2.1 Open Space Farming

Hanna Karg and Johannes Schlesinger

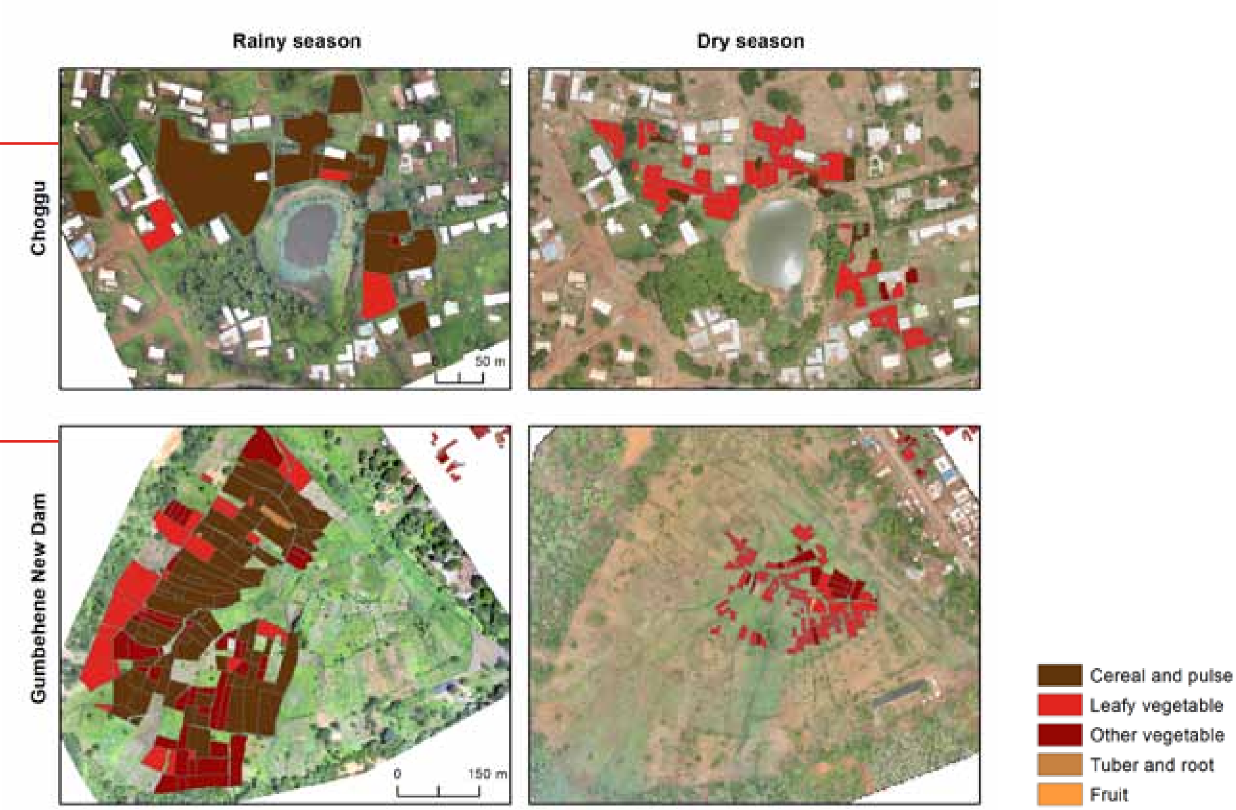

Figure 2.1. In-situ mapping of two selected open space farming sites in Tamale, Ghana (rainy season 2014, dry season 2015).

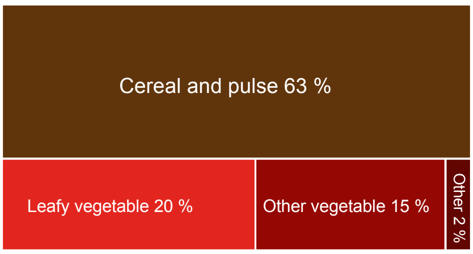

Figure 2.2. Crop mix in Tamale (Ghana) during the rainy season.

