of lead and cadmium in soil and vegetable crops along major highways in Agra (India). *E-Journal Chem.* 74: 1174-1183.
- Shi, W.; Wang, I.; Rousseau, D.P.L.; Lens, P.N.L. 2010. Removal of estrone, 17 $\alpha$ - estrogens by *Chlorella vulgaris*. *Applied and Environmental Microbiology* 68(2): 859-864.
- Shuval, H.I.; Adin, A.; Fattal, B.; Rawitz, E.; Yekutieli, P. 1986. *Wastewater irrigation in developing countries: Health effects and technical solutions*. World Bank Technical Paper No. 51. Washington: World Bank.

- Siegel, M.; Doner Lotenberg, L. 2007. *Marketing public health: strategies to promote social change*. 2nd edition. Boston, MA: Jones & Bartlett Publishers.
- Silverman, A.I.; Akrong, M.O.; Amoah, P.; Drechsel, P.; Nelson, K.L. 2013. Quantification of human norovirus GII, human adenovirus, and fecal indicator organisms in wastewater used for irrigation in Accra, Ghana. *Journal of Water and Health* 11(3): 473-488.
- Silverman, A.I.; Akrong, M.O.; Drechsel, P.; Nelson, K.L. 2014. On-farm treatment of wastewater used for vegetable irrigation: bacteria and virus removal in small ponds in Accra, Ghana. *Journal of Water Reuse and Desalination* (in press)
- Simmons, R.; Qadir, M.; Drechsel, P. 2010. Farm-based measures for reducing human and environmental health risks from chemical constituents in wastewater. In *Wastewater irrigation and health: Assessing and mitigation risks in low-income countries*, ed. Drechsel, P.; Scott, C.A.; Raschid-Sally, L.; Redwood, M.; Bahri, A., 209-238. UK: Earthscan-IDRC-IWMI.
- Simon, D.; McGregor, D.; Thompson, D. 2006. Contemporary perspectives on the peri-urban zones of cities in developing countries. In *The peri-urban interface: approaches to sustainable natural and human resource use*, ed. McGregor, D.; Simon, D.; Thompson, D., 3-17. London: Earthscan.
- Simon, D., Poku, O.; Nsiah-Gyabaah, K. 2001. *Survey of large industries in Kumasi: Water use and environmental impacts*. CEDAR-IRNR Kumasi Paper 6. 27 pp.
- Singh, A.; Sharma, R.K.; Agrawal, M.; Marshall, F.M. 2010. Risk assessment of heavy metal toxicity through contaminated vegetables from wastewater irrigated areas in Varanasi India. *Trop. Ecol.* 512: 375-387.
- Slovic, P. 1987. Perception of risk. *Science* 236: 280-285.
- Smith, O.B. 2002. Overview of urban agriculture and food security in West African cities. In *Advances in crop-livestock integration in West African cities*, ed. Akinbamijo, O.O.; Fall, S.T.; Smith, O.B., 17-36. ITC-ISRA-IDRC. Wageningen: Grafisch Bedrijf Ponsen en Looijen B.V.
- Sonou, M. 2001. Peri-urban irrigated agriculture and health risks in Ghana. *Urban Agriculture Magazine* 3: 33-34.
- Spengler, P.; Korner, W.; Metzger, J.W. 2001. Substances with estrogenic activity in effluents of sewage treatment plants in south-western Germany: 1. Chemical analysis. *Environmental Toxicology and Chemistry* 20: 2133-2141.
- Stevik, T.K.; Ausland, G.; Hanssen, J.F. 2004. Retention and removal of pathogenic bacteria in wastewater percolating through porous media. *Water Research* 38: 1355-1367.
- Stewart-Taylor, A.J.; Cherries, J.W. 1998. Does risk perception affect behavior and exposure? A pilot study amongst asbestos workers. *Annals of Occupational Hygiene* 42: 565-9.
- Suruchi; Khanna, P. 2011. Assessment of heavy metal contamination in different vegetables grown in and around urban areas. *Research Journal of Environmental Toxicology* 5: 162-179.
- Tallaki, K. 2005. The pest control systems in the market gardens of Lomé, Togo. In *AGROPOLIS - The social, political and environmental dimensions of urban agriculture*, ed. Mougeot, L., 51-67. Ottawa; IDRC, London: Earthscan.

