IWMI Working Paper

163

Characteristics of Urban and Peri-urban Agriculture in West Africa: Results of an Exploratory Survey Conducted in Tamale, Ghana, and Ouagadougou, Burkina Faso

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IWMI International Water Management Institute

CGIAR RESEARCH PROGRAM ON Water, Land and Ecosystems

UrbanFoodPlus

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Project

This report is the outcome of a field survey conducted under the auspices of the GlobE - UrbanFood^{Plus} project, an African-German partnership to enhance resource use efficiency in urban and peri-urban agriculture for improved food security in West African cities. It brings together the universities of the authors alongside other West African, German and international research institutions, such as IWMI.

Collaborators

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Contents

Summary

Urban and peri-urban agriculture (UPA) is an integral part of West African life. Descriptive, qualitative research has proliferated, but there have been few randomly sampled surveys of West African UPA. The GlobE - UrbanFood[Plus] (UFP) project undertook such a survey in 2013 in Tamale, Ghana, and Ouagadougou, Burkina Faso. The aim was to provide a broad overview of the state of UPA in the study cities and to provide a basis for future research endeavors.

The randomized sampling approach used aerial photography to identify ten sites in each of three categories of farm in each city. In both Ouagadougou and Tamale there were ten peri-urban village sites, ten open-space farm sites and ten residential sites containing isolated farms in people's backyards, on interstitial spaces such as between houses and on undeveloped plots. Within each site, up to ten farmers were randomly selected. They completed a questionnaire on their cropping and livestock-rearing activities. We also took soil samples from the farmers' fields in which they were questioned. Altogether, farm households sampled numbered 513. Focus groups and interviews with farmers sought their assessment of, and concerns about, the current status of their farming activities.

There were similarities between the cities, but the differences in the expression of UPA in Tamale and Ouagadougou were more intriguing. On average, farmers had used their land for at least nine years; the mean farm size was 1.98 hectares (ha) in Tamale and 2.87 ha in Ouagadougou.

Cultivation was concentrated in the wet season in both cities. In Tamale, commercial and dry-season production was slightly more common among open-space farmers, a trend that was far more pronounced in Ouagadougou. Production of staples dominated the rainy season in all farm types except Ouagadougou's open spaces, where lettuce was the commonest crop. Commercial leaf vegetable production came to the fore in other categories in the dry season, but whereas lettuce dominated in Ouagadougou, traditional leaf vegetables were more commonly cultivated in Tamale. Crops were usually sold to traders at the farm gate.

Livestock ownership was more common in Ouagadougou, but those who owned animals comprised a lower proportion of the inner city residents. In Tamale, where a higher proportion of the population constituted Muslims, it was rare to find cattle-rearing and, especially, pig-rearing. A greater proportion of livestock owners sold stock in Tamale.

Soils in Ouagadougou were significantly more fertile than in Tamale. In Ouagadougou, soils in isolated fields such as backyard farms and in open spaces were more fertile on average than those of peri-urban fields. This trend was reversed in Tamale. Soil fertility levels correlated best with inorganic fertilizer amendments, and yields correlated better with inorganic fertilizer applications than organic amendments or soil properties.

Farmers most commonly invested in seeds, followed by soil fertility management and crop protection inputs. In Tamale, where farms in backyards and interstitial spaces were more common, many people used fencing to protect crops from livestock. Farmers in Tamale more commonly used inorganic fertilizer than those in Ouagadougou, where compost and, especially, manure were more common.

Wells and ponds were more common as water sources in Ouagadougou and, in Tamale, farmers used piped water and reservoirs.

Farmers were particularly concerned about diminishing access to land in Tamale, where sales by chiefs to private investors were accelerating. In Ouagadougou, formal reallocation of land to homeowners by the state had similarly decreased available farmland. Water availability was a universal concern, and the quality of water used for irrigation was potentially more questionable in Ouagadougou than in Tamale. Farmers complained about the high price of inputs, and in

Ouagadougou they also felt that input quality was poor. Seasonal price fluctuations depressed farmers' profits, and many of them blamed this on poor storage facilities.

The trend of sales to female marketers at the farm gate reflects patterns found in UPA across West Africa, as does the concentration of production in the rainy season, which is a result of limited access to irrigation. The differences in the prevalence and commercial significance of cultivation in backyards and isolated interstitial spaces are likely to be due at least in part to bylaws forbidding cultivation of tall crops in Ouagadougou. Variation in the species grown also reflects the different consumption characteristics of the two cities, influenced by their heritage and differential status as national and regional capitals. Application of organic amendments to soils in Ouagadougou could be linked to higher livestock ownership and institutional promotion of compost.

The results point to the need for further work on uncontaminated, perennial water sources and soil fertility management, alongside focuses on commercialization of animal production and the legal, political and institutional context of UPA in different West African cities.

INTRODUCTION

Agriculture is a long-standing feature of urban and peri-urban West Africa. The technical, environmental, social and political implications of urban and peri-urban agriculture (UPA) have been researched throughout the twentieth century and into the twenty-first. Such work starts with description (Rakodi 1988; Lee-Smith 2013), and moves through valorization of UPA's environmental and social benefits (Smit and Nasr 1992) and identification of the technical complexities (Lado 1990; Obayelu et al. 2015) to consideration of the social and political implications (McClintock 2010; Maxwell 1995). To date, most investigations have been qualitative, examining niche concerns and locations (Naab et al. 2013; Drechsel et al. 2007), or have involved haphazardly sampled quantitative investigations and general descriptive summaries (Drechsel and Dongus 2010) rather than using randomly sampled surveys of entire cities. As a sound foundation for research, policy-making and planning related to agriculture in West African cities, however, a more systematic approach towards analyzing urban and peri-urban farming systems is needed.

This paper presents one of the first attempts to perform a randomized survey of UPA in West Africa, focusing on the cities of Tamale (Ghana) and Ouagadougou (Burkina Faso). It aims at systematically describing the current status and conditions of agricultural production in three predefined categories of urban and peri-urban farms in these two cities. Towards that purpose, we collected data on farm characteristics, cultivation patterns, crop marketing, livestock and inputs from 513 randomly sampled households. Soil samples were taken to assess the quality of urban and peri-urban soils and to correlate soil parameters with the socioeconomic survey data. The detailed data given here expand our knowledge of UPA in West Africa by highlighting the distinct characteristics of farming in the two cities.

This study was conducted as part of the GlobE - UrbanFood^Plus (UFP) project, an interdisciplinary research partnership of African, German and international institutions funded by the German Federal Ministry of Education and Research, which aims at enhancing resource use efficiency in West African cities by exploring the potential of agricultural innovations (cf. UFP website for further details: http://www.urbanfoodplus.org). UFP carried out this standardized exploratory survey in Tamale, Ghana and Ouagadougou, Burkina Faso, between September and November 2013, intending to characterize urban and peri-urban agriculture in Tamale and Ouagadougou to act as a basis for future research. This working paper gives an oversight of the results of the survey and identifies useful directions for further investigations of the UFP project and other research efforts concerned with West African UPA.

STUDY CONTEXT AND METHODS

Overview of the Research Areas

Tamale and Ouagadougou are comparable in that they are both in the savanna zone and have a monomodal rainfall season. The soils in both cities are poor in organic matter, nutrients and water-holding capacity (Jones et al. 2013). Both Ghana and Burkina Faso are urbanizing, albeit at decreasing rates, and the proportion of the population involved in agriculture is high (FAO 2015). The Mossi majority in Ouagadougou are ethnic cousins of the Dagomba people of Tamale. Yet, despite their similarities, these cities are different in many ways. The population of Ouagadougou, the capital city of Francophone Burkina Faso, is close to 2 million and, as an international city, it is fairly ethnically diverse. Tamale, on the other hand, is a regional capital with a population of just 370,000 in a less-advantaged region of an Anglophone country (Ghana Statistical Service 2013). While Ghana's Human Development Index is higher than that of Burkina Faso, its undernourishment rate is lower (FAO 2015). These differences, and others, are reflected in the following results.

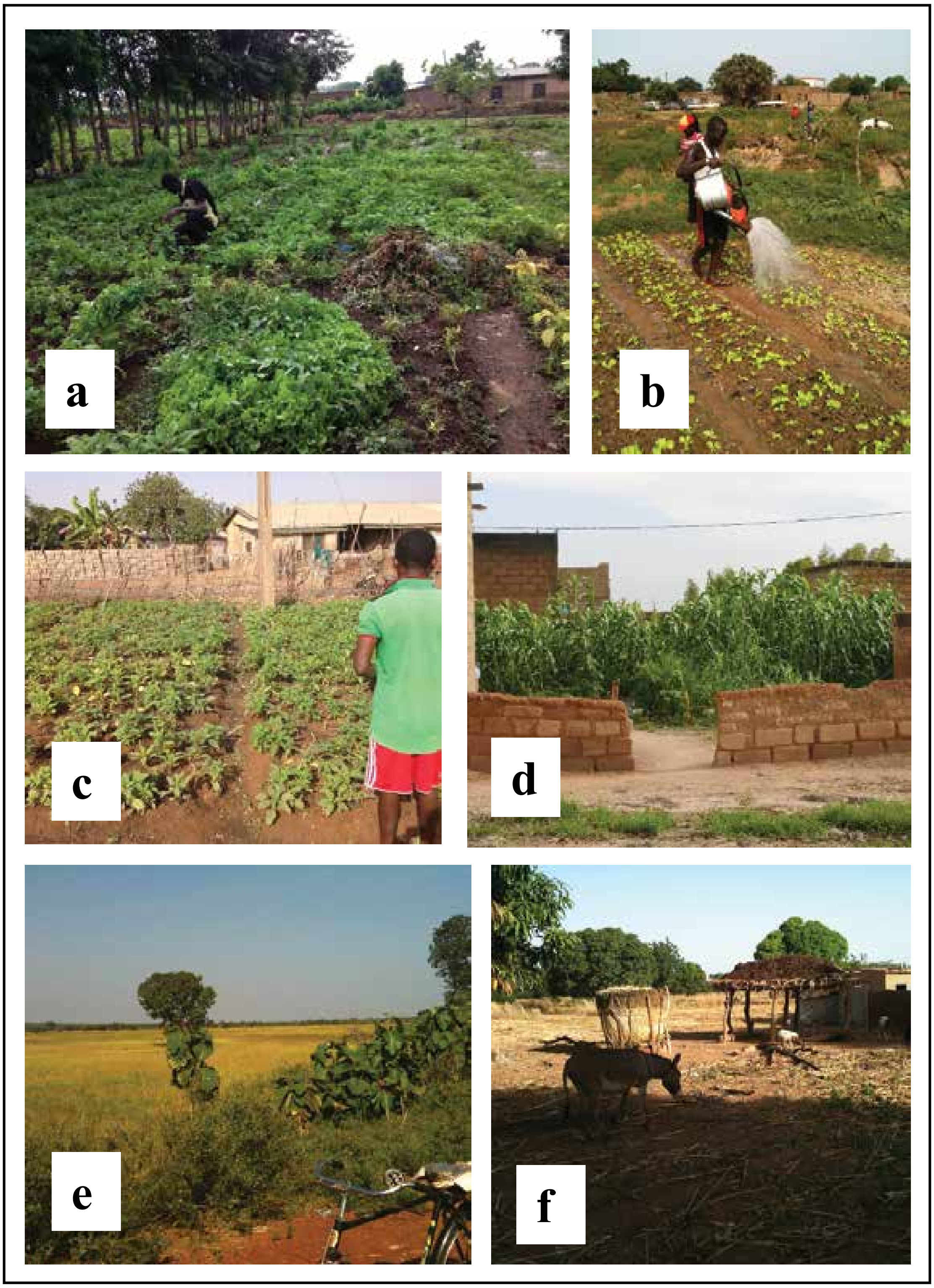
Categorization of Farms

Our aim was to sample randomly, which was a challenge due to the paucity of data on the total number of urban farmers in the study cities, their locations and the proportion of land devoted to agriculture. Some limited data were available on the location of contiguous farming zones in the study cities, a few of which had lists of names of farmers who were members of associations. However, we were also aware of, and concerned with, nonorganized farmers and farms in isolated backyards and other interstitial spaces within the city, for example on individual undeveloped plots. Another interest was peri-urban farming sites, including irrigated open spaces and nonirrigated villages that have links to urban input and output markets. Therefore, we employed a systematic spatial sampling strategy that would enable us to randomly sample whilst including all these various categories of farms and farmers.

