Chapter 11
Crop–Livestock–Waste Interactions in Nakuru's Urban Agriculture

Nancy Karanja, Mary Njenga, Kuria Gathuru, Anthony Karanja, and Patrick Muendo Munyao

Introduction

As a complement to the research in Nairobi presented in the previous chapter, which mapped materials and market flows of nutrients in Kenya's capital city, this chapter presents a more in-depth picture of sources and types of waste generated by farmers in an urban area and the management practices involved. Both studies are aimed at informing policy. Whereas the Nairobi study focused on the handling of nutrients by community-based organizations, this study of Nakuru focuses on how urban farming households handle waste, including that generated by livestock. Some of the health risks involved are examined in Chapter 12 of this book.

Nakuru is close to the Equator, about 60 km northwest of Nairobi in the Rift Valley, a major geological feature of the African continent. It lies on the north shore of Lake Nakuru, a protected World Heritage site adjoining a National Park. At 1700–1850 m above sea level, the town has a sub-humid equatorial climate with bi-modal rainfall of about 950 mm per annum and had a population of 239 000 in 1999 growing at the rate of 4.3 percent annually (Republic of Kenya 2000). Its main economic activities are commerce, industry (including a Union Carbide factory), agriculture and related tertiary services. Commerce is mainly concentrated in the town centre, with informal commercial activities on the increase. Vendors and small-scale businesses crowd transport termini and the reserves of major roads (MCN 1999).

Nakuru has both large- and small-scale farming within its boundaries. Large farms are located in the west of the town and include the giant farm owned by the Rift Valley Institute of Science and Technology (RVIST). Small farms are steadily increasing in numbers, especially in the peri-urban areas. Many farms have been sub-divided into urban residential plots where smallholder farming is practiced. Together, these urban farms supply 22 percent of the basic food intake of farming households, and 8 percent of the overall food and nutritional needs of the town, with most of the rest coming from the rich agricultural hinterland (Foeken 2006).

N. Karanja (✉)
Urban Harvest, c/o CIP, P.O. Box 25171, Nairobi 00603, Kenya
e-mail: nancy.karanja@cgiar.org

G. Prain et al. (eds.), *African Urban Harvest*, DOI 10.1007/978-1-4419-6250-8_11,

An estimated 35 percent of Nakuru's population engaged in urban farming in 1998 with 27 percent of all households growing crops and 20 percent keeping livestock (Foeken & Owour 2000; Foeken 2006), figures very similar to those from a study of six Kenyan towns in the 1980s by Mazingira Institute (Lee-Smith et al. 1987). Common crops in Nakuru are maize, kale (*sukuma wiki*), beans, onions, spinach, tomatoes and Irish potatoes while chicken, cattle, goats, ducks and sheep are common livestock (Foeken 2006).

We explored crop–livestock–waste interactions in the town so as to generate useful data for urban agriculture environmental management and policy development in Nakuru and similar urban areas in the region. We were able to situate our data, which emphasized the situation of livestock keepers, in relation to that from a random sample survey of urban farmers carried out 6 years previously, in 1998 (Foeken 2006).

The 1998 Nakuru study explored the relationship between UA and poverty, finding that the poor are proportionally less represented among urban agricultural producers than the better off, who derived greater benefit from agriculture mainly due to their more secure access to land (Foeken 2006). Livestock keeping was associated with commercial orientation and with being better off. Whether rich or poor, farming households were larger and healthier, but it was harder for Nakuru's poor to get some of the benefits from farming, with poor women-headed households benefiting least. The study showed that most of the town's poor – those who needed food and would have farmed if they could – did not in fact do so (Foeken 2006). Our study builds on these insights by taking a gendered approach to how crop–livestock–waste interactions are managed. Its findings are linked to ongoing policy and legal review in the Municipal Council of Nakuru.

Methods Used

Study Sites

Nakuru is divided into 15 administrative-electoral wards that constitute the residential areas and business district. For both this study and the one described in the following chapter, four wards were purposively selected for sampling, based on their having significant livestock populations along with crop farming, and representing a range of income and human population densities. Our aim was to sample the range of crop–livestock–waste systems (with an emphasis on cattle keepers) rather than to compare them, although a few comparisons are drawn in our discussion of the data.

Kaptembwo and Kivumbini are low-income urban areas to the West and South West respectively, with high human population densities and low livestock populations and small land sizes. Peri-urban Nakuru East has middle-income farm households with medium-sized land holdings, human and livestock population densities, most farmers having backyard farms. Peri-urban Menengai to the north has higher income farmers with larger pieces of land and lower human population densities with a higher ratio of livestock to people.

Participatory Urban Appraisals and Household Interviews

The baseline survey began with a participatory urban appraisal (PUA) in each ward, where the objectives, benefits and sampling frame of the study were first discussed with the farmers. Agricultural extension officers had a list of livestock and crop farmers, to which missing names were added during the PUAs. The focus group discussions (FGDs), held with men and women separately, covered crop–livestock–waste interaction and health risk assessment. The latter subject is dealt with in the next chapter.

