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Vegetable Production under Land Pressure and Resource Constraints: Insights from Urban Farming Systems in Cotonou, Benin

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Abstract

This study explores the socio-agronomic dynamics of urban and peri-urban vegetable production in Cotonou, Benin, with a focus on farmer characteristics, cultivated species, land use, irrigation practices, and market pricing. A total of 23 vegetable species were recorded, comprising 10 native and 13 introduced varieties. Beetroot, bell pepper, and lettuce emerged as the most economically valuable crops, with prices influenced by cultivation difficulty and intermediary-driven inflation. The surveyed farming population was predominantly male (93.24%), spanning five ethnic groups, with Kotafon and Fon being the most represented. Educational attainment was relatively high, with over 60% of respondents having completed secondary or university-level studies. Farmers operated on small plots under conditions of persistent land tenure insecurity. Irrigation relied on artisanal boreholes and motorized pumps accessing groundwater at depths of 7 - 8 meters. The Houéyiho site, one of the oldest and most populated urban farming zones, exemplifies both the opportunities and constraints of vegetable production in Cotonou. The findings underscore the need for integrated support strategies, including land access reform, irrigation innovation, pest management, and cooperative marketing, to enhance the sustainability and profitability of urban horticulture.

Keywords

Urban Horticulture, Vegetable Diversity, Land Tenure Insecurity, Cotonou

1. Introduction

Since the early 2000s, Africa has witnessed an unprecedented surge in urbanization, with the urban population exceeding 600 million by 2020 [1]. If current demographic trajectories continue, this figure is expected to double by 2050 [2], mark-

ing one of the fastest urban growth rates globally. Sub-Saharan Africa, in particular, is projected to undergo the steepest increases while grappling with persistent poverty and limited access to affordable, nutritious food.

In Benin, this urban expansion is especially visible in southern cities such as Cotonou, Porto-Novo, and Abomey-Calavi. Rising population densities and escalating infrastructure demands are rapidly transforming land use patterns, leading to a marked decline in space available for urban and peri-urban agriculture [3]. This spatial compression is constraining local food production and driving up the prices of fresh produce and traditional staples.

Across Benin, approximately 187 of the nation's 2807 native and naturalized plant species are used as vegetables [4] [5]. Vegetables, defined as the edible parts of plants consumed primarily for their nutritional value, span a wide array of botanical categories. These include leafy vegetables (spinach, lettuce, kale), stem vegetables (celery, asparagus), flower vegetables (broccoli, cauliflower, calyx and epicalyx of Guinea sorrel), fruit vegetables (tomatoes, cucumbers, eggplants), seed vegetables (watermelon and sesame), root vegetables (carrots, beets, radishes), and bulb vegetables (onion and garlic).

For many farming households, vegetables are more than food; they are vital livelihood assets. They provide protein, generate income through local markets, and contribute to soil fertility, particularly in low-input systems. Promoting legume cultivation and strengthening vegetable value chains can enhance food sovereignty and resilience. However, as informal settlements expand and land competition intensifies, small-scale cultivators face mounting barriers to accessing arable plots, irrigation, and market channels. The perishability, seasonal variability, and post-harvest sensitivity of vegetables further compound their vulnerability within urban supply chains.

However, urbanization has also accelerated the introduction of exotic species and commercial varieties, often favored for their short growth cycles, adaptability to constrained spaces, and market appeal [6]. These include fast-growing leafy greens, hybrids, and imported cultivars tailored to urban microclimates and consumer preferences. While such diversification offers economic and dietary benefits, it also threatens local agrobiodiversity, displaces traditional crops, and raises concerns about the long-term sustainability of urban food systems.

In response, the African Vegetable Biodiversity Rescue Plan (2025-2035) advocates for urgent investment in the conservation, documentation, and reintegration of traditional vegetables within national food systems. This study investigates the current state of vegetable diversity in southern Benin, with a particular focus on identifying species that are becoming rare. It also examines the key constraints affecting their production and availability, shedding light on the challenges faced by urban and peri-urban growers in sustaining agrobiodiversity.