We started by defining three sampling categories: urban open-space sites, peri-urban villages and urban areas where isolated backyards and other interstitial space farms could be found. A slightly different technique would be necessary to identify each category of farm. At the same time, we wanted to make the categories as broad as possible in order to allow patterns to emerge from the data.

Urban space can be defined based on a number of factors including population, infrastructural density and distance from the city center. Our definition of urban versus peri-urban space took into account travel time rather than absolute distance from the city center, meaning that it accounted for the density of the transport network. Villages were located in the peri-urban zone, whereas open-space and isolated backyard/interstitial space farms existed within urban spaces. Figure 1 illustrates some of the sites surveyed in the three categories.

FIGURE 1. (a) Open-space site, Tamale; (b) Open-space site, Ouagadougou; (c) Backyard farm, Tamale; (d) Backyard farm, Ouagadougou; (e) Peri-urban village, Tamale; and (f) Peri-urban village, Ouagadougou.



Photos: (a), (b), (c), (e) and (f): Imogen Bellwood-Howard; (d): Barbara Löhde.

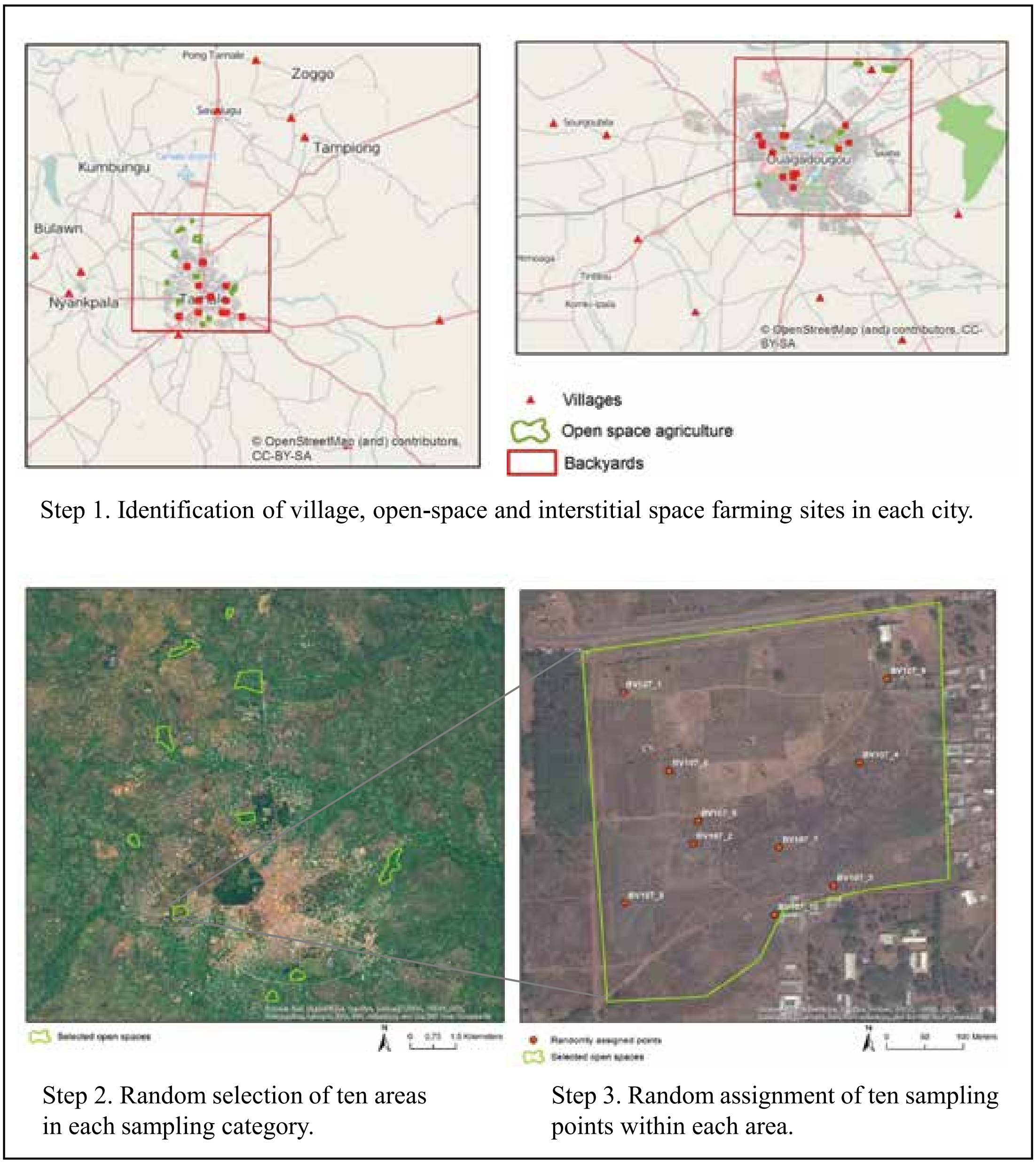
Sampling Approach

Altogether, 513 farmers were randomly sampled using a remote sensing-based approach, 269 in Tamale and 244 in Ouagadougou. High-resolution satellite images were used to classify built-up areas. In a second step, 30 cells were randomly selected in and around each city, stratified into urban (i.e. open-space cultivation and interstitial space/backyard gardening) and peri-urban production. The cells relating to interstitial space farming were defined as having shares of built-up areas between 50 and 80%. Those representing open-space farming were contained within the boundaries of sites identified from the satellite images. Peri-urban cells were villages outside the main urban area. Within each cell, ten fields were sampled using spatial random selection. Table 1 presents the sample composition and Figure 2 illustrates the sampling approach.

TABLE 1. Sample composition.

City	Sampling category	No. of households sampled	%
Ouagadougou	Urban open-space farms	96	39.3
	Urban isolated farms	55	22.5
	Peri-urban villages	93	38.1
	Total	244	100.0
Tamale	Urban open-space farms	75	27.9
	Urban isolated farms	96	35.7
	Peri-urban villages	98	36.4
	Total	269	100.0
	Total (both cities)		513

FIGURE 2. Sampling approach.



Step 1. Identification of village, open-space and interstitial space farming sites in each city.

Step 2. Random selection of ten areas in each sampling category.

Step 3. Random assignment of ten sampling points within each area.

The farmer cultivating each field was interviewed about his or her household and farming characteristics. Data were collected on each crop a farmer had grown in the particular field we visited in the past rainy and dry seasons. We recorded whether each was primarily for sale or consumption and the inputs and irrigation methods the farmer had used. As well as collecting data from individual farmers with reference to the field we met them in, we recorded some data referring to their entire landholding, such as the total holding area and all the crops cultivated in the previous year. In addition, farmers were asked which livestock species they raised, how many animals they kept and if they sold them. Inputs related to veterinary medicines and vaccines as well as outputs, i.e., the use of manure as a field amendment, were also assessed. Descriptive statistics were processed using the statistical software package SPSS 21.

Soil Sampling and Analysis

Soil samples were taken from 242 fields in Tamale and 185 fields in Ouagadougou. In each field, three soil sample replicates of 318 cm^3 were taken at 0-20 cm depth. The three replicates were dried at 40 °C and subsequently pooled, gently disaggregated and sieved to 2 mm for further analysis.

Organic C was quantified by dry combustion after dissolution of carbonates with 10% 0.01 M HCl. N was analyzed by dry combustion. Available P was measured with the calcium acetat lactat (CAL) method. Soil pH was measured from a suspension of 10 g soil and 25 ml 0.01 M $CaCl_2$. Exchangeable Ca^{2+}, K^+ and Mg^{2+} were extracted by ammonium chloride and measured by Inductively Coupled Plasma Spectroscopy (Ciros Charge Coupled Device, SPECTRO Analytical Instruments GmbH, Kleve, Germany). Effective cation exchange capacity (CEC) was calculated as the sum of exchangeable cations, accounting for their valence. Soil texture was determined by laser diffraction (Analysette 22 MicroTec plus; Fritsch GmbH, Idar-Oberstein, Germany) after treatment with hydrogen peroxide and sodium pyrophosphate.

A subset of 50 samples per city was analyzed for organic C, N, available P, pH, CEC, Ca^{2+}, K^+ and Mg^{2+} at the University of Bochum while the remainder of the samples was analyzed by means of Fourier transform infrared spectroscopy (FTIR). FTIR is a rapid method to accurately predict soil properties based on energy adsorption in the mid-infrared wave length. Spectra were recorded in five replicates using a Bruker Tensor 27 equipped with an automated high throughput device (Bruker HTS-XT, Ettlingen, Germany), operating with a liquid N_2-cooled mercury-cadmium telluride (MCT) detector. Comparison of results from conventional analyses with the FTIR spectra showed that soil properties could be predicted well, based on FTIR, so that these were used for the remainder of the samples. Predicted values outside the calibration range were removed as outliers.

Qualitative Data Collection

We also collected qualitative data. Haphazardly sampled focus group discussions and interviews were performed in the two cities between September and November 2013. Enumerators noted sites of interest during the course of quantitative data collection and returned to collect qualitative data. Further sites that had not been investigated during the quantitative stage of the research were haphazardly selected. Contact was made with farmers in those locations and focus groups and interviews were arranged, loosely based around six themes. These were: general overviews of the farm system, resource mapping, site walks, marketing, innovation, and problems and solutions. Each theme was addressed in each of the isolated field, open-space and village settings in both Tamale and Ouagadougou.

In the following sections we provide some key descriptive results.

RESULTS

Household and Farm Characteristics

With an average of nine members in Ouagadougou and 12 in Tamale, the households of urban and peri-urban farmers in the two study cities are large. The overwhelming majority of surveyed farmers in Tamale (93%) and more than half (53%) in Ouagadougou are Muslim. Polygamy is common, especially in Tamale, explaining the large average household size there. The data suggest an extremely low level of education among farming households, as 62% of 1,056 surveyed adults have not received any formal school education.

Landholdings in Ouagadougou are generally smaller as compared to Tamale (Table 2). Peri-urban village farms are the largest among the three categories in both cities. As will be further explained in the following sections, open-space cultivation of vegetables in Ouagadougou takes place on small, intensively cropped landholdings, whereas cultivation is more extensive in Tamale. In both cities, farms consist of an average of three individual, often spatially dispersed plots. As measured by Garmin Handheld Global Positioning Systems, the randomly sampled reference fields had an average size of 0.07 ha in Ouagadougou and 0.31 ha in Tamale. Despite farmers' concerns about insecure land-tenure arrangements, our survey found a surprisingly large persistence of UPA in both cities, and sites around government institutions such as power-generation facilities and schools are owned by the state. In Tamale, the majority of land has hitherto been customarily owned by the traditional authorities in trust for the people. In recent years, large swathes of these lands have been sold by those traditional leaders to private individuals. In Ouagadougou all land belongs to the state, but private individuals may have a land title if a plot has been allocated to or bought by them. In Ouagadougou, the randomly sampled fields have been used for 21 years on average, as compared to 14 years in Tamale. In contrast to open-space and peri-urban farming, interstitial space gardening appears to be a slightly more transient phenomenon, with an average cultivation period of nine years on sampled fields (Table 2).