To suit the purposes of the study of health risks described in Chapter 12, random samples of 40 cattle farmers at each site were selected from the lists generated. For this chapter's study of crop–livestock–waste interactions, 10 more farmers were added to this sample at each site. These farmers, who grew crops and kept other types of livestock (including poultry, sheep and goats), were randomly selected from the lists to make up a sample size of approximately 50 crop and livestock farmers in each ward, for a total of about 200. This means that our findings are biased toward cattle keepers.

For this chapter, a semi-structured questionnaire was administered to the selected households to gather information on household characteristics, food consumption, characteristics of crop and animal agriculture, waste generation and re-use, income sources and levels and gender issues. Both male and female interviewees responded to the questions on gender in the questionnaire. Data on gender issues were also generated through the FGDs held with men and women separately.

Estimating Organic Waste Production and Utilization

The types and quantities of waste generated were estimated based on figures obtained from the household questionnaires, validated by participatory investigation with selected households. As a by-product of the investigation, these households were also sensitized on source sorting and waste reuse and recycling. Each household received two garbage collection bags of different colours in which to place their organic and inorganic waste for a period of 24 h. The organic component was then hand-sorted into different crop types such as peelings of potato, banana, sweet-potato and so on, permitting estimation of the dry weights produced for each and determination of nutrient content. Production and utilization of organic waste from other sources such as institutions, markets and hotels were also established through the use of separate questionnaires, as well as by taking actual measurements where possible.

Data Analysis

The household survey data was coded, entered, screened and cleaned in a relational database designed using the survey questionnaire (Microsoft Office Access

2003® – Microsoft Corporation, USA). Links between hypothetically related variables and outcome measures of interest from different data tables were tested using MS Access and results were exported to statistical software (Instat+ for windows V 3.029- 2005®) for descriptive analysis, cross-tabulations and relationship hypothesis testing using either Chi-square test, Z-test and /or student's t-test as appropriate. Outcomes were compared across the sex of household heads, gender division of labour and the four study sites, and inferences drawn accordingly.

Results

Characterizing the Sample

The total number of respondents was 213, of whom 56 percent were women and 44 percent men. Most of the respondents were either household heads (44 percent) or their spouses (40 percent), while 11 percent were children over 20 years old and 5 percent were other adults, mainly workers and in-laws living with the household (Table 11.1). Out of the 213 households, 169 were mixed farmers, 11 grew crops only and 33 kept livestock only.

Many characteristics of our sample were similar to those from a random sample of Nakuru urban farmers drawn in 1998 (Foeken 2006), such as the proportion of women-headed households (16 percent) and the large size of farming households (six persons) compared to the norm for Nakuru (four). However, the much higher incidence of house ownership (86 percent compared to 22 percent) supports the correspondence between property ownership and livestock (especially cattle) farming, indicating that such farmers are relatively better off. Our household heads were also slightly older on average, at 49 years compared to 41 (Foeken 2006).

We were also able to confirm Foeken's finding that livestock keepers were more likely than crop growers to be farming for income purposes. Almost half (47 percent) of household heads had farming as their primary economic activity, and there was a significant gender difference ($p<0.05$), the large majority (63 percent) of women-headed households (defined as a household with no male head) engaging in farming as their main economic activity compared to 44 percent of the male-headed households. Only 23 percent in our sample had formal employment as their main occupation, about half the norm for Nakuru farmers and non-farmers in 1999 (Foeken 2006, p. 182), indicating a high level of dependence on farming as a source of livelihood (Table 11.1).

The fact that we found 32 percent of household heads had only primary school or no formal education, suggests that such households may select urban farming as a livelihood strategy. More men than women households heads were formally employed (25 percent compared to 9 percent, $p<0.01$) possibly associated with such women's lack of formal education (24 percent) compared to 4 percent of men heading households ($p<0.01$) and consistent with findings from a similar

study carried out in Dagoretti, Nairobi (Kimani et al. 2007). Furthermore, there was a significant difference ($p<0.01$) in household heads having college education (19 percent of men heading households compared to only 6 percent of the women). The average annual contribution of urban agriculture to the income of an urban farmer in our sample was KShs 86 850 (US$ 1240) from both livestock and vegetable production, representing 43 percent of their annual income.