2. Materials and Methods

2.1. The Study Area

The study was conducted in two urban sites, Cotonou and Abomey-Calavi, located

in the southern region of the Republic of Benin (Figure 1). Geographically, this zone stretches from the coastal belt inland to approximately 6˚21'0"N - 6˚24'0"N latitudes and 2˚21'0"E - 2˚30'0"E longitudes. It is characterized by a subequatorial climate, with two distinct rainy seasons interspersed by a long dry season (December to February) and a shorter dry spell (July to August), which rarely exceeds two months. Average annual temperatures range between 26˚C and 28˚C, while mean annual rainfall varies from 1100 to 1400 mm [5].

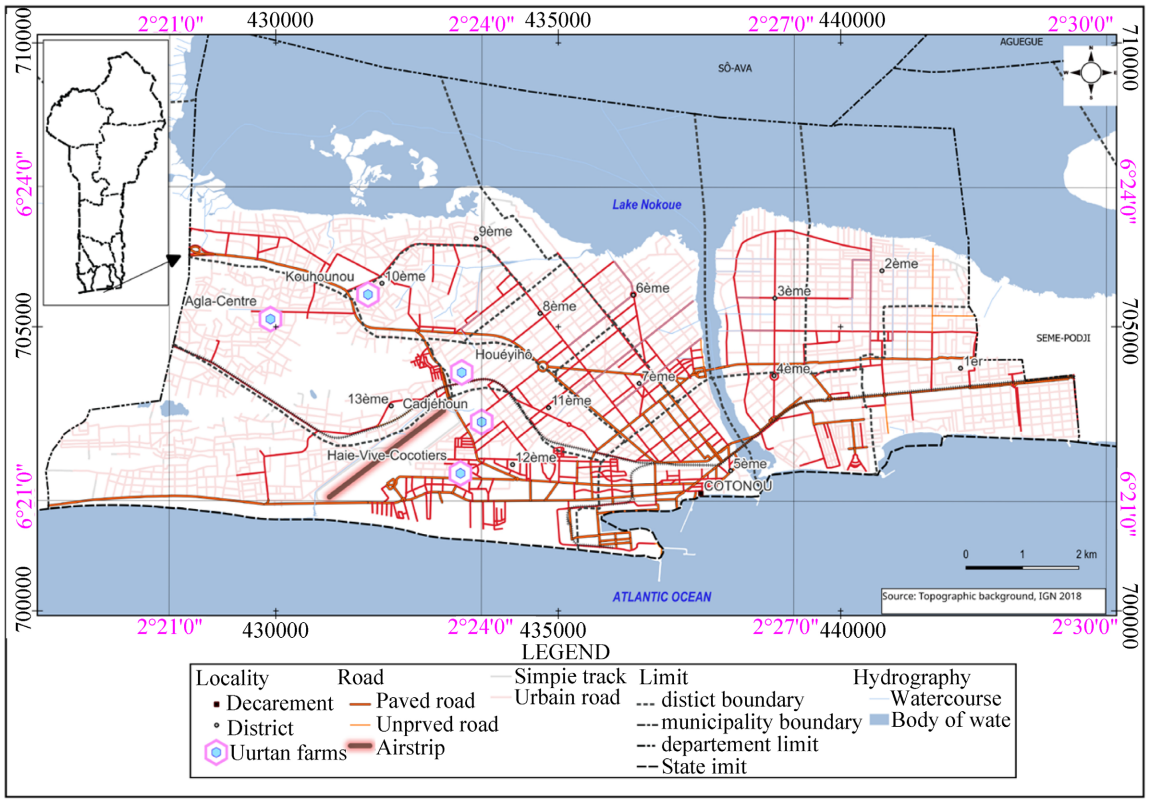

Figure 1. Map of the study site.

Benin hosts a rich floristic diversity, comprising 2807 documented plant species [5], including 187 vegetable species [4]. The selected study sites are among the country's most densely populated urban centers, marked by rapid demographic growth, accelerated urbanization, and evolving land-use dynamics. The population is ethnically diverse, with communities such as the Fon, Adja, Holly, Kotafon, Ouémènou, Pédah, Saxwè, Tori, Watchi, Xwla, and Yoruba [7], many of whom engage in farming activities.