TABLE 2. Landholding size and land use duration in Ouagadougou and Tamale.

City	Sampling category	n	Ø Landholding size (ha)	Ø Field size (ha)	Ø Field use duration (years)
Ouagadougou	Urban open-space farms	66	0.87	0.03	15
	Urban isolated farms	35	1.92	0.01	9
	Peri-urban villages	75	2.98	0.14	34
	All categories	176	1.98	0.07	21
Tamale	Urban open-space farms	72	2.58	0.31	17
	Urban isolated farms	83	1.81	0.11	9
	Peri-urban villages	96	5.64	0.47	19
	All categories	251	3.60	0.31	14
	Total sample	427	2.87	0.20	17

Cropping and Agronomy

Farmers were cultivating in open-space vegetable sites as well as isolated farms and peri-urban villages. We collected data from individual farmers firstly with reference to the field we met them in and secondly with reference to the whole of their farmholding, which was often spread across multiple sites. What follows in this section are selected results from the part of the survey that dealt with farmers' cropping characteristics. For each figure, we have indicated whether the results derive from the data relating to the field we met the farmer in or that relating to their whole farmholding.

The results in this section confirm trends already noted in UPA in West African cities – a dominance of rain-fed agriculture due to lack of access to irrigation, and presence of both commercial and subsistence production (Cofie et al. 2003). Like many studies, ours differentiates between different types of production systems, but this section adds detailed data on the temporal cropping patterns applied within each. Additionally, what is especially interesting in figures 3-10 is the difference in the role of different types of farm between the two cities. Data in this section thus begin to point towards the specificity of forms of UPA in different locations, even though they are within the same region.

Seasonal Cultivation

The data on seasonal cultivation of surveyed fields for Tamale confirm common production patterns in nonirrigated sites in West Africa: far more farmers cultivate in the wet than in the dry season, with a higher proportion of those in open-space sites producing year-round (Figure 3). In Ouagadougou, on the other hand, production is concentrated in open-space sites throughout the year (Figure 4). There was a statistically significant difference between the two cities in terms of the number of farmers cultivating in the dry seasons (chi-squared p<0.001), but not in terms of the number of farmers cultivating in the wet season.

FIGURE 3. Number of farmers in different farm types cultivating in Tamale through the year.

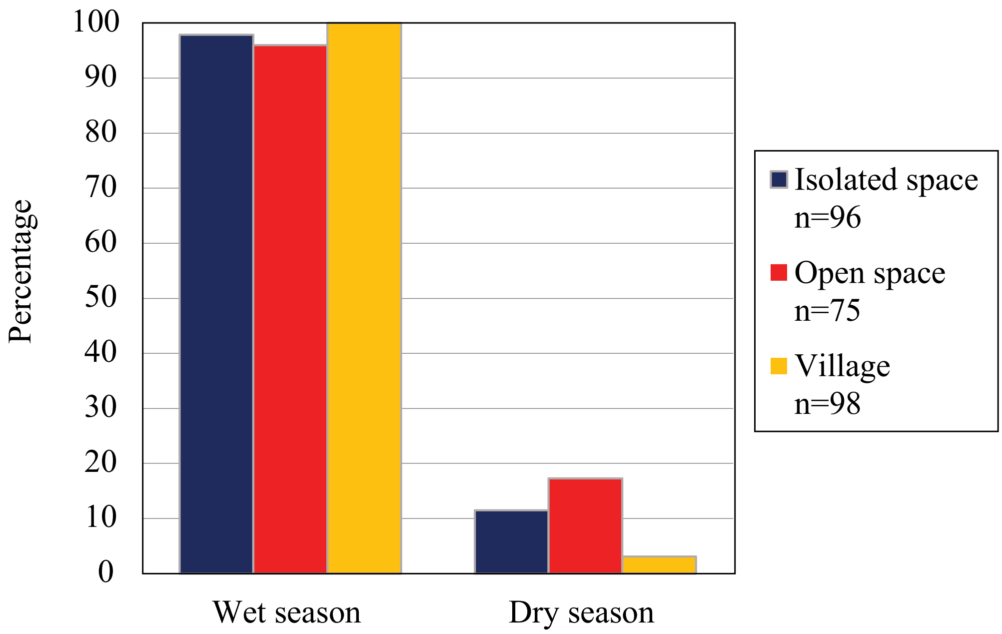
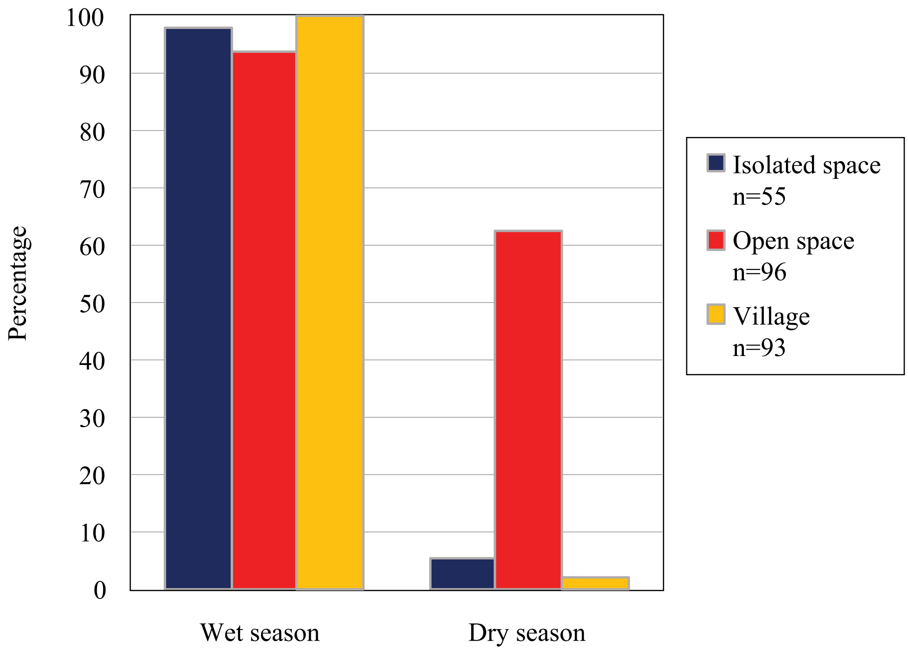


FIGURE 4. Number of farmers in different farm types cultivating in Ouagadougou through the year.



Seasonal Crop Prevalence

We collected data referring to all crops grown across each farmer's landholding. In Tamale, maize, the regional staple, is the most commonly grown rainy-season crop. Traditional leafy green vegetables such as amaranthus and jute mallow dominate dry-season cropping. The commercial nature of open-space sites in Ouagadougou is evident as the cultivation of market leaf crops continues into the wet season, as well as dominating production in all categories through the dry season. Nevertheless, staple production takes over in isolated farms and villages in the rainy season (Tables 3 and 4).

TABLE 3. Seasonal pattern of crop cultivation on different farm types in Tamale.

	Wet season			Dry season		
Sampling category	No. of times crops are mentioned	Crop	% of times crops are mentioned	No. of times crops are mentioned	Crop	% of times crops are mentioned
Urban open-space farms	312	Maize Rice Okra	30.4 15.4 8.0	38	Amaranthus Okra Roselle	21.1 21.1 15.8
Urban isolated farms	370	Maize Okra Rice	28.1 10.3 8.9	37	Roselle Amaranthus Cabbage	18.9 16.2 13.5
Peri-urban villages	516	Maize Rice Yam	27.7 13.0 11.4	5	Tomato Banana Pepper	*

Note: * Percentages not provided due to small absolute numbers.

TABLE 4. Seasonal pattern of crop cultivation on different farm types in Ouagadougou.

	Wet season			Dry season		
Sampling category	No. of times crops are mentioned	Crop	% of times crops are mentioned	No. of times crops are mentioned	Crop	% of times crops are mentioned
Urban open-space farms	277	Lettuce Amaranthus Okra	19.9 13.7 10.1	197	Lettuce Amaranthus Cabbage	31.5 19.8 9.1
Urban isolated farms	162	Maize Okra Groundnut	22.8 21.0 13.6	13	Lettuce Sweet potato Amaranthus	*
Peri-urban villages	350	Sorghum Maize Millet	36.0 18.9 15.7	45	Onion Cabbage Tomato	24.4 20.0 17.0

Note: * Percentages not provided due to small absolute numbers.

Commercial Cultivation

In Tamale, there was a fair amount of commercial production across the different categories of farms, and a larger number of commercial farmers in the wet season reflect the larger number of farmers overall in that season (Figure 5). In Ouagadougou, commercial production on the surveyed fields, like cultivation in general, was concentrated in open-space sites, and is fairly constant throughout the year, as these farmers have permanent access to irrigation (Figure 6). In chi-squared tests, the distribution of farmers who farmed commercially between the three sampling categories was significantly different between the two cities in both the dry season ($p = 0.002$) and the wet season ($p < 0.001$).

FIGURE 5. Number of farmers in different farm types cultivating commercial crops in Tamale through the year.

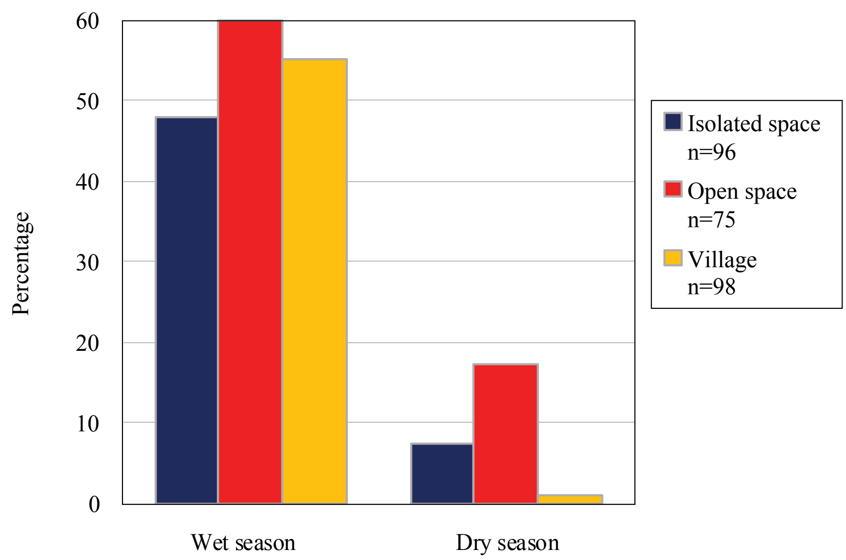
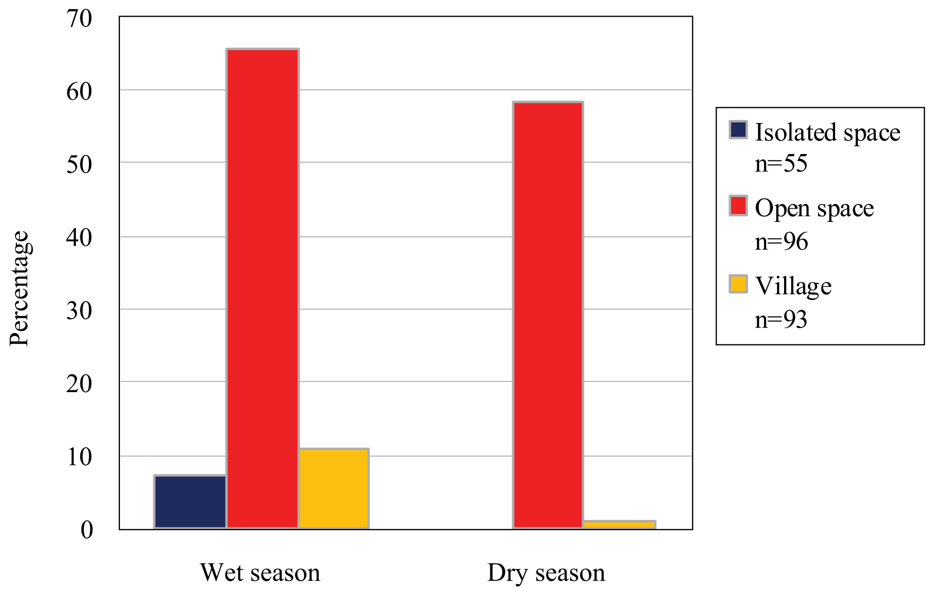


FIGURE 6. Number of farmers in different farm types cultivating commercial crops in Ouagadougou through the year.