Table 11.1 Population characteristics

Characteristic	Category	Statistics (% of *N*)
Sex of HH head	Male	84.0
(*N* = 213)	Female	16.0
	Total	**100.00**
Mean age of HH head	All households	49.4
(*N* = 210)	Male	49.8
	Female	47.2
Level of education	No formal	7.1
of HH	Primary	24.5
(*N* = 212)	Secondary	48.1
	College	17.0
	University	3.3
	Total	**100.00**
Residential status	Own house	86.0
(*N* = 212)	Tenant	9.4
	Govt./Co-op.	1.4
	Squatter	2.8
	Others	0.4
	Total	**100.00**
Main occupation of HH	Business	15.5
Head (*N* = 206)	Farmer	46.6
	Formal employment	22.8
	Informal employment and others	15
	Total	**100.00**
Mean HH size	All households	6.1
(*N* = 213)	Male-headed HH	6.3
	Female-headed HH	5.4

HH = household

Access to and Location of Urban Farming Plots

As with the finding on high house ownership, the large majority (81 percent) of the urban farm plots were owned by the farmers (Fig. 11.1). This compares with only 33 percent of Nakuru urban farmers in general being plot owners (Foeken 2006, p. 186) and 46 percent in Kampala (see Chapter 6, above) again suggesting our sample of mostly cattle keepers was biased toward the better off. Land ownership was significantly different ($p<0.05$) for male and female household heads. Traditionally, women in Kenya cannot inherit land, increasing their vulnerability to poverty.

Over 60 percent of the farmers studied used their backyards or compounds, while others farmed on roadsides (30 percent) or other open space such as under power lines or on institutional land (Fig. 11.2), a common pattern observed in the region

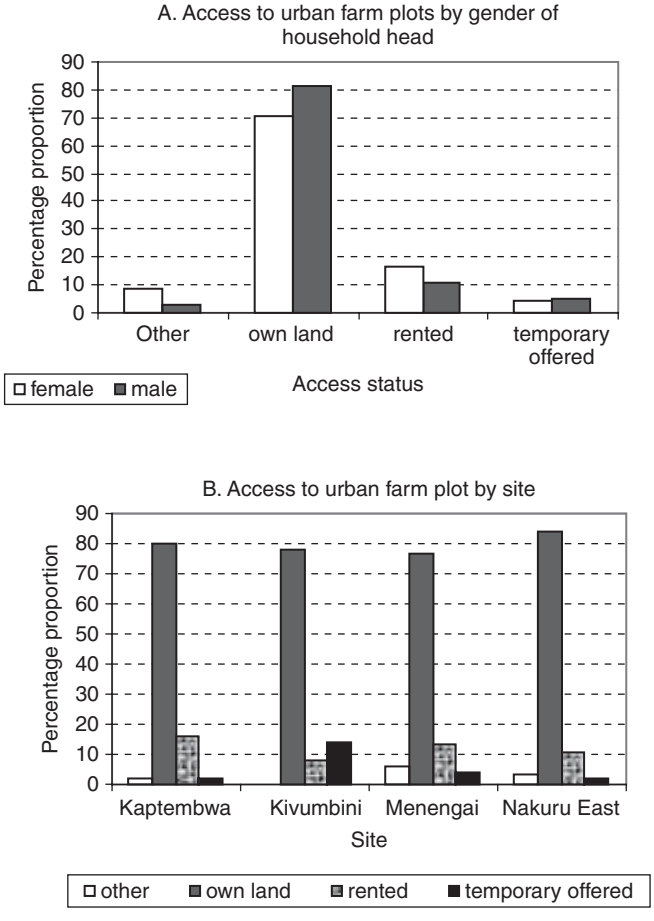

Fig. 11.1 Urban farming plots by gender of household head (A) and site (B)

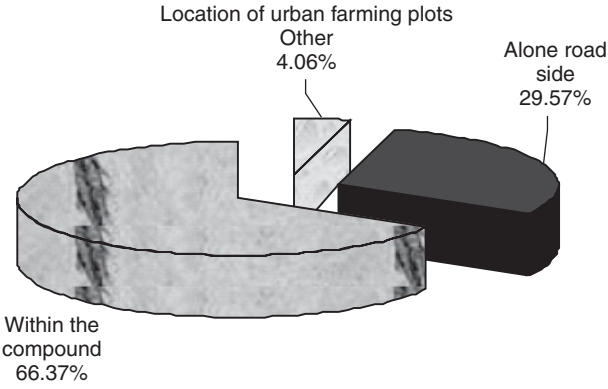

Fig. 11.2 Proportion of urban farming plots by location

(see the Kampala study, Chapter 6, above). The ten rural plots identified were all owned by men heading households, again attributable to restrictions on women's ownership of property.

Comparing neighbourhoods, it is worth noting that significant proportions of farmers used roadsides in higher-income Menengai with its larger plots, as well as in low-income high-density Kaptembwa, (24 and 36 percent respectively), indicating the opportunity even well-off farmers take to graze their livestock where publicly owned pasture is to be found.

Household Food Consumption

Households purchased 70 percent of food items they consumed, disaggregation showing that more than 50 percent of kale and spinach consumed was sourced from households' farms while tomatoes, oranges and cabbages were purchased. The commonest foods consumed in 1 week were Irish potatoes and maize (38 and 25 percent of all items noted respectively), indicating a potential source of household organic waste. We estimated a weekly per capita consumption of 17 kg of Irish potatoes and 13 kg of maize in households we studied and a total of KShs 1033 (US$ 14) per household being spent on food. Most money was spent on kale (21 percent), followed by dry maize (14 percent), tomatoes (17 percent) and onions (8 percent). These results illustrate the contribution of urban agriculture as a source of food as well as saving income through home production, taking kale as an example.