These agroecological and socio-demographic conditions collectively support a wide range of agricultural practices, notably urban and peri-urban vegetable cultivation, which play a vital role in local food systems and livelihoods.

2.2. Identification of Production Sites and Survey

Field visits and participatory methods facilitated the recognition and recording of

specific farming locations, with attention to accessibility, infrastructure, and local knowledge. For each urban vegetable production site (UVPS), we recorded the area covered, the total number of employees, the type of propagules, all vegetables produced, the period of cultivation, and the total number of units sold (including sachets, bottles, and plate items), noting the price per kilogram of each product, the invasive species, methods of management, and all constraints encountered. We also estimated the total area of each vegetable cultivated. In total, 90 producers were interviewed. Their geographic and ethnic background, gender, and educational level were documented, and interviews were conducted to assess the weekly sales volumes of vegetables produced. These data were used to estimate annual sales per producer and extrapolate site-wide trends. Producers were also asked to identify species that had become expensive or increasingly scarce, and to explain the factors contributing to price fluctuations, whether due to availability, seasonality, or other constraints.

2.3. Ethics

Prior to participation, each participant was provided with a Free and Prior Informed Consent document [8]. Those capable of reading and writing signed the form, while for others, the study's objectives were communicated orally, and verbal consent was duly recorded. In recognition of their time and the insights they contributed, informants received a small financial token. This compensation was negotiated and mutually agreed upon before the commencement of each interview.

2.4. Data Analysis

We then calculated the volume of vegetable matter offered per plate to estimate the total quantity of fresh produce available daily across the surveyed markets. The average price per kilogram for each product was derived from multiple unit weights and prices. This figure was multiplied by the observed volumes of each species to determine the total economic value of vegetable sales per UVPS. Finally, all species-level data were aggregated to estimate the annual volume and UVPS value of vegetable trade across the main studied sites. Plant identification and collection were conducted using standard botanical methods.

3. Results

3.1. Classification of Production Sites and Urban Farmers

During the survey, we sampled five urban farms (UFs) across Cotonou (**Table 1**). Their selection was based on accessibility, infrastructure, and local knowledge. They are distributed across four districts (10, 11, 12, and 13; **Figure 1**). The UFs include community plots (80% of UFs) and household-based cultivation (20%). The number of farmers varies according to the UF. Houéyiho is the most populated UF with 30 farmers. It is followed by Cocotiers, Cadjèhoun, Kouhounou,

and Agla with 19, 4, 2, and 1 farmers, respectively. In each UF, farmers group together based on shared interests. Reasons can include growing similar crops, adopting shared techniques, friendship, or negotiation. Space occupied by each farmer is typically grouped together within the boundaries of the UFs. UFs were classified into four categories based on their size. UFs with an area greater than 1000 m^2 were assigned as "large UFs," while those with less than 500 m^2 were categorized as "small UFs". The others, with areas between 500 and 1000 m^2, are defined as "mean UFs."

Table 1. Main characteristics of surveyed urban farms.

Location (Urban Farms)	Total Area (m^2)	Number of UFs	Number of Vegetables Produced	Average Weekly Income (USD)
Houéyiho	16,296	30	18	662
Cocotiers	11,568	19	14	477
Cadjèhoun	1960	19	6	308
Kouhounou	1162	2	7	154
Agla	592	1	5	102

3.2. Characteristics of Farmers

Among the surveyed farmers of vegetables, a significant majority were men, representing 93.24% of respondents. These individuals belonged to five distinct ethnic groups, namely Kotafon (43%), Fon (28%), Adja (16%), Saxwè (11%), and Ouémènou, being the least represented, accounting for 2% of the sample. In terms of educational background, only 4.56% of respondents had never attended school. A significant part (35.44%) had completed primary education, while a mere 42% had reached the secondary level and 18% the university. Age distribution revealed that 7.80% of farmers were young (under 30 years), while 92.20% were adults (between 30 and 60 years). There were no elderly people (over 60 years). The average age across the group was 42 years.