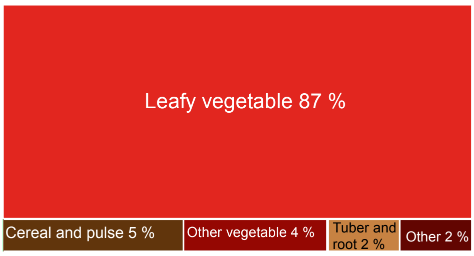

Figure 2.3. Crop mix in Tamale (Ghana) during the dry season.

Mapping open space sites revealed which types of crops were cultivated, the areal extent of cultivated sites, as well as seasonal variations (Figure 2.1). In total, four sites were mapped in each city, during both rainy and dry season. Results revealed that, in Tamale, the area under cultivation more than doubled in the rainy season as compared to the dry season. Crop mix also changed considerably across the two seasons on the mapped sites (see pages 20 and 21). Cereals such as maize and rice covered more than 60% of the cultivated area during the rainy season (Figure 2.2), while during the dry season, leafy vegetables, in particular traditional leafy vegetables, dominated, covering almost 90% of the area (Figure 2.3). The cultivation of perishable produce in urban agriculture is common and has been reported for other cities in Africa and Asia where the lack of cool storage does not allow for long distance–transportation of fresh produce.[2.3, 2.4]

Urban crop production shows **strong seasonal variations**, in terms of crop mix as well as area under cultivation.

Map 2.2. Locations of urban irrigated farming sites in Ouagadougou. Names of those sites that are examined in more detail later are given.[ii]

In Ouagadougou, most irrigated open space farming sites are located close to the centrally located dams (*barrages*) with a high groundwater level and wells for irrigation. Other irrigation water sources include streams (partly with diluted wastewater) and industrial wastewater. In total, 527 ha are under cultivation during the dry season within the urban boundary (see Map 2.2),[ii] more than 20 times the irrigated area in Tamale. Rain-fed cultivation is, unlike in Tamale, a minor activity within the urban boundary of Ouagadougou, one reason being the formal nature of urban planning in Ouagadougou (Chapter 2.2).

Figure 2.6. In-situ mapping of three selected open space farming sites in Ouagadougou, Burkina Faso (rainy season 2014, dry season 2015).

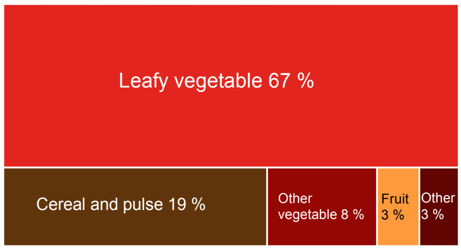

Figure 2.4. Crop mix in Ouagadougou (Burkina Faso) in the rainy season.

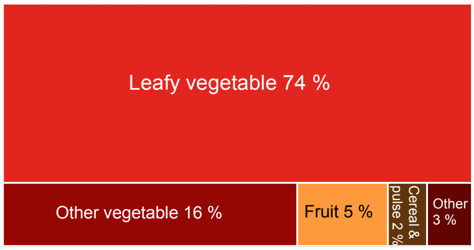

Figure 2.5. Crop mix in Ouagadougou (Burkina Faso) in the dry season.

In Ouagadougou, the sites that were mapped *in situ* produced a large number of different vegetables covering 75% (rainy season) to 90% (dry season) of the area under cultivation (Figures 2.4 & 2.5). Cereal production played a role in the rainy season, with maize and rice covering 19% of the area, far less than the scale of cereal production in Tamale.

Unlike in Tamale, the area under cultivation therefore decreased by more than 50% in the rainy season in Ouagadougou (Figure 2.6). The most common crop, lettuce, an exotic leafy vegetable, reflects the status of Ouagadougou as a Francophone capital city. Diversity of vegetables was also significantly higher in Ouagadougou compared with Tamale.

Figure 2.7. Cultivated areas in Boulmiougou, Ouagadougou, during the rainy season.

Figure 2.8. Cultivated areas in Boulmiougou, Ouagadougou, during the dry season.