Urban Livestock Production

Due to the bias in our sample, 83 percent of households studied kept cattle, compared with 12 percent for Nakuru urban farmers in general (calculated from Foeken

2006, tables 3.1 and 5.1). The gender difference among household heads was not significant ($p>0.05$) despite cattle keeping being traditionally associated with men. Most cattle keepers (85 percent) were mixed farmers and kept a range of livestock, similar to what is observed in other urban centres in the region, as reported by Tegegne et al. (2002) for Addis Ababa, Ethiopia; Ishani et al. (2002a, b) for Kisumu and Nairobi, Kenya; and Njuki and Nindi (2000) for Dar es Salaam in Tanzania.

Nakuru farmers have found zero-grazing more costly and time consuming, while keeping animals free-range runs more risk of theft or contamination of feed (Foeken 2006, pp. 70–71). Perhaps due to farmers juggling these constraints, we found that the proportions of cattle and chickens kept in these ways were more or less reversed from Foeken's earlier study, with fewer cattle keepers (48 percent) zero-grazing their animals and more chickens (56 percent) being kept in chicken houses. Sheep and goats were mainly left to range freely at least part of the time. Ducks and pigs were kept by only a few households, both being confined or semi-confined.

Types of Livestock Feeds and Their Sources

Measured by weight, more than half (53 percent) of the fodder fed to all livestock was grass, 30 percent was concentrates and 17 percent was organic refuse. Gathering grass for cattle – mainly from roadsides or other open public land but also from their own plantings of Napier grass – provides opportunities for small business operators on bicycles (Foeken 2006, pp. 72–73). However, we found that nearly half of the fodder for all livestock (41 percent) was obtained from the households' own urban farms or from their neighbours, 30 percent was purchased from these vendors, 21 percent came from households' own nearby rural farms, while the rest was purchased in rural areas. According to Tegegne et al. (2002) 87 percent of urban livestock keepers in Addis Ababa depend on purchased hay from residues of crops like teff, wheat and lentils.

Concerning cattle feed specifically, 42 percent consisted of concentrates (mainly dairy meal, all of which was purchased), 42 percent was grass, especially Napier grass, and 16 percent was organic waste. Almost two-thirds of the organic waste fed to cattle in our sample was from the farmers' own sources – mainly farm and kitchen waste – the rest being purchased. In Addis Ababa it was observed that 93 percent of the farmers gave supplements to the livestock while 47 percent fed them household organic waste (Tegegne et al. 2002).

By contrast, concentrates were said to constitute 99 percent of the total feed given to chickens (33 percent layers mash, 32 percent growers mash and 24 percent chick mash), and virtually all of this was purchased in urban areas. It must also be borne in mind, however, that the numerous free-range chickens also foraged on grass and refuse dumps in the neighbourhoods. It should also be remembered that farmers generally consume these free-range chickens themselves, preferring the taste, while they sell the chickens fed on concentrates as a source of income.

Purchased fodder and grass were mainly sourced by men while women were more often involved in sourcing the organic refuse, a division of labour observed in many studies where men prefer being involved in organized, less tedious and time consuming but tidy activities (Njenga et al. 2004). In the urban farms, the purchased fodder was mainly for zero-grazed cattle. Farmers transported fodder using bicycles (40 percent), humans or animals walking (38 percent) or vehicles (22 percent). Concentrates bought from feed stores, agro-vets, maize mills, shops or kiosks were similarly transported.

Use of Raw Organic Household Waste as Animal Feed

On average, 91 percent (by weight) of the total amount of raw household waste produced by these farming households was re-used, the largest proportion of this (96 percent) being fed to livestock. This indicates the useful role played by farming households, and in particular livestock keepers, in managing urban waste and recycling it for productive purposes. The practice is widespread (Njenga et al. 2004; Tegegne et al. 2002).

Gender analysis revealed another important dimension here, in that women played a greater role than men in such waste management. Sixty percent of adult women were involved in waste re-use compared to only 20 percent of adult men, while 62 percent of adult women made the decisions on how waste was to be re-used compared to 20 percent of adult men. Only 4 percent of the raw household waste was not fed to livestock, and was re-used by being given to neighbours, thrown in a pit to decompose into compost or scattered on the urban plots. Again this seemed to be up to the women, who managed the disposal of 83 percent of this residual waste, men taking care of only 16 percent. These findings are in line with others from the African region, indicating women are more likely than men to be the waste handlers (Lee-Smith 1999, 2006).