Marketing of Crops

All data on marketing routes and locations presented here refer to commercial crops cultivated on the reference field over the year preceding the survey.

In Tamale, most farmers were selling their crops to traders rather than to retail consumers, but whereas marketers traveled to urban farms to purchase, those from villages were obliged to transport their own goods to the markets. Likewise, in Ouagadougou, villagers who traded generally took their goods to the market. However, the vast majority of people who traded were cultivating in open-space sites. Traders traveled to these sites to purchase farm goods (Figures 7-10).

FIGURE 7. Purchasers of farm goods in Tamale.

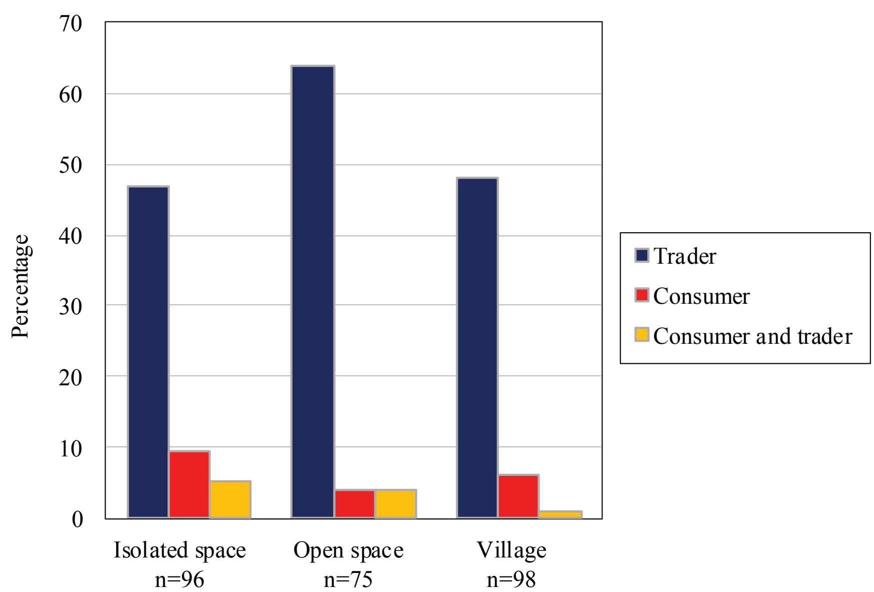


FIGURE 8. Sale locations in Tamale.

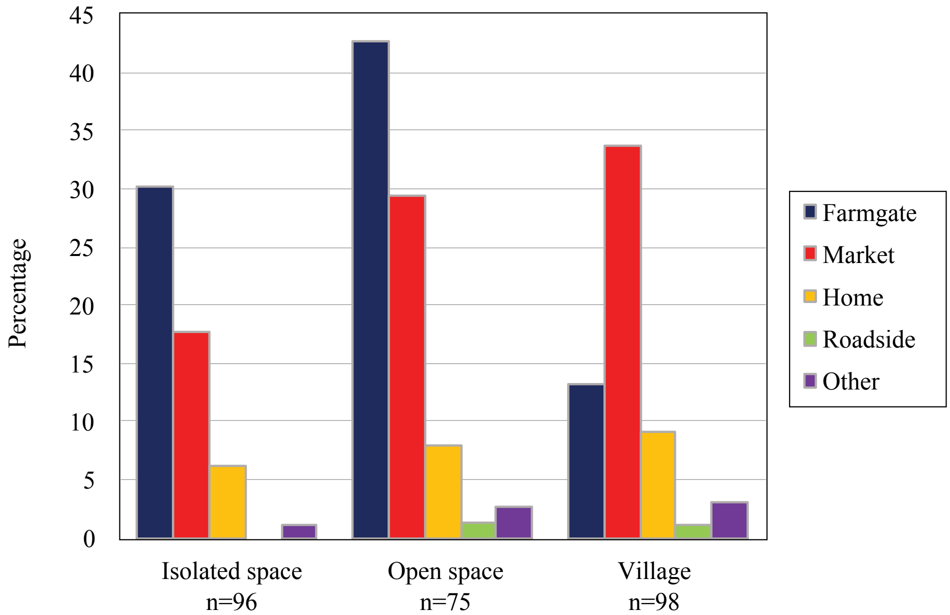


FIGURE 9. Purchasers of farm goods in Ouagadougou.

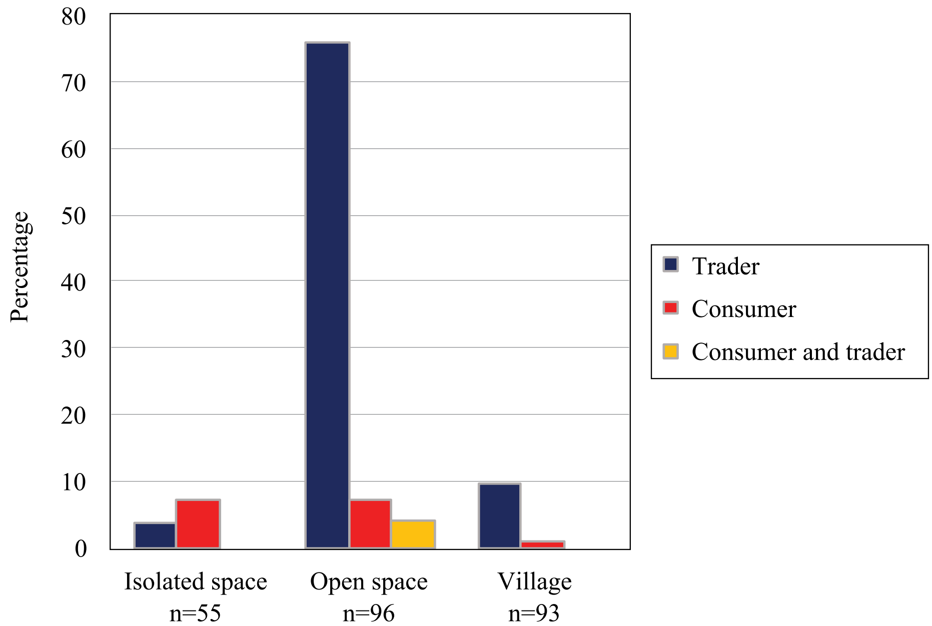
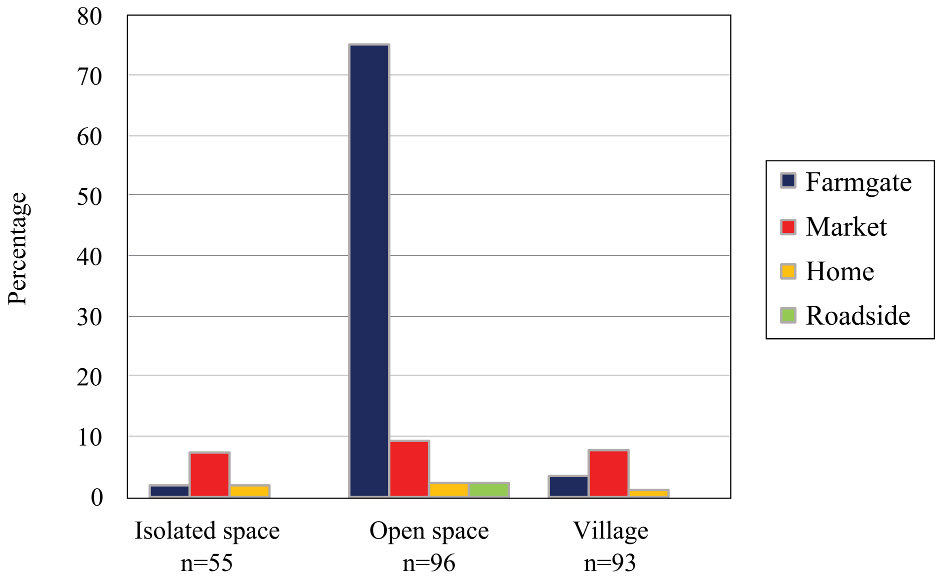


FIGURE 10. Sale locations in Ouagadougou.



Many farmers in Tamale described how they exchanged credit with the traders they worked with. Farmers sometimes obtained inputs such as seeds or fertilizers from traders, and traders often obtained goods on credit, paying farmers after they had sold the goods in the market.

Livestock Ownership

Livestock farming is another important element of UPA. Besides cultivating crops, 93% (n=251) and 63% (n=154) of all interviewed farmers in Tamale and Ouagadougou, respectively, also owned some livestock and/or poultry. While in Tamale livestock-rearing was more common among farming households in urban areas than in peri-urban villages (61% vs. 39% of farms), no significant difference could be observed in the distribution of livestock ownership between farm types in Ouagadougou (53% in peri-urban vs. 47% in urban areas) (Table 5).

TABLE 5. Livestock ownership of farmers in Ouagadougou and Tamale, by farm type.

	Ouagadougou	Tamale
Urban isolated farms (n)	27	83
Urban open-space farms (n)	46	71
Peri-urban villages (n)	81	97
Total farms with livestock (n)	154	251

In Tamale, most of the farmers who owned livestock owned more than one species. This was particularly so in peri-urban villages, where most farmers owned three or more species (74%). In urban areas (isolated farms and open-space farms), the share of farms with only one livestock species was higher than in peri-urban village farms (Figure 11). The household farms with only one livestock species mostly owned poultry (87%). Like in Tamale, most farmers in peri-urban villages around Ouagadougou owned more than one livestock species (86%). In contrast to Tamale, however, a minority of farmers in urban areas had several livestock species (17% on average). In particular, the farmers who were engaged in crop production in isolated farms such as backyards only owned poultry (Figure 12).

FIGURE 11. Number of livestock species per farm in Tamale.