Shifting Cultivation I

In Ouagadougou, the Boulmiougou farming site illustrates how lack or abundance of water influences spatial production patterns. While in the rainy season crop production is limited to vegetables in the elevated areas and the production of rice in the lower-lying land (Figure 2.7), the area under cultivation expands as previously waterlogged areas dry out. At the same time, cultivation in the center of the more elevated area decreases (Figure 2.8). Like in Tamale, the cultivation of particularly leafy vegetables is more common during the dry season.
Thus, water availability, or lack thereof, affects location and areal extent of production as well as the type of crops produced. Water availability is a function of season and location, with lowlands being waterlogged during the rainy season, and elevated areas too dry during the dry season. While water availability is an important factor for the choice of crop, it is not the only one. In the dry season, the demand for vegetables exceeds the supply, when (leafy) vegetables can only be cultivated in places with acces to irrigation water, and therefore it is highly profitable for farmers to grow vegetables in the dry season.[2.5]

Figure 2.9. Cultivated areas in Gumbehene Old Dam, Tamale, during the rainy season.

Shifting Cultivation II

The Gumbehene Old and New Dam farming sites have been cultivated for more than 50 years. Since 2007, the area of land under cultivation in these sites has remained constant due to institutional support from non-governmental organizations and research institutes that have lobbied for the permanent stay of farmers in these areas.These sites are designated green belt land by the local authorities, following flooding in the 1980s.[2.6]

We mapped the Gumbehene Old Dam site on a monthly basis (October 2014–March 2015) to detect finer temporal changes. The shift from rainfed cereal to irrigated vegetable production comes with uncultivated fallow land (during which plots are prepared for the next cropping cycle) (Figures 2.9 & 2.10). This shows that urban crop production is highly dynamic in terms of which crops are cultivated where (Figure 2.11). Therefore, the results of efforts to determine the size of urban farm land will depend on the timing of data collection.

Figure 2.10. Cultivated areas in Gumbehene Old Dam, Tamale, during the dry season.