- Tchobanoglous, G.; Burton, F.L.; Stensel, H.D. 1995. *Wastewater treatment systems. wastewater engineering: treatment, disposal and reuse*. 3rd edition. New Delhi, India: Metcalf and Eddy Inc., Tata McGraw-Hill. pp1017-1102.
- Turner, C. 2013. *Hybrid geography: Investigating urban agriculture within the Ghanaian city of Techiman – Integrating remote sensing and GIS within a socio-cultural political ecology perspective*. Master thesis, Lund University.
- Twum-Baah, K.A. 2002. Population growth of Mega-Accra: Emerging issues. In *Visions of the city. Accra in the 21<sup>st</sup> century*, ed. Mills-Tettey, R.; Adi-Dako, K., 31-38. Accra: Woeli Publishing Services.
- UN-DESA (UN Department of Economic and Social Affairs). 2012a. *World urbanization prospects: The 2011 revision*. Available at <http://esa.un.org/unup/CD-ROM/Urban-Rural-Population.htm>
- UN-DESA 2012b. *World urbanization prospects: The 2011 revision, methodology*. UN-DESA Population Division. Available at [http://esa.un.org/unup/pdf/WUP2011\\_Methodology.pdf](http://esa.un.org/unup/pdf/WUP2011_Methodology.pdf)
- UNDP (United Nations Development Programme). 1996. *Urban agriculture: food, jobs and sustainable cities*. UN Development Program, Publication Series for Habitat II, Vol.1. New York, USA: UNDP.
- US Environmental Protection Agency (USEPA). 1996. *Review of national air quality standards for ozone, assessment of scientific technical information*. OAQPS Staff Paper, EPA 452/R-96-007; USEPA Air Quality Criteria for Ozone and Related Photochemical Oxidants EPA/600/P-93/004Af UNESA 2009.
- Van der Hoek, W.; Tuan Anh, V.; Dac Cam, P.; Vicheth, C.; Dalsgaard, A. 2005. Skin diseases among people using urban wastewater in Phnom Penh. *Urban Agriculture Magazine* 14: 30-1.
- Vázquez, R.; Cofie, O.O.; Drechsel, P.; Mensa-Bonsu, I.F. 2002. Linking urban agriculture with urban management: A challenge for policy makers and planners. In *The sustainable city II. Urban regeneration and sustainability*, ed. Brebbia, C.A.; Martin-Duque, J.F.; Wadhwa, L.C., 925-934. Southampton, Boston: WIT Press.
- Weigert P. 1991 Metal loads of food of vegetable origin including mushrooms. In *Metals and their compounds in the environment, occurrence, analysis and biological relevance*, ed. Marian, E., 458-468. Weinheim: VCH.
- Weldegebriel, Y.; Chandravanshi, B.S.; Wondimu, T. 2012. Concentration levels of metals in vegetables grown in soils irrigated with river water in Addis Ababa, Ethiopia. *Ecotoxicol. Environ. Saf.* 77: 57-63.
- Weldesilassie, A.B.; Amerasinghe, P.; Danso, G. 2011. Assessing the empirical challenges of evaluating the benefits and risks of irrigating with wastewater. *Water International* 36(4): 441-454.
- WHO (World Health Organization). 1989. *Health guidelines for the use of wastewater in agriculture and aquaculture*. Report of WHO Scientific Group. Geneva: World Health Organization (WHO Technical Report Series No. 778).
- WHO. 1997. *Pesticide residues in food: 1997 evaluations*. World Health Organization Expert Group on Pesticide Residues, Geneva, Switzerland, 6-15 December, 1997.