Farmers' Attitudes to and Use of Crop Inputs

Previous studies in Kenya have suggested urban farmers use more organic than chemical inputs in their food production (Lee-Smith & Lamba 1991). In 1985, 35 percent of Nairobi farmers used vegetable matter compost and 29 percent farmyard manure, while only 18 percent used chemical fertilizer (Lee-Smith et al. 1987, pp. 125–126, p. 129). Nakuru showed higher use of chemicals in 1999, 36 percent of farmers using them, while 38 percent used compost and 53 percent manure (Foeken 2006). Our study found that women-headed households were more likely to irrigate their crops, and that 84 percent of male-headed households used chemical fertilizer compared to 78 percent in the female-headed households, although the difference was not significant ($p>0.5$). While cost and crop yields were the major factors in farmers' choice of inputs, the amount of work involved in processing organic inputs

may hinder their use. Irrigation is associated with higher yields as is the use of more than one input, whether organic or chemical (Lee-Smith et al. 1987; Foeken 2006, pp. 55–61). We noted a slight increase in use of chemical fertilizers (39 percent of urban crop farmers) compared to 36 percent found by Foeken and Owour (2000). Of the 110 crop farmers who did not use chemical fertilizer, 78 percent said they had enough manure while 13 percent thought it was too expensive.

Our study examined farmers' attitudes as well as their practices and found almost all (96 percent) perceived low soil fertility as a constraint to crop production with no significant difference between men and women respondents ($p>0.05$). When asked how soil fertility could be improved, 78 percent favoured using manure while a further 10 percent favoured mixing manure and fertilizer (Fig. 11.3). Other methods of improving soil fertility included use of crop residues, fallowing or crop rotation.

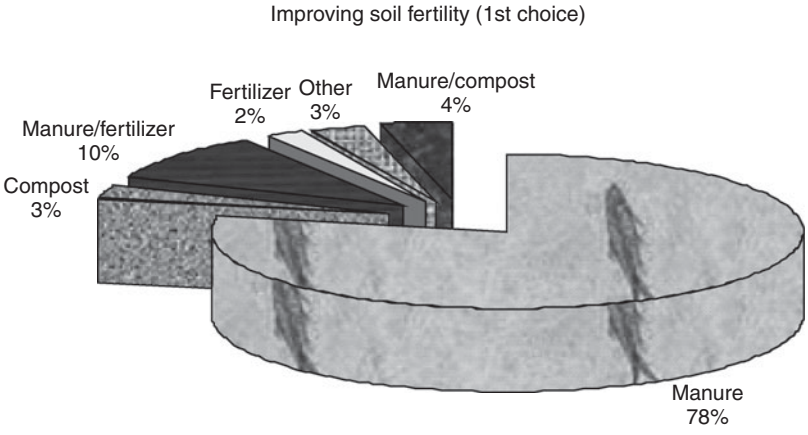

Fig. 11.3 Soil fertility management options ($N = 176$)

Decisions about the use of different crop inputs were generally made by adult males in the households when it came to chemical fertilizer and compost (64 and 57 percent male decisions respectively, compared to 30 and 36 percent decisions by adult women). Decision making over the use of crop residues was equally by men (48 percent) and women (50 percent).

Nakuru crop farmers using chemical fertilizer used 29 kg on average, spending KShs 853, with no real difference between men and women farmers. The proportion of crops grown using chemical fertilizer were maize (35 percent), kale (15 percent), maize intercropped with beans (13 percent) and potatoes (7 percent). Of the 17 households using vegetable compost, 15 used material from their own farms while two obtained it from community groups who produced compost.

All the crop residues used for soil fertility improvement were obtained from individual plots with no significant differences by gender of household head ($p>0.05$). Most of the crop residues, like organic domestic waste, were fed to livestock (Table 11.2).

Table 11.2 Uses of crop residues by Nakuru farmers

Gender	Fed to livestock	Fuel	Left on farm	Other	Sold	Total
Female- headed HH	14 (48%)	1 (3.4%)	9 (31%)	2 (6.9%)	3 (10%)	29
Male- headed HH	100 (55.6%)	14 (7.8%)	42 (23.3%)	15 (8.3%)	9 (5.0%)	180
Total	**114 (54.5%)**	**15 (7.2%)**	**51 (24.4%)**	**17 (8.1%)**	**12 (5.7%)**	**209**

N = 209 responses

In assessing knowledge of compost making we found that 58 percent of the farmers knew how to make compost and the difference between men and women was not significant ($p>0.05$). The knowledge was gained from schools, seminars, agricultural shows and farmer field schools. However, only 10 percent of respondents made compost on their farms while a few belonged to a group that was involved in compost making. The reasons given by those who did not make compost were that they had enough animal manure, or that it was too labour intensive, or they lacked space or did not have enough knowledge on how to make it.

Manure Production and Use

Earlier work in Nakuru found that almost half (48 percent) of livestock farmers used all or some of the manure produced by their animals for crop cultivation on their own mixed farms, thus recycling the nutrients effectively for food production purposes. However, while another 15 percent gave away or sold some of it for the same useful purpose, almost half (45 percent) also simply dumped some of the waste in the streets or on refuse dumps (Foeken 2006, p. 77, table 5.6).