3.3. Vegetables Produced and Prices

In total, 23 vegetables were recorded during our survey, of which 10 were native, and 13 were introduced species (Figure 2; Table 2).

Among them, beetroot stood out as the most expensive, with an average unit price of USD 13.82 ± USD 2.52 per plot of 6 m^2, followed by bell pepper (USD 9.30 ± USD 1.86) and (USD 8.68 ± USD 1.12) (Table 2). We noticed that the minimum and maximum prices of plots vary according to the vegetable (Table 2).

Lettuce, parsley, and cabbage were the three most expensive vegetables recorded (minimum price ≥ 10 USD). While our survey documented these high prices, all informants attributed the cost primarily to cultivation difficulties related to pest

pressure and soil or nutrient demands. About eight farmers mentioned an additional factor: price inflation driven by trade intermediaries who adjusted prices at their discretion.

Figure 2. Some vegetables recorded: (A) Beetroot (©: https://www.africa-uganda-business-travel-guide.com/); (B) Smooth amaranth; (C) Bitter leaf; and (D) Spearmint.

Table 2. Vegetables cultivated at Cotonou.

Vernacular Name	Scientific Name	Status	Part Sold	Crop Value (USD)		
				Min	Max	Mean
Onion	*Allium cepa*	Native	Bulb	1.78	4.46	3.23 ± 0.70
String onion	*Allium fistulosum*	Introduced	Bulb	3.57	4.46	3.46 ± 0.54
Smooth amaranth	*Amaranthus hybridus*	Native	Leaf	0.89	1.78	1.09 ± 0.17
Beetroot	*Beta vulgaris*	Introduced	Root	8.02	14.26	8.35 ± 1.71
Cabbage	*Brassica oleracea*	Introduced	Leaf	14.26	17.83	13.82 ± 2.52
Turnip	*Brassica rapa* ssp. *rapa*	Introduced	Leaf	5.35	8.91	7.02 ± 1.21
Chinese cabbage	*Brassica rapa* ssp. *pekinensis*	Introduced	Leaf	2.14	12.48	7.76 ± 4.01
Bell pepper	*Capsicum annuum*	Introduced	Fruit	5.35	6.24	4.99 ± 0.54
Coriander	*Coriandrum sativum*	Introduced	Leaf	5.35	12.48	9.30 ± 1.86
Cucumber	*Cucumis sativus*	Native	Fruit	5.35	6.24	4.99 ± 0.54
Carrot	*Daucus carota*	Native	Root	5.35	12.48	8.68 ± 1.12

Continued

Bissap	*Hibiscus sabdariffa*	Native	Leaf	1.78	2.67	2.30 ± 0
Lagos spinach	*Celosia argentea*	Native	Leaf	8.91	9.80	7.68 ± 0
Wild lettuce	*Launaea taraxacifolia*	Native	Leaf	8.91	9.80	7.68 ± 0
Lettuce	*Lactuca sativa*	Introduced	Leaf	14.26	17.83	6.19 ± 0
Mint (hybrid mint)	*Mentha* × *smithiana*	Introduced	Leaf	3.57	4.46	3.07 ± 1.35
Spearmint	*Mentha spicata*	Introduced	Leaf	3.57	4.46	3.07 ± 0
Wild basilic	*Ocimum gratissimum*	Native	Leaf	3.57	4.46	1.85 ± 0.38
African basil	*Ocimum americanum*	Native	Leaf	1.78	2.67	1.79 ± 0.44
Sweet basil	*Ocimum basilicum*	Native	Leaf	1.78	2.67	9.22 ± 1.33
Parsley	*Petroselinum crispum*	Introduced	Leaf	10.70	12.48	3.99 ± 0
African eggplant	*Solanum macrocarpon*	Native	Leaf and Fruit	3.57	10.70	2.04 ± 0.41
Bitter leaf	*Vernonia amygdalina*	Native	Leaf	1.78	3.57	3.23 ± 0.70