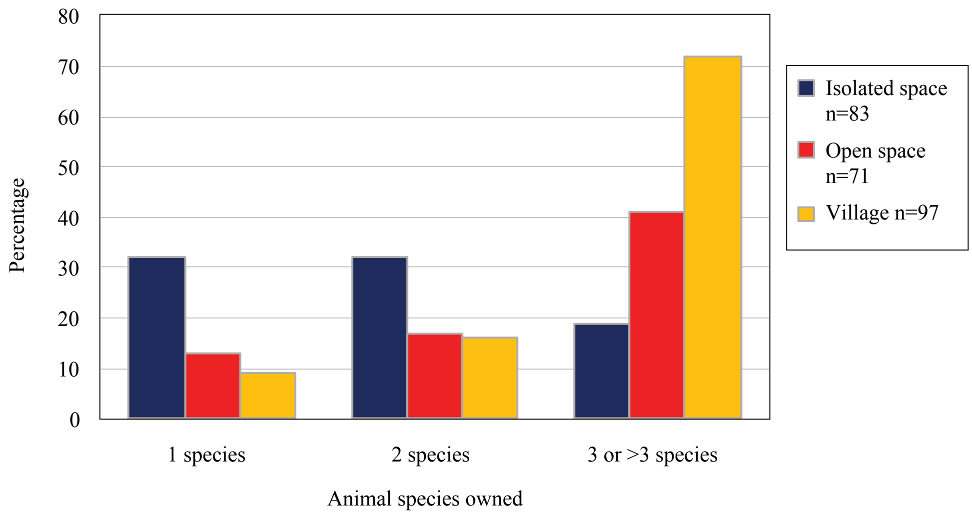
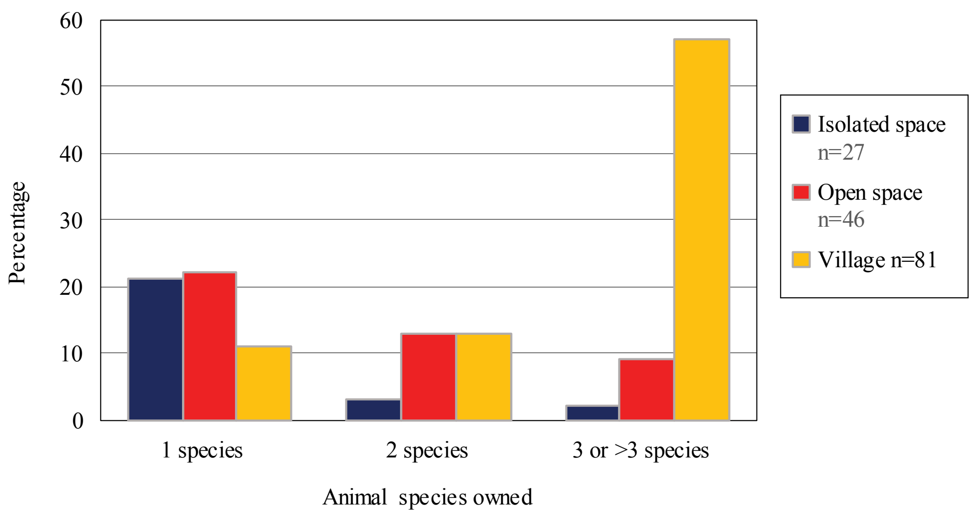


FIGURE 12. Number of livestock species per farm in Ouagadougou.



The most common livestock species kept by farmers interviewed in Tamale was poultry (94%), followed by goats (60%) and sheep (51%). In contrast, cattle and pigs were rarely owned by the Tamale respondents (Figure 13), the latter result reflecting the higher proportion of Muslims in Tamale than in Ouagadougou. As could be also observed for Tamale, poultry were the most widespread livestock in Ouagadougou, irrespective of the farm type (87% of farmers). Looking at the distribution of the other livestock species across the different farm types, we observed a greater prevalence of sheep over goats for open-space farmers (52% vs. 26%) and farmers in isolated farms (15% vs. 11%), which is in clear contrast to Tamale, where goats were owned by a larger number of farmers than sheep. It was only in peri-urban villages that goats were the second most important livestock species, owned by 78% of the interviewed farmers. Cattle were reared by 44% of the village farmers, which is again in clear contrast to the village farmers in Tamale. Pig-rearing was more common in Ouagadougou than in Tamale. Here, pigs were owned on all types of farms, with a larger share of pig owners among village farmers (21%) and those farming in isolated urban spaces (19%) than in open-space farmers (4%) (Figure 14).

FIGURE 13. Types of livestock owned by farmers in Tamale.

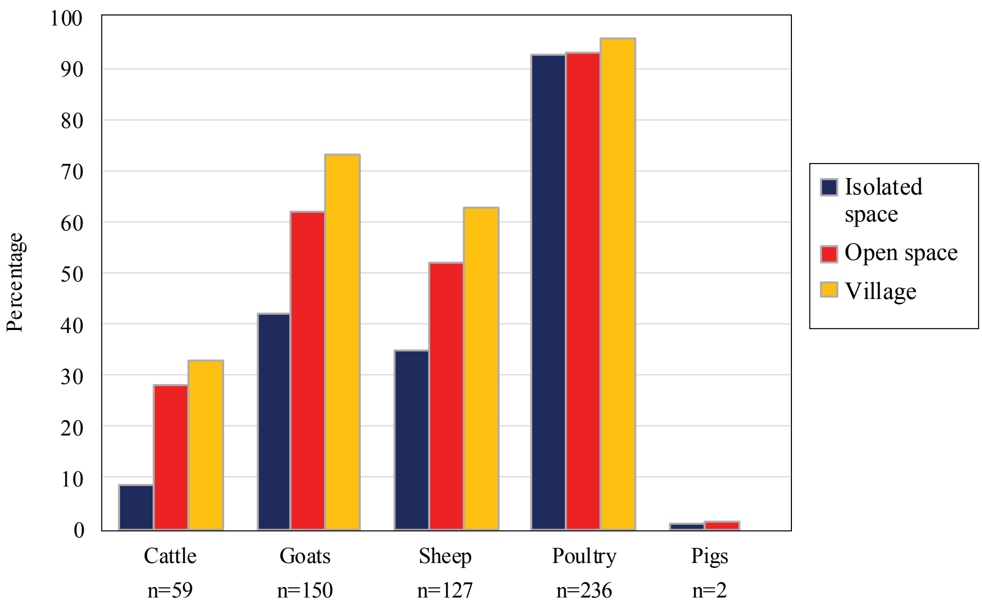
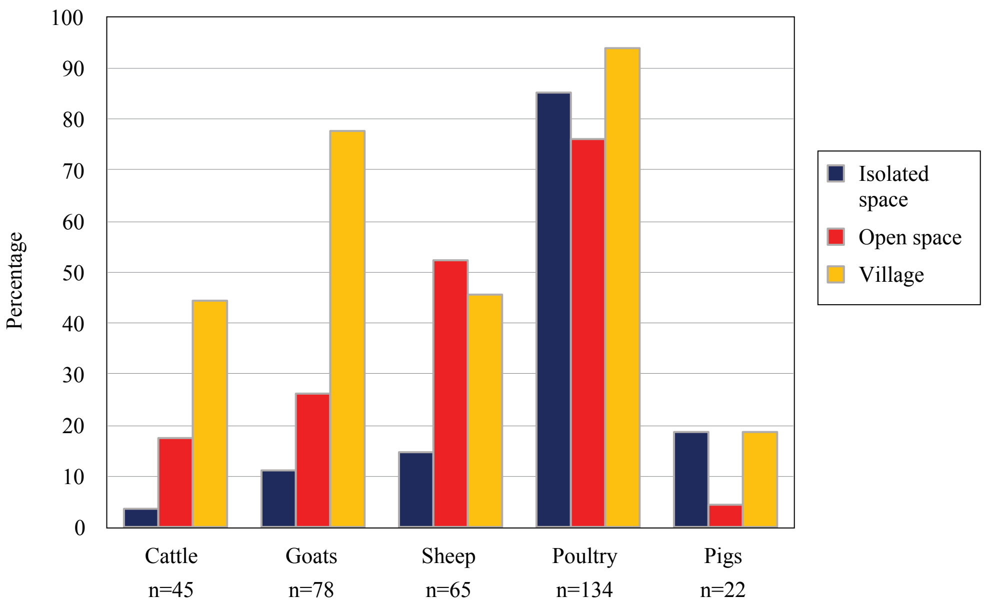


FIGURE 14. Types of livestock owned by farmers in Ouagadougou.



The mean herd size for all farms with livestock in Tamale was 5.4 tropical livestock units (TLU, corresponding to 250 kg live weight of animals). Herds in the villages were significantly larger than those owned by farmers in isolated urban fields (7.6 vs. 2.2 TLU), but not different from herds of open-space farmers (6.0 TLU). This difference was mostly due to a larger number of cattle in the villages, although the number of cattle in TLU was statistically not different between the groups (Table 6). The average herd sizes in Ouagadougou were considerably smaller than in Tamale, irrespective of the livestock species (Table 7). Cattle herds in particular were larger in Tamale than in Ouagadougou (17.1 vs. 2.7 TLU). As a consequence, the total number of livestock in TLU amounted to only 1.8 in Ouagadougou versus 5.4 in Tamale. Like in Tamale, the overall herd size was significantly larger in the villages, and also significantly different from the herd size of open-space farmers (2.5 vs. 0.5 and 1.3; $p<0.001$). In contrast to Tamale, the cattle herds were smaller in the villages than in open-space farms in urban areas, although not statistically different (2.5 vs. 3.7 TLU). In Ouagadougou, the larger overall herd sizes in the villages resulted from the larger number of poultry (0.2 compared to 0.11 and 0.08 on open spaces and isolated fields, respectively; $p<0.01$) and larger goat herds (0.8 vs. 0.5 for both urban farm types).

TABLE 6. Mean livestock herd size (in TLU) of farms in Tamale.

Livestock species	n	Isolated farms	n	Open-space	n	Village	n	Total	p-value
Total livestock	83	2.2	71	6.0	97	7.6	249	5.4	0.04
Poultry	77	0.27	66	0.43	93	0.37	236	0.35	n.s.
Goats	35	0.95	44	0.75	71	0.95	150	0.89	n.s.
Sheep	29	0.91	37	0.95	61	0.90	127	0.91	n.s.
Cattle	7	14.4	20	16.4	32	18.1	59	17.1	n.s.

Note: n.s. = nonsignificant.

TABLE 7. Mean livestock herd size (in TLU) of farms in Ouagadougou.

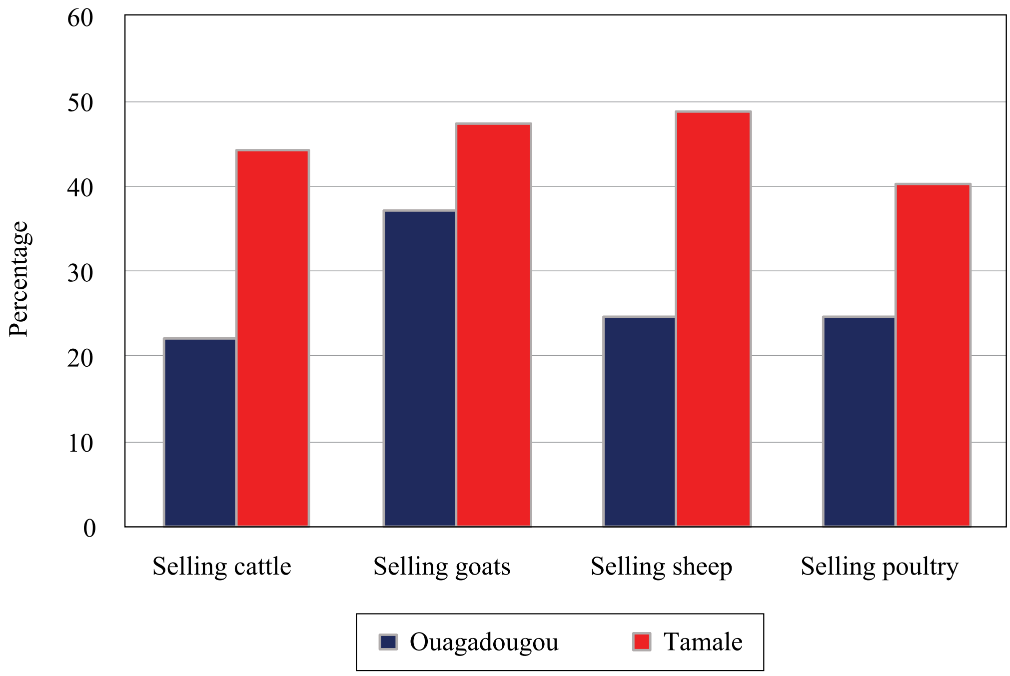
Livestock species	n	Isolated farms	n	Open-space	n	Village	n	Total	p-value
Total livestock	27	0.5	46	1.3	81	2.5	154	1.8	<0.001
Poultry	23	0.08	35	0.11	76	0.20	134	0.15	<0.01
Goats	3	0.5	12	0.5	63	0.8	78	0.7	n.s.
Sheep	4	0.7	24	0.7	37	0.7	65	0.7	n.s.
Cattle	1	24	8	3.7	36	2.5	45	2.7	n.s.