This study attempted to go further into the utilization of farm and domestic wastes than the earlier study where emphasis was more on the pollution aspects of wastes, especially manure. Foeken and his colleagues noted that there was higher utilization of manure from large livestock, including cattle, than of small livestock, mainly chickens (98 percent compared to 56 percent using it on their own farms or giving it to their neighbours). That study also found a strong connection between waste re-use and mixed farming incorporating cattle and better waste re-use by farmers who had more space in their compounds. Getting rid of manure seemed to be more of a problem for the farmers in high-density areas with little space (Foeken 2006, p. 77). Our findings support these conclusions and examine in greater detail the quantities of manure produced in each area and its re-use.

Table 11.3 shows that growing their own crops in town was the main use to which livestock farmers in all areas put manure. Usually, growing their own rural crops was next most important, followed by sales of manure and a mix of other uses. Our data confirm the lower re-use of manure in areas with high population density and small farming plots, namely Kivumbini and Kaptembwa, with very high efficiency of re-use in the middle-income backyard mixed farms of Nakuru East.

Table 11.3 Total annual production of manure (tones) by sampled households in each area, and their ways of re-use and disposal

Ways of re-use and disposal of manure	[b]Kivumbini ($n=50$)	[b]Kaptembwa ($n=43$)	[c]Menengai ($n=59$)	[d]Nakuru East ($n=50$)	All areas ($n=202$)
Own crop production in urban areas	116.9	149.0	375.1	487.0	1128.0
Own crop production in rural areas	38.4	19.9	4.5	48.6	111.4
Sold	10.5	12.9	18.3	9.7	51.4
Other uses[a]	17.0	53.7	202.2	292.7	565.6
Subtotal Re-used	**182.8**	**235.5**	**600.1**	**838.0**	**1856.4**
Dumped or disposed of	914.1	538.2	651.2	119.9	2223.4
Total manure produced	**1096.9**	**773.7**	**1251.3**	**957.9**	**4079.8**
% Re-use	**(16.7)**	**(30.4)**	**(48.0)**	**(87.5)**	**(45.5)**
Average produced/ HH	**21.9**	**18.0**	**21.2**	**19.2**	**20.2**

[a] Biogas, planting flowers or trees, growing pasture, giving for free, making poultry feed

[b] low income

[c] high income

[d] medium income

Since average household production of manure in the four areas was similar, the overall average was used to project a total manure production for Nakuru of 282 800 tonnes of manure annually, using Foeken's estimate of 14 000 households keeping livestock in the town in 1998 (Foeken 2006, p. 39). The figure of 20.2 tonnes of manure per household refers to wet weight.

The breakdown of data by men and women farmers in each area, shown in Table 11.4, allows for gender analysis of the findings.

It is immediately apparent from these figures that, while manure production is consistently lower for women-headed farming households, efficiency of re-use is generally higher. The exception is the high-income area of Menengai, where efficiency of re-use is slightly lower for women-headed households, in contrast to low-income Kaptwemba, where such households are considerably more efficient in manure re-use than those headed by men.

The higher production of manure by men-headed households is probably due to the stronger association of men with cattle, which produce larger amounts of manure, whereas even women who keep cattle may more often also keep poultry which produce smaller amounts. The manure that was not re-used was thrown away – heaps were a common site in the streets, especially in the high-density residential areas.

Kale, maize and bananas were the crops most often treated with manure as a fertilizer by farming households, with chicken manure being preferred for kale and cattle manure for growing maize. The detailed figures are shown in Table 11.5.

Table 11.4 Gender breakdown of annual manure production and use in tones, by site

Ways of re-use and disposal of manure	Kivumbini (*n* = 50)		Kaptembwa (*n* = 43)		Menengai (*n* = 59)		Nakuru East (n = 50)		Grand Total
	Female (13)	Male (37)	Female (4)	Male (39)	Female (6)	Male (53)	Female (8)	Male (42)	(202)
Total manure produced	**228.7**	**868.2**	**60.7**	**713.0**	**58.8**	**1192.5**	**82.0**	**875.9**	**4079.8**
Own crop production in urban areas	22.6	94.3	6.1	142.9	10.6	364.5	38.7	448.3	1128.0
Own crop production in rural areas	23.4	15.0	0.0	19.9	0.0	4.5	0.0	48.6	111.4
Sold	10.5	0.0	6.0	6.9	0.0	18.3	0.6	9.1	51.4
Other uses[a]	0.3	16.7	26.0	27.7	15.9	186.3	37.3	255.4	565.6
Subtotal re-used	**56.8**	**126.0**	**38.1**	**197.4**	**26.5**	**573.6**	**76.6**	**761.4**	**1856.4**
Dumped	171.9	742.2	22.6	515.6	32.3	618.9	5.4	114.5	2223.4
% Re-use (re-use/ total×100)	**24.8**	**14.5**	**62.8**	**27.7**	**45.1**	**48.1**	**93.4**	**86.9**	**45.5**
Average produced/ hh	**17.6**	**23.5**	**15.2**	**18.3**	**9.6**	**22.5**	**10.3**	**20.9**	20.2

[a]Other uses include biogas, planting flowers or trees, growing pasture, giving for free, making livestock feed.