- WHO 2005. *Nickel in drinking-water*. WHO/SDE/WSH/05.08/55. Accessed on 17/7/2012 at [http://www.who.int/water\\_sanitation\\_health/gdwqrevision/nickel2005.pdf](http://www.who.int/water_sanitation_health/gdwqrevision/nickel2005.pdf)
- WHO. 2006. *Guidelines of the safe use of wastewater, excreta and grey water; vol. 2: Wastewater use in agriculture*. Geneva, Switzerland: WHO.
- WHO/UNICEF, 2013. Joint Monitoring Programme on Water Supply and Sanitation. Ghana, April 2013. Geneva: WHO/UNICEF: Available at [www.wssinfo.org/documents-links/documents/?tx\\_displaycontroller\[type\]=country\\_files](http://www.wssinfo.org/documents-links/documents/?tx_displaycontroller[type]=country_files)
- Will, M.; Guenther, D. 2007. *Food quality and safety standards as required by EU law and the private industry – with special reference to the MEDA countries' exports of fresh and processed fruit and vegetables, herbs and spices – A practitioners' reference book*. 2nd revised and up-dated edition. Eschborn: GTZ.
- Yeboah, E.; Antwi, B.O.; Ekyem, S.O.; Tetteh, F.M.; Bonsu, K.O. 2013. Biochar for Soil Management: Effect on Soil Available N and Soil Water Storage. *Journal of Life Sciences* 7 (2): 202-209
- Zachary, G.P. 2004. Cheap chickens: Feeding Africa's poor. *World Policy Journal* 212: 47-52 (summer 2004).
- Zakaria, S.; Lamptey, M.G.; Maxwell, D. 1998. Urban agriculture in Accra: A descriptive analysis. In *Urban agriculture in Greater Accra Metropolitan Area*, ed. Armar-Klemesu, M.; Maxwell, D. Final report to IDRC. Centre file: 003149. Noguchi Memorial Institute for Medical Research, University of Ghana.
- Zeza, A.; Tasciotti, L. 2008. Does urban agriculture enhance dietary diversity? Empirical evidence from a sample of developing countries (draft). Available at <ftp://ftp.fao.org/docrep/fao/011/aj304e/aj304e.pdf>
- Zibrilla, I.; Salifu, A.A. 2004. Information gathering from urban and peri-urban communities with potential land areas for vegetable production. Report submitted to Urban Agriculture Network – Northern Ghana. 30 June 2004. 16pp. (mimeo)
- Zickermann, J.; Kornahrens, M.; Boateng, S.A.; Drechsel, P. 1998. Poultry manure availability, composting, application and impacts-Results of the IBSRAM satellite trials in Ghana. In *On-farm research on sustainable land management in Sub-Saharan Africa: Approaches, experiences and lessons*, ed. Drechsel, P; Gyiele, L. 105-114. IBSRAM Proceedings 19. Bangkok: IBSRAM.

The attached CD plays in computer DVD drives and in any newer DVD player.

If there is no CD attached to the back cover, please access the featured films online at

<a href="http://youtu.be/m-6EURne8RU">http://youtu.be/m-6EURne8RU</a>	Land use and land planning under urban growth
<a href="http://youtu.be/myNUzg_HHXw">http://youtu.be/myNUzg_HHXw</a>	Sanitation challenges and irrigation
<a href="http://youtu.be/Aa4u1_RblfM">http://youtu.be/Aa4u1_RblfM</a>	Safe farming practices
<a href="http://youtu.be/DXHkQE_hFg4">http://youtu.be/DXHkQE_hFg4</a>	Safe practices in the street food sector
<a href="http://youtu.be/f_EnUGa_GdM">http://youtu.be/f_EnUGa_GdM</a>	Case study on wastewater use in the La area

# **Irrigated Urban Vegetable Production in Ghana: Characteristics, Benefits and Risk Mitigation**

**2014**

**Up to 800,000 city dwellers eat exotic vegetables daily in Ghana's urban streets, canteens and restaurants, often as a side dish with popular fast food. Most of the perishable vegetables are produced on open spaces in the city or its fringes where farmers can access water for crop irrigation. This labor-intensive farming activity is highly profitable and can lift vulnerable groups out of poverty. It can also contribute to flood control, land reclamation and city greening while preventing the misuse of buffer zones. However, poor farmers are increasingly experiencing problems in finding unpolluted water sources in urban vicinity.**

**The second edition of this book presents new and updated research findings on urban and peri-urban agriculture and vegetable farming in Ghana's major cities with a special focus on the risks and risk mitigation related to the use of polluted water sources as it is common across Sub-Saharan Africa.**

**The book is a valuable resource for students, extension officers, academia and policy makers.**



**www. Iwmi .org**