agriculture

Article

Farming Practices and Disease Prevalence among Urban Lowland Farmers in Cameroon, Central Africa

Annie Stephanie Nana [1,2,*], Timo Falkenberg [1,3], Andrea Rechenburg [3], Annet Adong [1], Anne Ayo [2], Pierre Nbendah [2] and Christian Borgemeister [1]

[1] Center for Development Research (ZEF), University of Bonn, 53113 Bonn, Germany; falkenberg@uni-bonn.de (T.F.); annetteadong@gmail.com (A.A.); cb@uni-bonn.de (C.B.)
[2] Laboratory of Biotechnology and Environment, Department of Plant Biology, Faculty of Science, University of Yaoundé I, Yaoundé 812, Cameroon; annayo718@gmail.com (A.A.); pnbendah@yahoo.fr (P.N.)
[3] Institute of Hygiene and Public Health, Medical Faculty, University of Bonn, 53127 Bonn, Germany; andrea.rechenburg@ukbonn.de
* Correspondence: s7annana@uni-bonn.de

Abstract: Urban growth, coupled with increasing vegetable demand, has led to the utilization of lowlands in Cameroon for agricultural production. This study investigates the factors influencing the farming practices and the prevalence of diseases in vegetable producers through a cross-sectional survey of 130 farmers. Using logistic regression models, we found a positive association between education level and farm size with the overall quantity of fertilizer, both organic and mineral, used. Pesticide usage was positively associated with the number of years a farm had been cultivated, but it was negatively associated with land ownership. However, the number of years that farms had been cultivated was negatively associated with mineral fertilizer applications. In general, the prevalence of waterborne diseases was linked to the education level, while malaria prevalence was linked to the gender of the farmers. The location of cultivated areas significantly influenced the likelihood of reporting malaria and headaches. Despite the associated health risks, vegetable production is necessary for farmers' livelihoods in the lowlands of Yaoundé. Therefore, policymakers should provide measures to optimize the benefits of urban agriculture, including training in safe farming techniques to minimize the associated health risks.

Keywords: urban agriculture; untreated water; lowlands; pesticides; human health; Cameroon

Citation: Nana, A.S.; Falkenberg, T.; Rechenburg, A.; Adong, A.; Ayo, A.; Nbendah, P.; Borgemeister, C. Farming Practices and Disease Prevalence among Urban Lowland Farmers in Cameroon, Central Africa. *Agriculture* **2022**, *12*, 230. https://doi.org/10.3390/agriculture12020230

Received: 10 December 2021
Accepted: 2 February 2022
Published: 5 February 2022

1. Introduction

Yaoundé, the political capital of Cameroon and second largest city of the country, has been facing a rapid demographic growth after the economic crisis in the 1980s [1]. The population in the city increased from 2.4 million [2] to about 4 million inhabitants [3]. This rapid population growth has led to high unemployment and high demand for food. Food insecurity is one of the key consequences of rapid urbanization [4]. The majority of the urban population disburses approximately 60–80% of their income to meet food needs [5,6]. Yet, their food consumption remains insufficient in quality and quantity [7]. According to WHO [7], in many regions of the developing world, the consumption of fruits and vegetables falls far short of the minimum daily intake of 400 g per person per day, or about 150 kg per person per year as recommended by the joint WHO-FAO Expert Consultation on Diet, Nutrition and Prevention of Chronic Diseases for the prevention of noncommunicable diseases and micronutrient and vitamin deficiencies [8,9]. Low fruit and vegetable intake are among the top 10 selected risk factors for global mortality [10]. Thus, reducing poverty and improving health conditions can be sought by growing and consuming fruits and vegetables. Therefore, urban dwellers are encouraged to adopt alternative livelihood strategies, such as urban agriculture to improve their income and nutrition [11].

Diverse types of food are usually produced in rural areas and brought freshly to the city. Providing city-dwellers with fresh food is difficult as most vegetables start to spoil within a few days of harvesting. The poor state of roads in Cameroon leads to heavy losses of produce in transit from rural areas. Fresh food deteriorates further in the city due to the lack of cold storage, both in markets and in the vast majority of urban households [12]. Urban agriculture has thus been proposed to improve food supplies, enhance income in urban regions, address the food shortage, and help to reduce unemployment [13,14]. Urban agriculture is, essentially, a "local food" system that provides urban populations with a wide range of horticultural crops, mainly fruits and vegetables, including herbs, roots, tubers, ornamental plants, and mushrooms grown within the city or in its surrounding areas [12].