Female = female headed HH, male = male headed HH

Table 11.5 Comparison of cattle and chicken manure use for various crops

Crop	Manure type (% of household)		Chi sq.	*P* value
	Chicken	Cattle		
Kale	34	18	9.1	0.002
Maize	19	27	1.8	0.17
Banana	21	6	9.6	0.002
Beans	12	16	0.7	0.42
Others	11	33	14.1	0.0002
	97	100		

Sources of Manure for Crop-Only Farmers

Of the eleven farmers in our sample who produced crops only, three were female-headed households. These farmers used 28 urban plots, all in the low-income high-density neighbourhoods of Kaptembwa and Kivumbini, where they mostly grew vegetables, beans and maize intercropped with other traditional vegetables, which clearly contributed to their livelihoods through sales in addition to food. The three women-headed households owned a quarter of these plots, with male-headed

households predominantly renting the rest. Manure collected from urban residential areas provided crucial inputs to these production systems.

Policy Influencing and Technology Transfer in Nakuru Municipality

The findings of this study, along with others carried out earlier, were used as inputs to a formal process of the Municipal Council of Nakuru (MCN) aimed at developing urban agriculture bylaws. Following resolutions of a workshop for Nakuru councillors in May 2005, MCN's Department of Environment led a consultative law-making process to enable and regulate farming within the municipality. In fact, the review process, consultative meetings and drafting of the bylaws were supported by the project because they were activities in line with its stated objectives. The research project inception and feedback workshops, held in Nakuru in December 2004 and March 2006 respectively, were seen as a way of creating awareness on urban agriculture as a productive sector and strengthening dialogue for the bylaw development process. An earlier, parallel process in Kampala, Uganda, also supported by Urban Harvest, was likewise used as a model in Nakuru (Lee-Smith et al. 2008).

In 2009, the draft urban agriculture bylaws (MCN 2006) were awaiting in-depth farmer consultations from all the 15 wards. Meanwhile, collaborative training courses on crop–livestock production and waste management for urban agriculture and mushroom production using agricultural waste, including marketing, were held in December 2005. Partners involved were the Ministries of Agriculture and Livestock and Fisheries Development, the Nairobi and Environs Food Security, Agriculture and Livestock Forum (NEFSALF) and the German Society for Technical Cooperation (GTZ). Thirty-four women and 24 men involved in urban agriculture and organic waste re-use were trained, along with 11 agriculture and livestock extension staff (Karanja et al. 2006).

Conclusions

Our study confirms earlier findings from the end of the 1990s in Nakuru and shows that mixed crop–livestock farmers in the town tend to be among the better off, owning their own housing and land, and to be more oriented than urban farmers in general towards income generation from farming, though they also use it to feed themselves. However, we also established that this group of farmers is slightly older and less educated, and less often engaged in wage employment than farmers in general as measured in the late 1990s, suggesting that persons with these characteristics can more easily find a means of livelihood in farming, and that this applies especially to women heading households.

The farmers run small-scale enterprise farm systems that are efficient in nutrient recycling, using domestic organic waste as fodder and manure as fertilizer, especially where they have backyard space. Thus we confirm the earlier findings that the lower income groups find it harder to farm effectively. With an average of 20 tonnes of manure produced by an urban farmer in Nakuru, those in a middle-income area with backyard mixed farms achieved a very high re-use rate of 88 percent, mostly applied to their own crops, while those in a low-income area with higher density and less space only achieved 17 percent re-use, resulting in dumping and environmental contamination. Some intensive vegetables producers in these low-income areas were making good use of this manure and the practice could be expanded. Low re-use of manure could also have been as a result of inadequate technical skills and knowledge on the benefits of closing the nutrient loop in crop–livestock farming systems.

Using a gender analysis, we also established that women tended to be more involved than men in managing the nutrient cycling of domestic organic waste as livestock fodder, and, further, that they had higher rates of efficiency of re-use of manure from livestock in all but the high-income areas of Nakuru studied. Further, while use of chemical fertilisers appears to be higher and increasing in Nakuru (39 percent) compared to some other towns, we found women farmers tend to use these chemicals less often than men, perhaps due to their high cost. Men were also noted to sell manure more than women.

Overall, the farmers in our study recycled nearly all their domestic organic waste, mostly as livestock fodder, and this must be seen as a benefit to the town in terms of waste management and efficient food production. However, using our data and that of earlier studies, we were able to project that about 283 000 tonnes of wet manure is produced annually in the livestock and mixed farms of Nakuru, and that just over a half is not re-used in farming.