Note: n.s. = nonsignificant.

Livestock Sales

Farmers in Ouagadougou and Tamale did not commonly sell livestock. In general, the share of farmers selling livestock was higher in Tamale than in Ouagadougou across all livestock species. Although poultry were the most commonly owned livestock owned in both cities, the highest percentage of farmers who sell livestock could be observed for those owning goats in Ouagadougou (37%) and sheep in Tamale (47%) (Figure 15).

FIGURE 15. Livestock sales in the last 12 months (% of farmers), n as in figures 11 and 12.



Soil Fertility

The dominant soil types in both Ouagadougou and Tamale were Plinthosols, Lixisols, Gleysols, Cambisols and Arenosols (IUSS Working Group WRB 2007). The studied topsoils were naturally low in contents of organic C, total N, available P, exchangeable Ca^{2+}, Mg^{2+}, K^{+}, clay contents and CEC. The pH values were neutral to moderately acid. At some sites in Ouagadougou low carbonate contents were found.

Soils in Ouagadougou were significantly more fertile than in Tamale (Table 8). This was attributed to the more arid conditions in Ouagadougou with a shorter rainy season and higher evapotranspiration than in Tamale. High evaporation rates lead to a net accumulation of exchangeable cations, available P and effective CEC and a higher pH in the topsoil compared to the subsoil. Semiarid conditions in Ouagadougou limit C and N mineralization rates and, at similar biomass inputs in both the cities, lead to higher organic matter contents than the more moist conditions in Tamale. Maize yields were not significantly different between the two cities (data not shown).

TABLE 8. Soil properties at 0-20 cm soil depth and maize yields by city and spatial farm category.

	C (%)			N (%)			pH			P (mg/kg)			CEC (mmolc/kg)		
	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
Ouagadougou															
Isolated fields	39	0.91	0.53	40	0.08	0.04	29	7.1	0.2	37	141.4	87.5	39	265.7	129.0
Open spaces	70	1.31	0.71	68	0.11	0.04	65	6.8	0.5	69	110.0	87.3	68	198.8	122.9
Villages	72	0.86	0.63	72	0.08	0.05	69	6.6	0.5	73	53.7	56.1	74	95.6	63.0
Tamale															
Isolated fields	86	0.78	0.77	78	0.06	0.04	85	6.1	0.6	82	67.6	80.3	85	90.2	103.6
Open spaces	63	0.71	0.64	59	0.06	0.04	63	5.8	0.8	62	55.9	71.8	60	73.4	69.3
Villages	89	0.87	0.78	86	0.07	0.04	88	6.1	0.7	86	47.3	55.1	90	110.7	111.3

	Ca (mg/kg)			K (mg/kg)			Mg (mg/kg)			Clay (%)			$CaCO_3$ (%)		
	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
Ouagadougou															
Isolated fields	36	4,722.1	2,270.1	36	198.7	114.6	37	193.6	100.1	40	5.1	1.3	31	0.17	0.09
Open spaces	68	3,595.2	2,139.6	68	148.6	94.0	69	188.9	78.1	70	7.1	2.7	56	0.14	0.09
Villages	74	1,697.0	1,209.8	71	147.5	102.0	71	142.8	88.8	72	4.9	1.3	37	0.10	0.07
Tamale															
Isolated fields	82	1,428.1	1,564.4	67	97.8	75.7	81	130.7	79.9	84	4.4	1.1	46	0.08	0.06
Open spaces	58	1,207.1	1,188.8	50	92.8	95.0	58	118.3	84.2	61	4.7	1.5	27	0.07	0.05
Villages	90	1,826.9	1,860.6	83	166.5	110.8	84	153.8	83.1	88	5.1	1.2	37	0.08	0.05

In Ouagadougou, soils in the urban fields (isolated fields and open spaces) were more fertile on average than the soils of peri-urban fields. This trend was reversed in Tamale (Table 8). Correlation analyses suggested that the trends had much to do with application of amendments. Application rates of inorganic fertilizers in the year preceding the survey correlated positively with most soil properties, i.e. pH, Ca, bulk density, CEC, P, N, C and Mg (r in decreasing order). This can be explained by larger biomass production under inorganic compared to organic fertilizer inputs. Under high yields more below-ground biomass (and to a variable degree harvest residues) remains in the field and acts as a source of soil organic carbon and nutrients.

Organic fertilizers (compost and farmyard manure) correlated among the soil properties only with pH, Ca and bulk density (r in decreasing order). During the data collection high variations in quality of organic fertilizers were observed. It is likely that this explains the limited soil conditioning effects of organic fertilizers in the study area.

While correlation coefficients between yields and soil properties were significant, correlation coefficients between yields and inorganic and organic inputs were much higher (Table 9).

TABLE 9. Pearson correlation coefficients (2-tailed) between yields, soil inputs and soil properties.

		Bulk density	Organic C	Total N	C/N	pH	Available P	Ca^{2+}	CEC	K^{+}	Mg^{2+}	Inorganic fertilizer application rates	Organic fertilizer application rates
Maize yield	r	-0.31**	0.31**	0.27**	0.16	0.31**	0.27**	0.37**	0.32**	0.13	0.20*	0.60**	0.40*
	n	130	132	126	126	126	124	127	129	115	124	60	40
Inorganic fertilizer	r	-0.32**	0.27**	0.28**	0.07	0.39**	0.29**	0.38**	0.31**	0.13	0.21*	1	0.54**
	n	120	123	117	117	120	118	116	117	104	113	124	61
Organic fertilizer	r	-0.21*	0.12	0.16	-0.07	0.24**	0.17	0.22*	0.17	0.13	0.10	0.54**	1
	n	108	114	112	111	112	113	112	114	104	109	61	115

Note: Significance levels: * 0.05; **0.01

Inputs

As regards farmers' use of inputs on the surveyed reference fields, the importance of seeds goes without saying. It is relevant to note that soil fertility amendments were commonly used in Tamale across all farm categories, followed by crop protection inputs. Fencing was widely used in the farms in Tamale that were sited in isolated spaces, in people's backyards, undeveloped plots and other interstitial spaces. The importance of these farms for commercial production has been noted (Figure 16). In Ouagadougou, soil fertility amendments, seeds and crop protection inputs were again important. However, in isolated fields, soil fertility and agrochemical inputs were less important, indicating the subsistence nature of these farms in Ouagadougou as compared to Tamale (Figure 17).

FIGURE 16. Farm inputs used in Tamale.

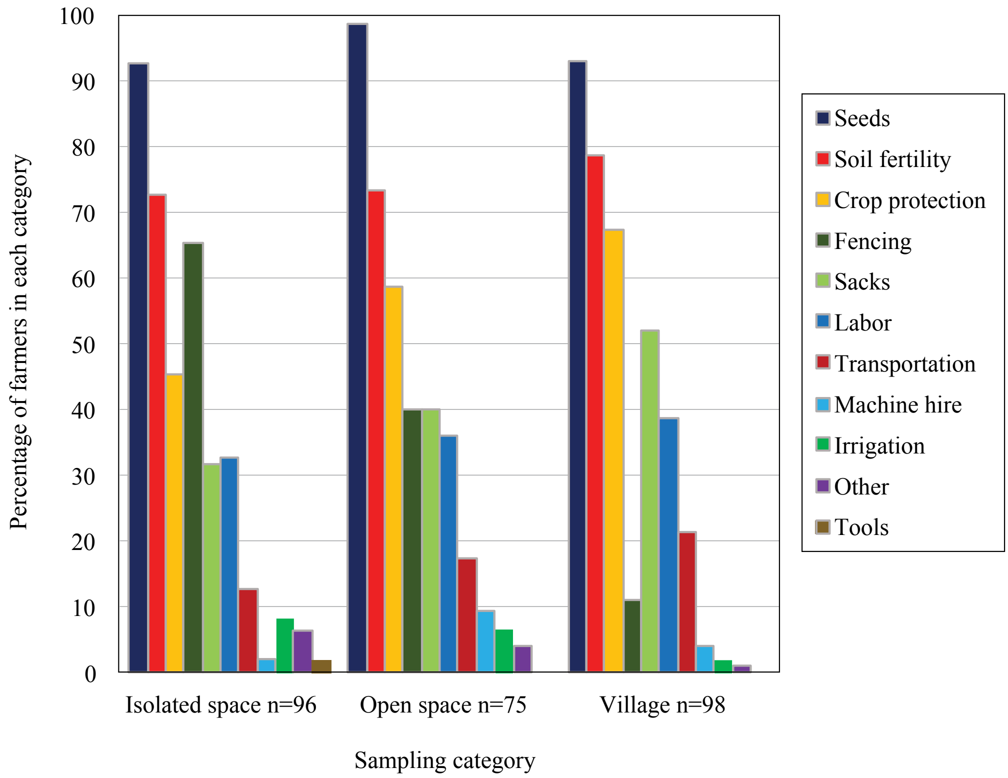
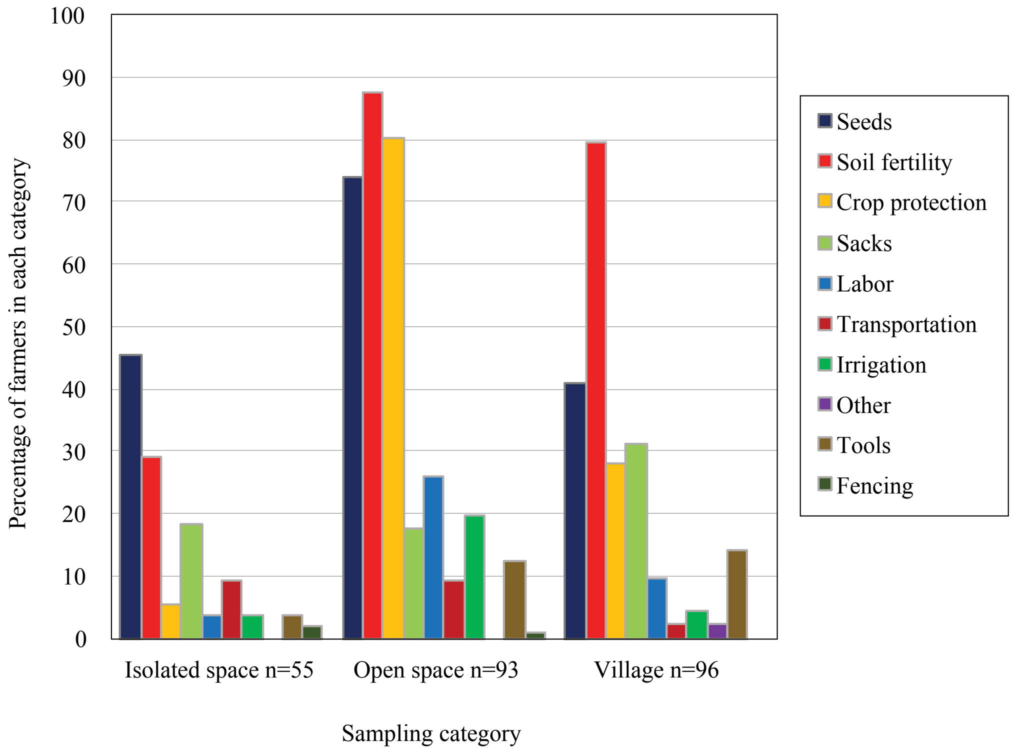


FIGURE 17. Farm inputs used in Ouagadougou.