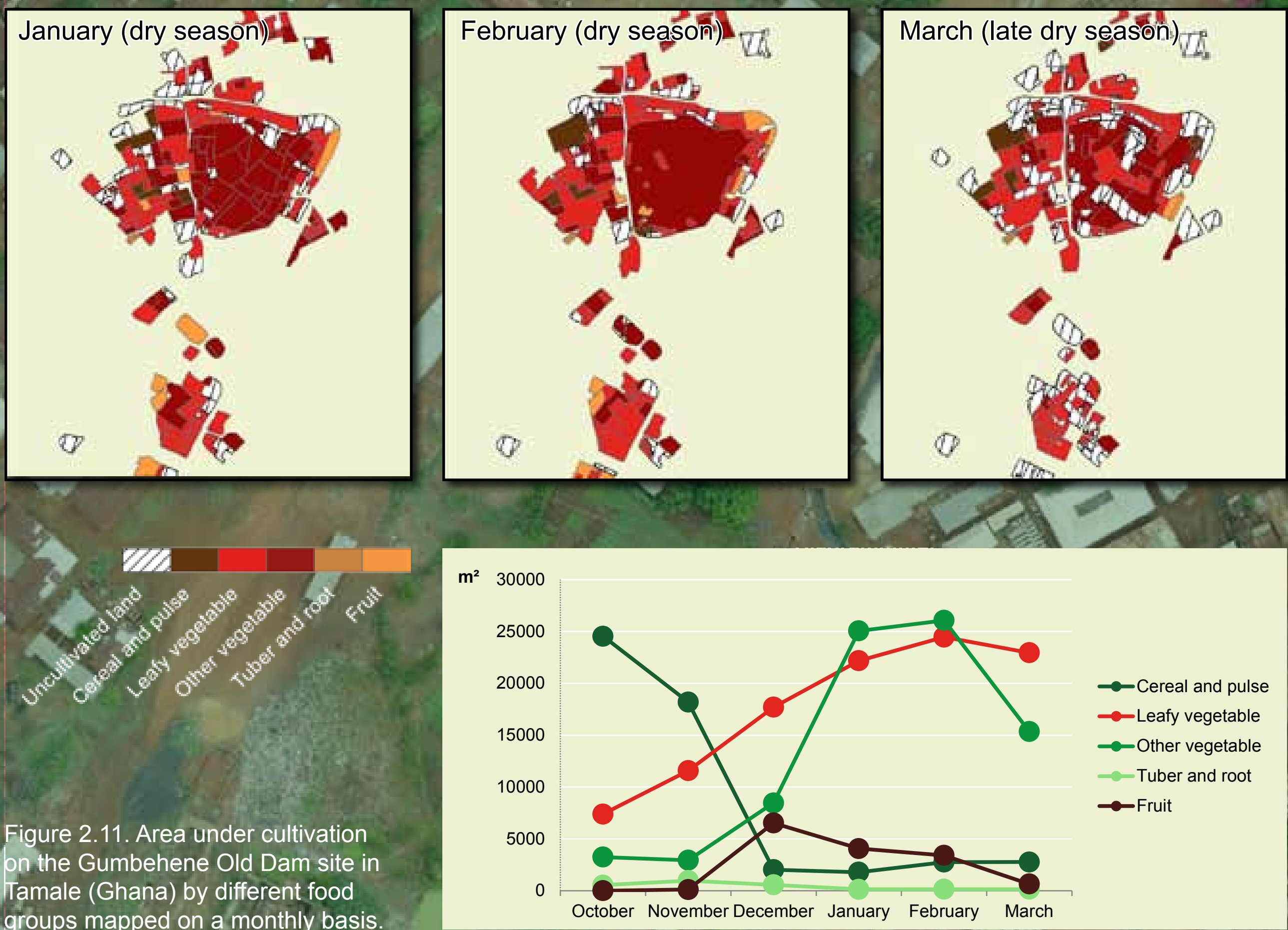

Figure 2.11. Area under cultivation on the Gumbehene Old Dam site in Tamale (Ghana) by different food groups mapped on a monthly basis.

Soil managment in urban agriculture

Steffen Werner

Soil fertility and health is crucial for agricultural productivity and the reduction of negative environmental impacts. The management of soil in urban agriculture in West Africa is dominated by the use of mineral fertilizer, manure and irrigation with mostly untreated wastewater. In the case of Tamale, less than 30% of farmers use manure or compost, while in Ouagadougou about 70% of the farmers use manure, and 45% use compost besides mineral fertilizer.[2.7] The Central Field Experiment of the UrbanFood^{Plus} project showed a significant reduction in soil carbon and pH under local farmers' soil management in Tamale (only mineral fertilization) and an increase in Ouagadougou (manure and mineral fertilization) (Figures 2.12a and 2.12b). These parameters are generally very important for soil fertility, and the findings underline the importance of organic soil amendments, such as manure or compost. The irrigation with pathogen polluted wastewater is a health risk for farmers and consumers and needs special treatment (see page 25). However, the nutrient loads in wastewater have beneficial effects on crop growth and can reduce the need for mineral fertilization (Figure 2.12c).

For more information:

Häring, V.; Manka'abusi, D.; Akoto-Danso, E.K.; Werner, S.; Atiah, K.; Steiner, C.; Lompo, D.J.P.; Adiku, S.; Buerkert, A.; Marschner, B. 2017. Effects of biochar, wastewater irrigation and fertilization on soil properties in West African urban agriculture. Scientific *Reports* 7(1): 10738.

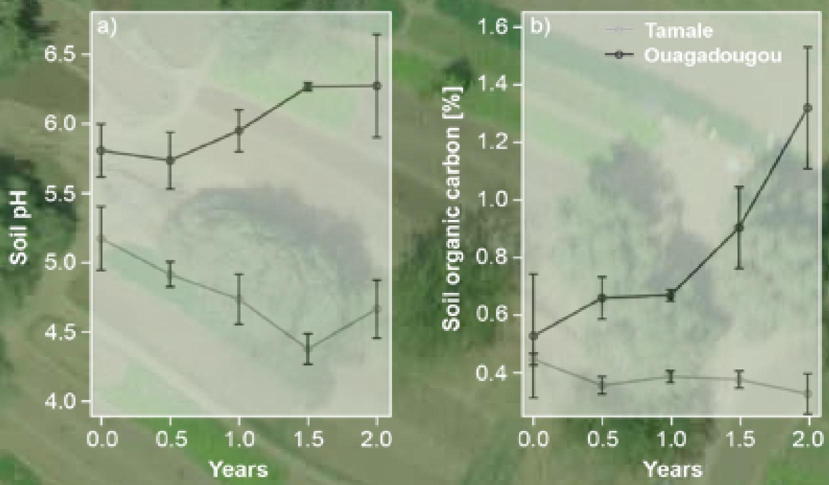

Figure 2.12a & 2.12b. Development of a) pH and b) soil organic carbon in the UrbanFood^{Plus} field trials of Tamale (only mineral fertilization) and Ouagadougou (manure and mineral fertilization).