3.4. Agricultural Practices, Cultivation Abandonment, and Constraints

In the study area, vegetable cultivation primarily takes place on sandy soil. A notable share of farmers (31% of respondents) establish their plots on recently cleared fallow or waste lands situated along the younger coastal strip, benefiting from the inherent soil fertility. The remaining 69% cultivate vegetables on older coastal strips, where the sandy soils are either rarely or never subject to flooding. Farmers reported that weeding, plowing, and ridge formation are the main methods of soil preparation. Fertilization is carried out using NPK and urea fertilizers, supplemented with compost and/or poultry manure. Regarding crop irrigation, it is carried out using water from artisanal boreholes, dug with locally constructed embankments. A motorized pump draws groundwater from a depth of 7 to 8 meters, which is then conveyed through 100 mm PVC pipes. Our findings indicate that, for certain vegetable species, the leaves are harvested and sold two to three times during the production cycle. In situations where new land is unavailable, producers often introduce some legumes to maintain soil fertility and productivity. These strategies can include tuber crops (Taro root) or fruit (banana), depending on local practices and market demand.

Across the study site, farmers indicated that they have discontinued cultivation of certain vegetables. All of them mentioned tomato as an abandoned vegetable, making it the most notable example among several others, such as long chili pepper, cucumber, and cabbage. The reasons reported were factors such as pest outbreaks, water scarcity, and notably, input costs.

Farmers identified six major constraints to cultivation, with two emerging as particularly significant: limited land availability (47%) and insufficient financial resources (29%) (**Figure 3**).

According to respondents, small landholdings hinder both the expansion and

diversification of cropping systems. Additionally, financial limitations restrict their ability to acquire essential inputs, tools, and improved agricultural technologies. By contrast, direct sowing and price fluctuations during the rainy season were infrequently cited by respondents (Figure 3). While direct sowing poses technical and physical challenges under local agronomic conditions, seasonal market instability contributes to unpredictable income during critical production windows.

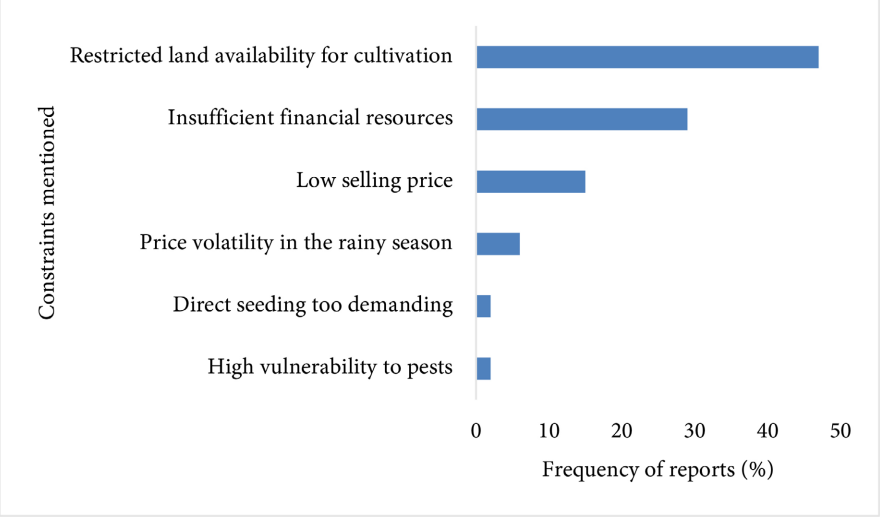

Figure 3. Major constraints to vegetable cultivation in Cotonou.

4. Discussion

4.1. Strategic Role of Houéyiho in Urban Vegetable Production

We noticed that the surveyed area is marked by spatial constraints and persistent land tenure insecurity. Production units are typically small, with plot sizes. This information has already been reported by Assogba-Komlan *et al.* [9] and Ahouangninou *et al.* [10], who have indicated that the size of production units is generally below 0.25 hectares in peri-urban areas and less than 0.05 hectares in urban settings. In this area, Houéyiho stands out as the most densely populated urban farming site, with 30 active vegetable producers. This concentration reflects both the accessibility of land and water resources, as well as the proximity to urban markets. The high number of farmers suggests a dynamic production hub with potential for collective action, knowledge exchange, and coordinated input management. However, such density also raises challenges related to land pressure, resource competition, and environmental sustainability.