Urban agriculture in Yaoundé encompasses poultry, fish production, husbandry and crop production; for the latter, this includes a wide range of crops, such as tubers, cereals, legumes, flowers, etc. A variety of vegetables are the main perishable crops in the lowlands in the Yaoundé metropolis [15]. Due to their high nutritional and short life cycles values [12], vegetables are highly valuable to the population and serve as a good source of income [16]. The increasing demand for daily fresh vegetables has led to the intensification of production in lowlands in terms of fertilizer and pesticide use, with potentially adverse health effects on both growers and consumers [17]. Moreover, lowlands in Yaoundé, situated at the bottom of the valleys, are the receptacle of various municipal wastes (solids and liquids), especially from areas where household waste collection services are inefficient, and the sanitation systems are almost inexistent. Regarding the farming practices and the socio-demographic characteristics, vegetable production in these areas may be associated with health risks. This study investigates the factors influencing the farming practices and the prevalence of diseases in vegetable producers in the Yaoundé lowlands.

2. Materials and Methods

2.1. Study Area

Yaoundé (3°47′–3°56′ N and 11°10′–11°45′ E) is located in the center region of Cameroon (Figure 1). It covers about 256 km^2 and is situated at altitudes ranging from 700 to 850 m above sea level (m.a.s.l.). With the dominance of slight and steeper slopes mixed with small plateaus, Yaoundé is often called the "seven-hill city". The city has a bimodal climate with each two alternating dry and rainy seasons, defining the first and second cropping phases. The dry seasons occur from December to February and from July to August, while the rainy seasons are from September to November and from March to June [18]. The mean annual rainfall is about 1564.7 mm, with an average temperature of 23.5 °C [18].

Yaoundé has an exceptionally dense hydrologic network comprised mainly of the Mfoundi river and its perennial affluent. The soil in the lowlands is hydromorphic with a mixture of fine sand and organic material in decomposition [19].

The town had an estimated population of 2.4 million inhabitants in 2011 with a density of 14,000 inhabitants/km^2 [20]. The employment rate in Yaoundé is about 38%, with a predominance of the informal (69.9%) and agricultural sectors (10.4%), while the formal sectors, public and private sectors, account for 11.2% and 8.3 %, respectively [21,22].

We initially performed a preliminary screening in Yaoundé to identify the main cultivated lowland areas located in the urban area, i.e., within the city's seven subdivisions used for urban vegetable production. We then selected six lowlands located in the districts of Yaoundé I (Emana), II (Mokolo Elobi), IV (Ekoumdoum, Ekounou), and VII (Nkolbisson, Minkoameyos) for the main study.

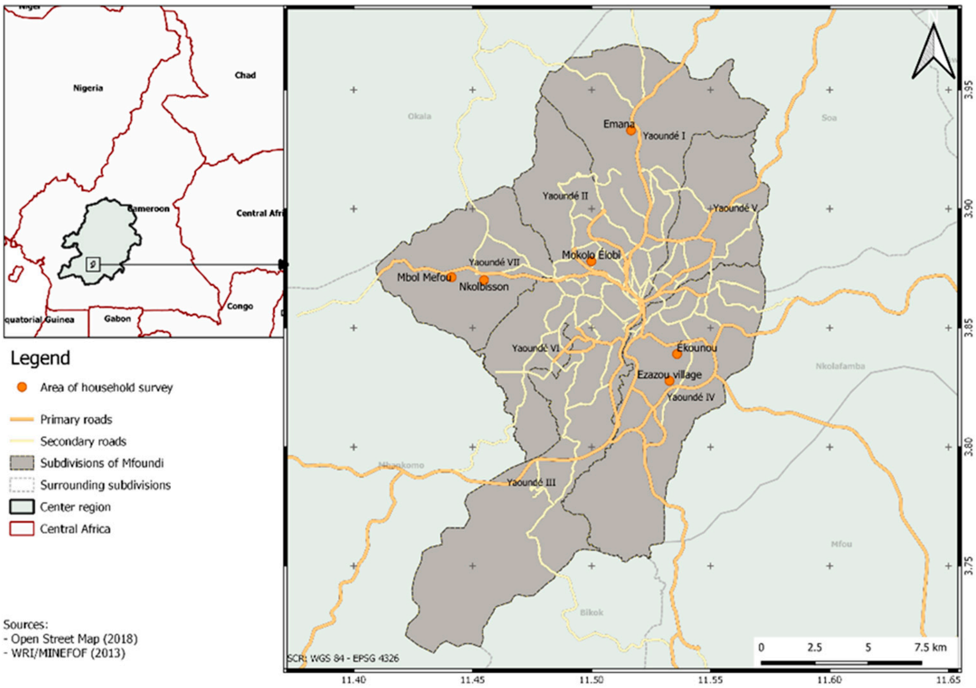

Figure 1. The location of the selected lowland areas in Yaoundé, Cameroon.