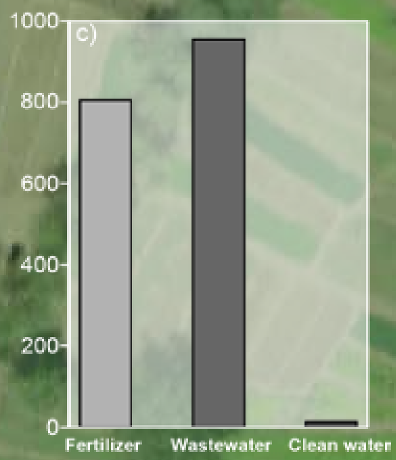

Figure 2.12c. Nitrogen input in field trials from fertilization and irrigation water source (wastewaster or clean water) in Tamale.

Agronomic effects of biochar and wastewater on crop production in urban agricultural systems of Tamale and Ouagadougou

Edmund K. Akoto-Danso and Delphine Manka'Abusi

We studied the effects of a single biochar application, fertilization, and irrigation water quality and quantity on soil properties and yields in Ouagadougou and Tamale. The incorporation of biochar at 20 tons ha^{-1} from corn cobs and rice husks had no effect on soil pH, but rice husks retained nitrogen. Wastewater irrigation increased soil pH over time. Biochar addition significantly increased yields in both cities, by 9% after two years. This reveals the potentials of biochar in an agricultural system characterized by consumer-driven high input levels. The positive effects of biochar were observed on fertilized plots, which further highlights that biochar can be a valuable resource to improve fertilizer use efficiency in intensive urban agricultural systems of West Africa. This is probably due to improved soil physical conditions rendering it more conducive for root growth and nutrient uptake. Wastewater was more effective in Tamale due to its high nutrient input from raw untreated sewage. It increased yields ten to twentyfold on unfertilized plots during the dry seasons, and fourfold in the rainy season, compared to clean water. Biochar from agricultural waste, such as corn cobs and rice husks, can thus be a low-cost resource that may improve input use efficiency in urban horticulture and that would have otherwise been a nuisance to the environment.

Incorporation of biochar into the soil.

For more information:

Manka'abusi, D.; Steiner, C.; Akoto-Danso, E.K.; Lompo, D.J.P.; Haering, V.; Werner, S.; Marschner, B.; Buerkert, A. Submitted. Agronomic effects of biochar application and wastewater irrigation in urban vegetable production in Ouagadougou, Burkina Faso.

Akoto-Danso, E.K.; Manka'abusi, D.; Steiner, C.; Werner, S.; Häring, V.; Nyarko, G.; Marschner, B.; Drechsel, P.; Buerkert, A. 2018. Agronomic effects of biochar and wastewater irrigation in urban crop production of Tamale, northern Ghana. *Nutrient Cycling in Agroecosystems* 543(295): 1–17.

Anticipated impact of biochar amendment on farmers' income and amaranths production in Ouagadougou and Tamale

Lesley Hope and Wilhelm Löwenstein

Biochar amendment can improve soil quality and hence farming yields. So, what are the effects of this intervention on farm income for urban farmer households? What is the effect on the supply of vegetables and salad in the urban area? The evidence for Ouagadougou and Tamale provides a mixed picture on these questions, given the differences between these two sites. The anticipated impact of biochar application on urban farmers in Ouagadougou is higher than in Tamale. While on average, each farmer in Ouagadougou is expected to increase his farm revenue by USD 517 per annum, in Tamale this increment is expected to amount to USD 57 only.