Taking a closer look at the use of soil fertility amendments, the most frequently mentioned ones in Tamale are chemical fertilizers, particularly for open-space farms. Livestock manure also plays a role, while the use of compost as soil fertility amendment is uncommon in Tamale, irrespective of the farm type (Figure 18). In Ouagadougou, this is also the case in open-space farm sites, whereas use of the different types of soil fertility amendments is nearly equally distributed in isolated fields and village farms (Figure 19). Farmers usually use several types of soil amendment (Figure 20). Manure is applied in both seasons in Ouagadougou. However, use of manure is more frequent in the wet season than in the dry season, when staple crops are not cultivated. Still, over 40% of farmers fertilize their fields in the dry season. In Tamale, manure is mostly used in the wet season. Use of manure was significantly different ($p<0.001$) between the cities in the dry season but not in the wet season.

FIGURE 18. Soil fertility amendments used on farms in Tamale.

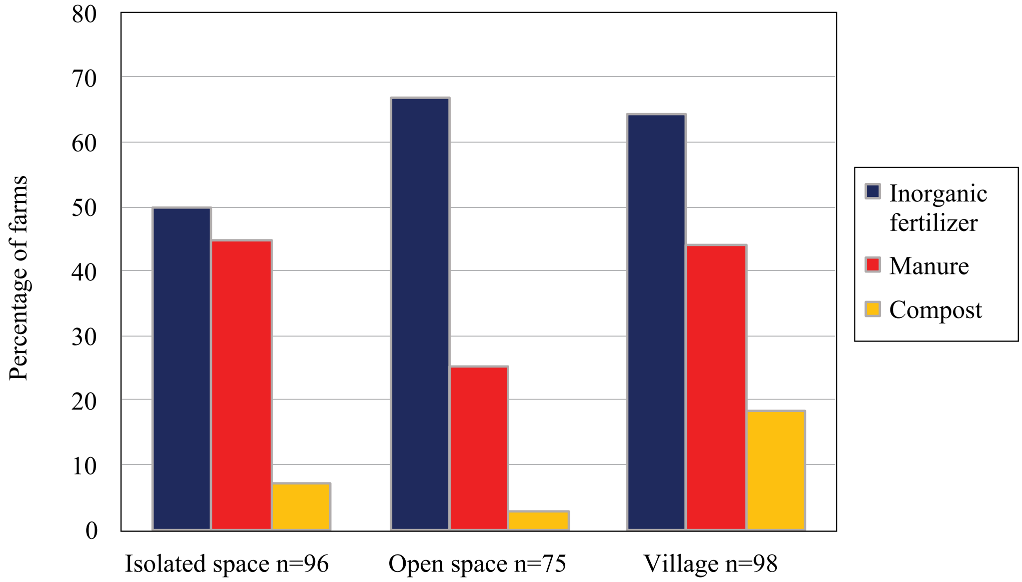


FIGURE 19. Use of soil amendments on farms in Ouagadougou.

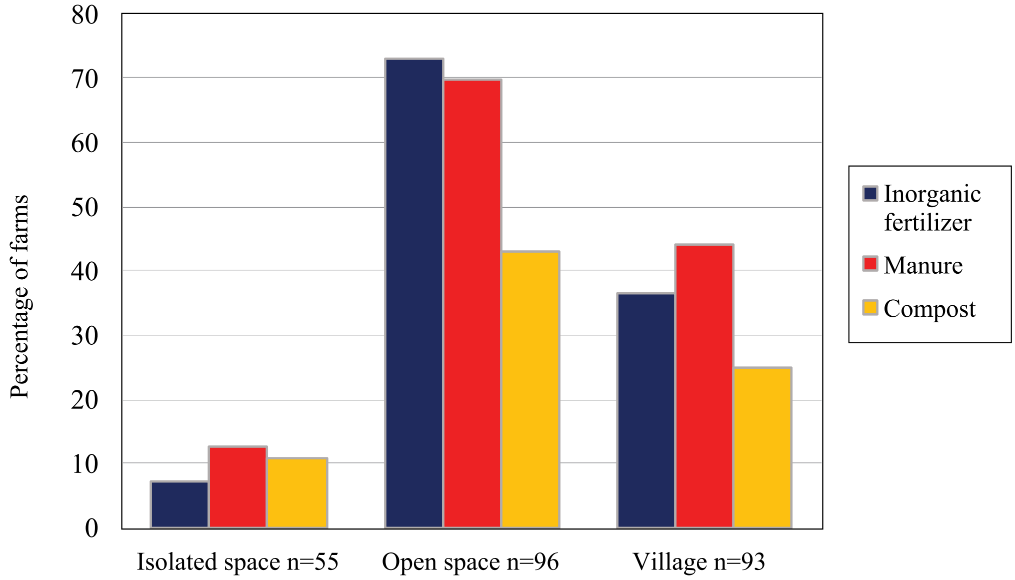
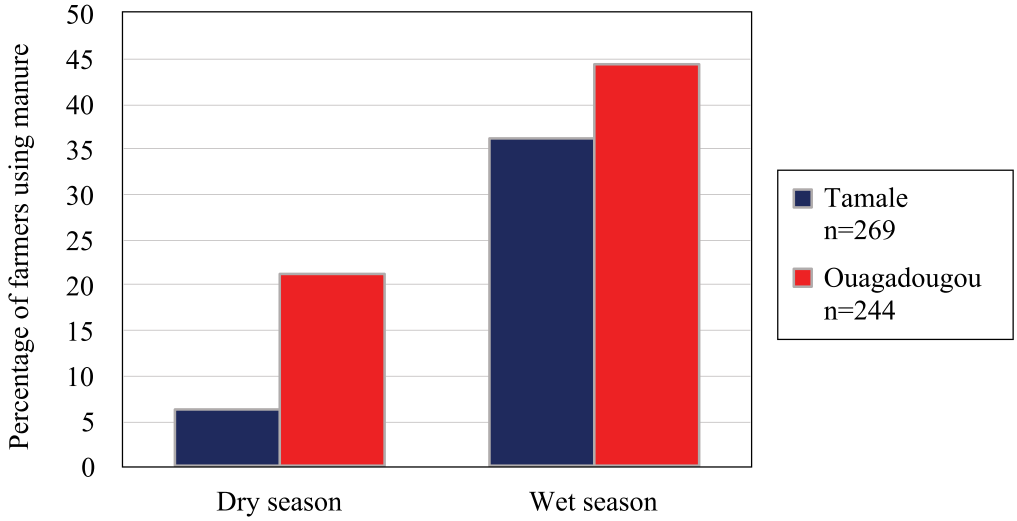


FIGURE 20. Seasonal pattern of manure use in Tamale and Ouagadougou.



Irrigation Sources

Farmers indicated whether they used any type of irrigation in the dry season. The total number of farmers who mentioned using irrigation at all was very low. In Ouagadougou, those farming in open-space sites were using potentially contaminated sources of water, while those farming in isolated urban spaces and in Tamale's open spaces were preferentially using the cleaner, but more costly and less available, publicly supplied piped water (Tables 10 and 11).

TABLE 10. Percentages of farmers in Tamale using various irrigation sources, by farm category.

	Isolated fields n=96	Open space n=75	Village n=98
River	1.0	0	0
Pipe	8.3	6.7	0
'Wastewater'	0	4.0	0
Pond	0	0	0
Dugout/dam	0	1.3	2.0
Well/spring	0	0	0
Other	0	5.2	0

TABLE 11. Percentages of farmers in Ouagadougou using various irrigation sources, by farm category.

	Isolated fields n=55	Open space n=96	Village n=93
River	0	1.0	0
Pipe	3.6	3.1	0
'Wastewater'	0	3.1	0
Pond	0	18.8	1.1
Dugout/dam	0	2.1	0
Well/spring	3.1	31.3	1.1
Other	0	5.2	0

Farmers' Concerns

During our investigations, we met farmers in 31 exploratory interview and focus groups in Tamale and 18 in Ouagadougou. Several themes were raised in these episodes, but four in particular stood out, which are detailed below.

Land

Land was rapidly becoming less available to farmers in both locations. Urbanization and development were occurring apace in both cities. In Ouagadougou the state's reallocation of land to householders through *lotissement* had contributed to this. Lotissement was a process through which the government divided land into regularly shaped plots and allocated them to householders, facilitating legal ownership and the development of roads and infrastructure. At the time of our survey the process had been halted, but had well influenced the structure of extensive areas of Ouagadougou. In contrast to Burkina Faso, where land is owned by the state, most land in and around Tamale, particularly in villages, was still owned by traditional authorities, who ostensibly held it in trust for the people. However, in Tamale sales of land by traditional chiefs to property developers were ongoing (Naab et al. 2013). Farmers were particularly concerned about this when it happened on the small proportion of state-owned land that they perceived should be available for public purposes, among which they counted their farming activities. This had led to violent conflict between farmers and developers in one site, and was the basis for establishment of a farmers' union.

Water

Water availability was a universal concern, reflected in the results above showing the low prevalence of dry-season cropping. Farmers' innovation in terms of providing dry season water had been supported by the state in peri-urban irrigation sites such as Koubri (Ouagadougou) and Golinga (Tamale). However, there had also been many instances of small-scale innovation where farmers used dugouts and hand-dug wells, especially in Ouagadougou. Those who could afford fuel-powered pumps were in an advantageous position as they could use dugouts and reservoirs. Farmers were therefore keen to source capital for such machines. The higher prevalence of farming in isolated spaces and backyards in Tamale meant that water pipes were also more widely used here when farms overlapped with residential areas. As a result, not all farmers were paying commercial rates for their pipe-borne irrigation water.

Inputs

Farmers were preoccupied with what they saw as the poor quality of inputs, especially in Ouagadougou, and with regard to crop protection products. Price was a concern in both locations, especially for soil fertility management amendments, particularly inorganic fertilizers, despite the subsidies that had been in effect even in the year of the survey. Many farmers therefore described how they had begun using Integrated Soil Fertility Management (ISFM). This was especially prevalent in the peri-urban areas of Ouagadougou, where the Ministry of Agriculture had been instrumental in introducing composting, termed *biriboka* by many farmers.

Prices

Seasonal price fluctuations were often mentioned by farmers as a problem, especially in Tamale. The prominence of perishable goods such as lettuce and the absence of storage mechanisms meant that seasonal gluts depressed prices, similar to elsewhere in West Africa (Gockowski et al. 2003). Establishment of a formal central storage and distribution system had been an aim of the Tamale farmers' union, but one that had never come to fruition. Thus, farmers and marketers attempt to maintain and develop existing networks of loyal market relations to try to stabilize supply and demand throughout the year, and in particular to secure constant access to the market.

DISCUSSION AND CONCLUSIONS

The data show some similarities in the way UPA is carried out in the two cities. In both Tamale and Ouagadougou, production is concentrated in the wet rather than in the dry season because of a lack of access to irrigation, and staple production becomes important across the board in the rainy season. Ownership of multiple livestock species is concentrated in villages and poultry comprise the commonest species. In both cities, seed is the most important input, followed by soil fertility management amendments.