Thus our study suggests that urban agriculture in the town would work much better if the lower income farmers were encouraged to farm more efficiently using crop–livestock systems on land set aside for the purpose. Alternatively, or in addition, the systematic collection and re-use of livestock wastes from low-income farms in high-density areas would greatly increase efficiency of food production as well as waste management. This could be done through organized collection and distribution points and effective information to crop farmers through the official channels of agricultural extension services as well as the Municipal Council's Environment Department. The dumped manure could also be co-composted with other types of organic waste and packaged as a bio-fertilizer.

Apart from better urban waste management, this fairly simple institutional innovation would enhance agriculture productivity as well as incomes for an important group of urban residents, those with fewer jobs and less education, and especially women heading households. In turn, such a measure would contribute to the achievement of the Millennium Development Goals of alleviating hunger and poverty.

References

Foeken, D 2006, *"To subsidise my income" urban farming in an East-African Town*, Brill, Leiden, Boston, MA.

Foeken, D & Owour, S 2000, *Urban farmers in Nakuru, Kenya*, ASC Working Paper no. 45, Africa Studies Centre, Leiden and Centre for Urban Research, University of Nairobi.

Instat + for windows V 3.029- 2005®; Statistical Services Centre, The University of Reading, UK and Genstat Release 4.2 Discovery Edition, 2005® –VSL International Limited, Waterhouse Street, Hemel Hempstead, UK.

Ishani, Z, Gathuru, PK & Lamba, D 2002a, *Scoping study of interactions between gender relations and livestock keeping in Kisumu*, Mazingira Institute. A report prepared for Natural Resources International.

Ishani, Z, Gathuru, PK & Lamba, D 2002b, *Scoping study of urban and peri-urban poor livestock keepers in Nairobi*, Mazingira Institute, Nairobi.

Karanja, N, Njenga, M, Gathuru, K, Kangethe, E, Karanja, A, Njehu, A, Odumbe, M, Kiarie, S, Kimani, I, Wokabi, S, Getanda, C, Kingori, P, Mugo, P, Njenga, A & Kirima, F 2006, *Local Participatory Research and Development on Urban Agriculture and Livestock Keeping in Nakuru*. Supported by DFID-LPP. Project Report.

Kimani, VN, Ngonde, AM, Kang'ethe, EK & Kiragu, MW 2007, 'Gender perceptions and behaviour towards health risks associated with urban dairy farming in Dagoretti Division, Nairobi, Kenya', *East African Medical Journal*, Nov, vol. 84, no. 11 (Supplement), S57–S64.

Lee-Smith, D (ed) 1999, *Women managing resources: African research on* gender, urbanisation and environment, Mazingira Institute, Nairobi.

Lee-Smith, D 2006, 'Risk perception, communication and mitigation in urban agriculture: community participation and gender perspectives', in Boischio, A, Clegg, A & Mwagore D (eds) *Health risks and benefits of urban and peri-urban agriculture and livestock (UA) in Sub-Saharan Africa*, Urban Poverty Environment Series Report #1, IDCR, Ottawa, pp. 75–84.

Lee-Smith, D, Azuba, SM, Musisi, JM, Kaweeza, M & Nasinyama, GW 2008, 'The story of the Health Coordinating Committee, KUFSALCC and the urban agriculture ordinances', in Cole, D, Lee-Smith, D & Nasinyama, GW (eds) *Healthy city harvests: Generating evidence to guide policy on urban agriculture*, CIP/Urban Harvest and Makerere University Press, Lima, Peru.

Lee-Smith, D & Lamba, D 1991, 'The potential of urban farming in Africa', *Ecodecision*, December, pp. 37–45.

Lee-Smith, D, Manundu, M, Lamba, D & Gathuru, PK 1987, *Urban food production and the cooking fuel situation in urban Kenya,* Mazingira Institute, Nairobi.

MCN (Municipal Council of Nakuru) 1999, *Strategic structure plan. Action for sustainable urban development of Nakuru town and its environs*, Municipal Council of Nakuru (Final Draft), Nakuru.

MCN (Municipal Council of Nakuru) 2006, *Urban agriculture by-laws*, draft three. Laws of Kenya (Cap. 265).

Microsoft Office Access 2003, Microsoft Corporation, USU.

Njenga, M, Gathuru, K, Kimani, K, Frost, W, Carsan, C, Lee-Smith, D, Romney D & Karanja, N 2004, *Management of organic waste and livestock manure for enhancing agricultural productivity in urban and peri–urban Nairobi*, Project Report.

Njuki, JM & Nindi, SJ 2000, *Gender and urban agriculture: cattle raising and its implication for family welfare and the environment in Dar es Salaam, Tanzania*, Mazingira Institute, Nairobi.

Republic of Kenya 2000, *Economic survey 2000,* Nairobi, Government Printer.

Tegegne, A, Tadesse, M, Alemayehu, M, Woltedji, D & Sileshi, Z 2002, *Scoping study on urban and peri-urban livestock production in Addis Ababa, Ethiopia.* International Livestock Research Institute and Ethiopia Agricultural Research Organization, Addis Ababa, Ethiopia.