This difference also prevails in the supply increment of agricultural produces, e.g., with respect to amaranth. This produce forms a critical part of the diet in both cities. In Ouagadougou, the amendment of biochar would yield an increase in annual production by more than half a ton per urban farmer. In Tamale, amaranths production would increase by 44 kg per farmer per year.

An amaranth farm in Gumbehene Old Dam, Tamale, Ghana.

For more information:

Hope, L. 2018. *Biochar amendments to agricultural soils and changes in urban food supply in Tamale and Ouagadougou*. PhD thesis. Ruhr University Bochum, Germany.

Anaerobic biochar filtration of domestic wastewater in West Africa for safer food production and enhanced crop yield

Korbinian Kaetzl, Manfred Lübken and Marc Wichern

Untreated wastewater is frequently the only available water source for urban and peri-urban irrigation in West Africa. Hence, a simple and efficient low-cost wastewater filtration plant in Tamale for the production of safer irrigation water with locally produced corn con and rice husk biochar was developed. This water treatment system allowed a reduction of hazardous bacteria by 99.9% and organic substances by 90.0% and improved irrigation water quality to a normal surface water level in Tamale. Thereby, essential plant nutrients such as nitrogen and phosphorous remained in the water and treated wastewater retained its fertilizer effect. Crops irrigated with treated wastewater were to no greater extent contaminated with harmful bacteria than crops irrigated with tap water, and clearly less contaminated than crops irrigated with untreated wastewater (Figure 2.13). Beside safer vegetable production, irrigation with purified wastewater increased crop production by 30% compared to raw sewage and more than double in comparison with tap water and commercial fertilizer (Figure 2.14).

This effect may have been caused by the removal of iron as a chelator of phosphorus in the wastewater. Hence, wastewater treatment with locally available materials allows higher and safer vegetable production and may contribute to food security in West African cities.

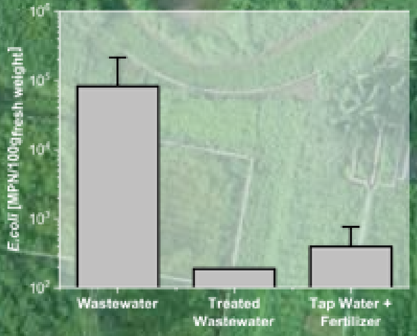

Figure 2.13. *E. coli* contamination of jute mallow (*Corchorus spp.*), irrigated with wastewater, treated wastewater and tap water with commercial fertilizer (NPK).

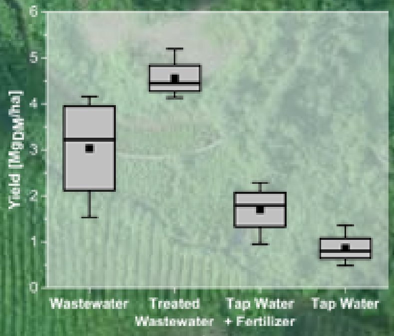

Figure 2.14. Yield of jute mallow (*Corchorus spp.*) in kg dry matter per hectare irrigated with wastewater, treated wastewater and tap water with commercial fertilizer (NPK) and without fertilizer.

Risk and profits associated with pesticide use in dry season vegetable farming

Eileen Bogweh Nchanji

Pesticide use and management in Tamale differ depending on the community's land ownership and needs of farmers. In Sangani, the area of the land used for dry season vegetable cultivation has not decreased even with increased value of land. This is because this land is sacred, making it impossible for *chiefs* to lease it for economic gain. Religion and tradition interact nicely on this site where a mosque has been built. This is the only site in our study area where farmers use only organic fertilizers (chicken droppings) with hardly any pesticides. They mainly grow lettuce, amaranth and green pepper. Only people from within this community can farm here. This is different at the Gumbehene Old Dam site, which is a melting pot of farmers from different clans interacting with the application of research innovation in cabbage. It is a site where researchers have also introduced improved amaranth seeds and compost. The main crop grown here is cabbage, which is profitable (Table 2.1) but requires regular application of pesticides. Farmers are aware of the risk of pesticides on their health and that of consumers. However, as a result of decreasing urban farmlands, farmers are concentrating more on the profit accrued with increased cabbage yield than the health risk involved. Changes in climate is another factor influencing increased use of pesticides as pests become more rampant and difficult to manage.