However, the differences between the two sites are more intriguing, especially in the cropping data (Table 12). In Ouagadougou, commercial farming is dominated by production of lettuce in open-space sites, which carries on all year-round. In Tamale, commercial production concentrates more on traditional leaves, is more evenly spread between farm categories and is concentrated in the wet season. In Ouagadougou, most sales were made at the farm gate to traders. In Tamale, this is also the case, but village farmers also bring their goods to the cities. More people own livestock in Ouagadougou, but have smaller herd sizes. Livestock-keeping in Ouagadougou includes pigs, which are almost entirely absent in Tamale. In Ouagadougou, soils are more fertile in urban than in peri-urban sites, a trend which is reversed in Tamale. In contrast to Tamale, manure and compost are more important than organic fertilizers in Ouagadougou. Burkinabé farmers commonly irrigate their crops using ponds, dugouts, wells and springs, whereas in Tamale the most commonly used source of irrigation water is publicly provided tap water, followed by dugouts. In Tamale, fencing in the wet season is an important input for farms on isolated urban fields, which are more common and more involved in commercial production than in Ouagadougou. In the latter, quality of chemical inputs is a primary concern, and in Tamale farmers are especially worried about urbanization displacing them from urban farm sites (Naab et al. 2013). Overall, soils were low in organic C, N, CEC and available P in both cities, while soils were more fertile in Ouagadougou than in Tamale.

TABLE 12. Key similarities and differences between the two study cities.

Ouagadougou	Tamale
Soils more fertile, more so in urban sites	Soils less fertile, especially in urban sites
More use of manure and compost	Inorganic fertilizer use dominates
Commercial production is concentrated in open-space farms. Isolated space farms are few.	Isolated space farming makes a contribution to commercial production
Production more strongly concentrated in the rainy season in sites other than open spaces	Production concentrated in the rainy season
More use of wells	More use of piped water
Animals are more commonly sold	Animals less commonly sold
Seeds and Soil Fertility Management inputs are most commonly paid for inputs	

The differences in soil qualities between the cities can be associated with different climatic conditions. A shorter rainy season and more arid conditions in Ouagadougou imply more evapotranspiration, less leaching and consequently higher residual levels of exchangeable cations, effective CEC, pH and available P. Simultaneously, lower rates of mineralization result in higher organic matter contents in Ouagadougou than in Tamale.

The low organic C levels and coarse structure of the soil in both sites mean that nutrient retention is low. Thus, maize yield corresponds most to the application of inorganic fertilizer in the reference season.

Looking in more detail at the differences in cropping patterns between the cities, other West African cities display a similar trend towards rain-fed staple production in the wet season, and a shift towards cash vegetable cropping, particularly of leaves, in the dry season. In Kumasi in the dry season, farmers add cash vegetables to the subsistence crops they grow in the rainy season (Danso et al. 2002). In Yaounde, extensive peri-urban leaf production dominates over intensive urban production in the rainy season. In the dry season, intensive urban production, with a focus on leaf vegetables, takes over (Gockowski et al. 2003).

Similar patterns occur in East Africa. Foeken and Mwangi (1998) describe a minority of commercial producers in Nairobi, in a system where rainy-season staple production dominates. In a description of Dar es Salaam, Kiango and Amend (2001) explain this trend, noting that leaf vegetable producers are able to exploit a niche in the dry season market place for perishable, thirsty leaf vegetables, due to their preferential access to irrigation and markets. Orsini et al. (2013) similarly explain dominance of leafy green vegetables by their high added value and perishability, giving cities an advantages over rural areas when it comes to their sale. These reasonable explanations hold good in our study sites as well.

Commercial production is typically considered a characteristic of open-space farming sites (Cofie et al. 2003; Drechsel et al. 2006). However, our data show that the picture is more nuanced. We saw commercial engagement and subsistence production in isolated fields, backyards and open-space sites. Similarly, Eaton and Hilhorst (2003) describe how differentiation in commercial orientation is a function of crop type rather than of location, with staples in Bamako and Ouagadougou destined for consumption and vegetables for sale, in both urban and peri-urban farms. In Kumasi too, type of farm did not dictate crops grown, as traditional subsistence tubers were grown in backyards as well as in peri-urban open-space sites (Nsiah-Gyabaah and Adam 2001).

The main differences between the two cities in terms of cropping relate to the different roles of different categories of farm. Open-space sites are far more important to overall production and volumes of sale in Ouagadougou than in Tamale, where isolated urban fields play an important and possibly hitherto overlooked role in food production and sale. Factors likely contributing to this include the gridded form of urban space in Ouagadougou compared to Tamale, which is partly a result of lotissement and partly simply a function of Ouagadougou's greater size and longer history as a capital city. In Tamale, as urbanization continues, new development has surrounded and absorbed formerly peri-urban villages. As such zones have not been re-demarcated into grid systems, the compound farms of such villages have continued to exist as backyard and interstitial space farms. Drescher and Iaquinta (2002) name such farms 'absorbed periurban' fields.

Another factor contributing to difference in cropping patterns between the cities is legislative. The 1997 bylaw Arrêté N° 97-027/MATS/PKAD/CO/ forbids the cultivation of tall crops in Ouagadougou town, on sanitation grounds. The legal status of UPA is similarly vexed elsewhere in Africa (Bryld 2003; Cissé et al. 2005), as it is rarely recognized or facilitated, often restricted and occasionally banned. The situation in Nairobi is similar to that in Ouagadougou (Foeken and Mwangi 1998). In Dar es Salaam, UPA is permitted but regulated (Jacobi et al. 2000), and similarly in Kampala UPA is recognized, but commercial producers must be licensed (Ayaga et al. 2005).

More broadly, it is important to note that these intercity differences in cropping patterns reflect trends occurring across the continent. As an example from the West African Region, in Cotonou, Brock and Foeken (2006) found that there were barely any backyard farms because property was considered too valuable to farm on. Meanwhile, Jacobi et al. (2000) call backyard farming 'the most important' UPA system in Dar es Salaam. Different geographical, legislative, cultural and historical environments between cities contribute to these differences.

The higher prevalence of lettuce cultivation in Ouagadougou, compared to Tamale, where indigenous leaf vegetables are commoner, reflects different market demands. In the Francophone capital, Ouagadougou, salad is part of the more cosmopolitan dining scene than in Tamale. As a town in a peripheral region of an Anglophone nation, the latter has fewer international tastes to satisfy.

Livestock production characteristics also vary between the two cities, and this again reflects the variability between other study cities across West Africa. Amadou et al. (2012) similarly characterized livestock ownership in three cities of West Africa; Bobo Dioulassou in Burkina Faso, Kano in Nigeria and Sikasso in Mali. In these cities, as in Tamale and Ouagadougou, most farmers kept more than one species. However, although poultry was the most commonly kept species in Tamale and Ouagadougou, in Amadou et al.'s (2012) study they dominated only in Sikasso.

The larger number of people owning livestock in Ouagadougou could be related to the higher proportion of people who applied manure there, even though herd sizes there were smaller than in Tamale. However, there may be many other reasons for differential use of inputs such as fertilizers between different cities. Low use of inorganics in Cotonou, Ibadan and Lagos was ascribed to high costs (Brock and Foeken 2006; Oladokun 2001) and similarly, poor availability of vehicles to transport organic manures was mentioned in Kumasi and Lome (Nsiah-Gyabaah and Adam 2001; Schreurs and van Reuler 2001). Both these factors were cited by the farmers we surveyed in Tamale and Ouagadougou. Successful promotion of compost by the Ministry of Agriculture in Ouagadougou may also have contributed to the higher prevalence of its use there. Sewage is used as fertilizer in both our study cities (Eaton and Hilhorst 2003; Cofie et al. 2005), but our random sample did not encounter any of the farmers concerned. There is a large-scale composting plant in Tamale, as in Ibadan and Accra (Agbola 2001; Etuah-Jackson et al. 2001), but, as in those towns, it is beset by marketing issues. Composting on a personal scale is time-intensive, meaning that its use is rare.

The issue of contaminated irrigation water is a central concern of authors such as Drechsel and Keraita (2014) in Ghana, in a book focusing mostly on the south of the country. However, there has been little quantitative data on the actual prevalence of its use. Keraita and Cofie (2014) give qualitative information on water sources in Ghana's three main cities, characterizing the situation in Accra and Kumasi as more dominated by use of wastewater than we found in Tamale. They mention the possible sources of irrigation water used in Tamale, without giving figures or number of farmers using each source. Drechsel et al. (2006) present similar figures for the whole of West Africa, giving the variety of water sources listed below that may be found across the subregion, but no figures are given on the prevalence of each in specific cities.

1. Shallow (dugout) well
2. Deep well
3. Pipe-borne water
4. River and stream
5. Inland valley
6. Stormwater drain
7. Larger water tank or reservoir
8. Partially treated wastewater

During the course of our survey we observed the first six water sources listed above in Ouagadougou and Tamale. The extent of use of different water sources really depends on the specific situation of a given city – in Cotonou, for example, a high water table means farmers find it less necessary to use surface wastewater (Brock and Foeken 2006), the opposite of the situation that occurs in our study city of Tamale. The common use of tap water we found in Tamale is in contrast to results reported by Zibrilla and Salifu (2004), cited in Drechsel and Keraita (2014). They claimed, on the basis of anecdotal data, that around half of Tamale's farmers were irrigating their crops with wastewater. In Ouagadougou, due to the higher water table than in Tamale, well digging was more successful. The sources of water most commonly used were therefore the potentially contaminated ponds and wells, used in the sites where lettuce, which is eaten raw, was commonly farmed.

Marketing is one area where there were many similarities between the cities. Indeed, a pattern of male farmers and female traders is fairly ubiquitous in sub-Saharan West Africa and was observed in Ouagadougou and Tamale, too. Drechsel and Keraita (2014), for example, describe the situation in Accra, where female traders harvest crops at the farm gate. Gockowski et al. (2003) encountered female traders in Yaoundé. Women also dominate the market in Lomé. Here, as in Tamale, they engage with farmers through a credit system (Schreurs and van Reuler 2001).

FUTURE RESEARCH IMPLICATIONS

The value of this work is to clearly demonstrate, with randomly sampled data, that UPA is shaped by site-specific factors, even between locations that have several factors in common. Although both our study cities are part of a phenomenon of production for income generation and food security in West Africa, how this is expressed differs, for reasons which need further investigation. This work therefore provides a rationale for further, site-specific research.

The data indicate at least four important themes for such research:

Investigation into differential extents of commercial livestock production would highlight reasons for differences between locations.

Farmers' concerns over the cost of inorganic fertilizers combine with the observation that inorganic fertilizer application is related to soil fertility parameters to imply a place for research into Integrated Soil Fertility Management and its adoption. Considering the work that has been done on fecal sludge application, such less-conventional nutrient sources or soil conditioners should also be considered (Eaton and Hilhorst 2003; Cofie et al. 2005). UFP is working on the application of biochar as an alternative soil conditioner in the study cities.

Bearing in mind the use of potentially contaminated water sources in sites where commercial salad crops are grown, and the potentially unsustainable use of piped water in areas with poor drinking water supply, more practical work into safe and sustainable irrigation practices would be useful. The contribution of UPF in this regard is to investigate the effectiveness of biochar as a water filter, possibly with application in drip irrigation systems.

A need to contextualize such research is clear, so elements that should not be forgotten include the institutional, political, economic and historical factors that frame land markets, price fluctuations and the form of growing cities. These are inextricably linked to questions about the land tenure situation of the different types of farms located on isolated urban spaces. UFP therefore involves parallel research strands investigating the social and anthropological context within which technologies such as soil conditioners and filter systems are implemented.

A stakeholder dialogue process as initiated with assistance of the RUAF Foundation (www.ruaf.org) should continue to link the results of research to policy stakeholders in the study cities.

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