As noted by Pazou *et al.* [11], this site ranks among the earliest market gardening zones in Cotonou. Established in 1972 as part of a government initiative to regroup the city's market gardeners [12], it now spans 15 hectares and continues to experience notable expansion. One of its key assets lies in its diverse and accessible water sources, which include rainwater, groundwater, and surface water from nearby marshes and swamps, resources that underpin the organization and

sustainability of horticultural activities at the Houéyiho site.

4.2. Socio-Demographic Profile of Vegetable Farmers

The demographic profile of vegetable producers in the study area reveals a strong gender imbalance, with men comprising 93.24% of respondents. This male dominance reflects broader gender dynamics in land access, labor allocation, and decision-making within the agricultural sector. The ethnic composition, led by Kotafon (43%), Fon (28%), and Adja (16%) communities, highlights the cultural diversity of the farming population and may influence crop preferences, land tenure systems, and knowledge transmission.

Educational attainment among farmers shows a relatively favorable trend compared to national rural averages. While a small fraction (4.56%) reported no formal education, a combined 95.44% attended at least primary school, with 42% reaching secondary education and 18% attaining university-level training. This educational base influenced agricultural practices, including the adoption of new technologies and marketing strategies. It also presents opportunities for targeted capacity building, particularly in areas such as agroecological practices, market access, and digital tools for agriculture.

The age structure is skewed toward adults (30 - 60 years), who represent 92.20% of the sample, with an average age of 42 years. The absence of elderly farmers and the limited presence of youth (7.80%) may signal a generational gap in agricultural engagement. This trend underscores the need for youth-inclusive strategies, such as vocational training, access to land and finance, and the promotion of urban and peri-urban agriculture as a viable livelihood pathway.

4.3. Diversity and Pricing Dynamics of Cultivated Vegetables

The survey revealed a rich diversity of vegetable crops, with 23 species cultivated, 10 native, and 13 introduced, reflecting both agroecological adaptability and market-driven diversification. This mix underscores farmers' responsiveness to consumer preferences and seasonal demand, while also highlighting the integration of exotic species into local production systems. The specific richness found in this study appeared weaker than the 187 species reported by [4] during their ethnobotanical survey across the national area. This difference can be attributed to the size of the investigation area. These authors covered many regions of Benin where life is still traditional and, in terms of food, local communities remain dependent on nature.

Price analysis showed significant variability across species, with beetroot emerging as the most expensive crop (USD 13.82 ± USD 2.52 per 6 m^2 plot), followed by bell pepper and other high-value vegetables. Notably, lettuce, parsley, and cabbage consistently recorded minimum prices above USD 10, positioning them as premium crops within the urban market. Farmers attributed these elevated prices to agronomic challenges, including pest pressure, high nutrient requirements, and soil sensitivity factors that increase production costs and risk. Hounguè and Kin-

domihou [13] highlighted that, beyond the commonly cultivated crops, local populations are increasingly interested in growing carrots, cucumbers, and parsley. This trend reflects the evolving dynamics of urban agriculture, driven by changing consumer preferences, nutritional awareness, and market opportunities.

In addition to biological constraints, economic factors also influence pricing. Several producers cited the role of trade intermediaries (agricultural wholesalers) in inflating prices, often adjusting them arbitrarily based on market fluctuations or perceived scarcity. Indeed, their influence is most significant at the post-harvest and distribution stages, where they control access to markets, set purchase prices for farmers, and determine resale margins. Because farmers often lack direct market access, storage facilities, or bargaining power, intermediaries can exploit this dependency by inflating prices as crops move from production zones to markets. This markup not only affects consumer affordability but also reduces the share of value retained by producers. This highlights the need for transparent value chain mechanisms and strengthened producer-market linkages to ensure fair pricing and reduce dependency on informal middlemen.

Overall, the interplay between species selection, cultivation difficulty, and market dynamics shapes both the profitability and sustainability of urban vegetable farming. Strategic support in pest management, soil fertility enhancement, and cooperative marketing could help stabilize prices and improve farmers' incomes.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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