Table 2.1. Cabbage production profitability in the wet and dry season per ha of land in Tamale (Ghana).
Values are given in USD based on an exchange rate of $USD 1:3.8 Ghanaian Cedi.

Season	Production cost	Revenue	Gross margin
Dry	1085.7	4318.3	3232.6
Wet	615.1	2265.5	1650.3

For more information:

Nchanji, E.B.; Hope, L.; Nchanji, Y.K.; Abia, W.A.; Donkoh, S.A.; Schareika, N. 2018. Pest management among smallholder cabbage growers. *International Journal of Vegetable Science*: 1–16.

Agrobiodiversity of okra gardens under different intensities of management and urbanization

Kathrin Stenchly and Andreas Buerkert

Along the rural–urban gradient around Ouagadougou and Tamale, we studied 72 fields with okra (*Abelmoschus esculentus*) cultivation. Weed that grow in and next to these fields were affected by urbanization in different ways (habitat degradation, anthropogenic impact) and by agricultural intensification (increasing input of mineral fertilizers and pesticides). The results show that okra production can benefit significantly from insect visits during flowering. These beneficial insects are strongly related to certain weed species within and around crop fields that provide alternative food resources and refuge.

In our study, we found a strong relationship between gender- and market-orientedcultivation of okra which may be explained by gender roles whereby, particularly in Ghana, cash crop farming is predominantly considered men's work. Hence, most women cultivated okra primarily for self-consumption and with low agricultural inputs on either small fields within rural areas or in backyard gardening systems within peri-urban and urban areas. The management of okra and associated soil properties was highly variable and influenced by farmers' socioeconomic background. This affected the functional diversity of beneficial weeds, particularly on urban okra fields, where we found fewer insect-pollinated plants and more species with seeds distributed by birds (Figure 2.15).

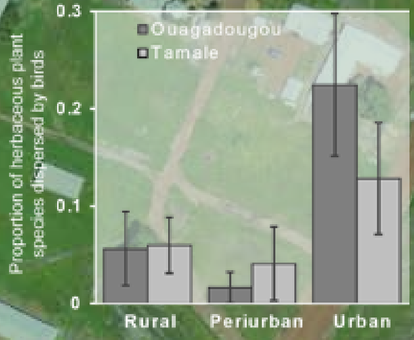

Figure 2.15. Community weighted mean (± standard deviation) of plant species dispersed by birds and their distribution on and around okra fields located in rural, peri-urban and urban areas of Ouagadougou and Tamale.

For more information:

Stenchly, K.; Lippmann, S.; Waongo, A.; Nyarko, G.; Buerkert, A. 2017. Weed species structural and functional composition of okra fields and field periphery under different management intensities along the rural-urban gradient of two West African cities. *Agriculture, Ecosystems & Environment* 237: 213–223.

Use of treated industrial wastewater for irrigation in Kossodo, Ouagadougou

Juliane Dao

Food production in Ouagadougou is limited to the rainy season or to areas with access to irrigation water. Where water for irrigation is available, urban gardens can be highly productive and supply the city with fresh vegetables, as production can take place year round. In an attempt to reduce the number of unofficial gardens in the city, land in Kossodo, an industrial and previously rain-fed farming area in the northeast of Ouagadougou, was given to urban farmers in 2010 by the municipality. An irrigation system was created at the outlet of a wastewater treatment plant, which was fed with wastewater from a slaughterhouse, a tannery and a brewery. However, pollutants in the water were more challenging than expected, negatively affecting soil quality. One underestimated factor was the sodium content of the brewery wastewater that was not taken care of in the treatment plant. The discharge of sodic and alkaline water led to an accumulation of sodium in the soil, followed by an irreversible damage of soil structure that impedes plant growth. Not only the irrigated fields were affected, but the whole area around the wastewater channel as soil water movement distributed the pollutants. Finally, cultivation declined over years.

For more information:

Dao, J. 2017. *Effects of irrigation water quality on soil properties and crops in urban gardens of Ouagadougou, Burkina Faso.* PhD thesis. Universität Kassel, Germany.

Canal diverting water from the treatment plant to the fields

Spinach field in Kossodo