2.2. Data Collection

From May to June 2019, 130 farmers in the selected 6 lowland areas (Ekoumdou, Ekounou, Nkolbisson, Emana, Mokolo, and Minkoameyos) participated in the study with vegetable production as the principal inclusion criteria. Cross-sectional surveys and a spot-check approach were used to gain further insight into the confounding factors. This implied two surveys to collect information on farming practices in the selected lowlands, intending to explore certain confounding factors, such as the use of fertilizers, pesticides, and irrigation water. At the time of this study, there was no recent database or list of farmers engaged in urban agriculture in Yaoundé. The only available data from the year 2011 indicated that, at the time, there were 121 crop producers in 11 lowlands, both in the central areas and in the periphery of Yaoundé [23]. In our preliminary screening, only six lowlands passed our selection criteria to be included in the main study. Given the unavailability of information, a snowball sampling approach [24] mixed with random sampling was used to sample a total of 431 households engaged in agriculture production in the lowland areas. Out of these 431 farmers, we retained 130 farmers who were engaged in vegetable production, thus fulfilling the main inclusion criteria of this study. Snowball sampling involved asking the households to list six nearby households who were also engaged in urban crop production. We randomly chose two farmers from each of the mentioned six farmers to be part of our sample. In the end, the interviewer asked for the name of nearby farmers, and the process was repeated. The same operation was conducted in all six selected lowland areas. Thus, depending on the population size of farmers engaged in crop production in a given locality, in total, 11 farmers were enrolled in Emana, 20 in Mokolo, 16 in Minkoameyos, 24 in Nkolbisson, 26 in Ekounou, and 33 in Ekoumdoum. Each selected farmer was first informed about the study to seek informed consent.

The questionnaire was divided into five main sections: demographic characteristics, farming, agricultural inputs, irrigation water, sanitation, and occupational health (for more details, see Table A1). During the interviews, farmers were explicitly asked if they had experienced any of the following diseases, i.e., malaria, typhoid, diarrhea, headaches, coughing, and skin diseases during the past seven days and after specific farming operations, such as fertilizer and pesticide applications. All data were collected using the Kobo toolbox [25]. The spot-check method of Ruel [26] was used to validate the findings regarding farming systems, occupational health and safety, and pesticide and fertilizer use. This observational approach allowed us to cross-verify the farm surveys with the farmer attitudes and behaviors during farming activities [26].

The response rate was 100 percent; none of the sampled farmers refused to participate after seeking their consent. Nevertheless, for some responses, such as fertilizer and pesticide use, the response rates were low because the farmers could not remember the names of the chemicals or had lost the packaging of the materials.

2.3. Data Analysis

Descriptive statistics using frequencies and the chi-square test were performed to explore associations between categorical variables using Stata version 15.1. Chi-square was chosen because two categorical variables were compared [27]. We used regression analysis to test the difference between the mean values, and all the model was checked for homoscedasticity and corrected using robust when necessary [28]. To correct the normality, the models were bootstrapped [29]. Box plots were used to illustrate the fertilizer use as they are useful when the variables are not normally distributed as the box shows the quartiles of the data, while the whiskers extend to show the rest of the distribution [30].

Pairwise comparison of marginal effects was then used to assess the difference between areas at a 95% confidence interval.

Two logistic regression models were used to examine the relationship between dependent and independent variables. The first model was used to examine the relationship between socio-economic characteristics and the use of agrochemical inputs. The second model was used to examine the relationship between human diseases and the associated confounding variables.

Previous studies in Cameroon indicated that the adoption of farm inputs and farmer behavior was affected by various individual characteristics, such as age and education [14,31]. We thus employed model (1) to investigate the decision of farmers to apply synthetic pesticides and fertilizers (both organic and mineral) in their farms.

$$\begin{gathered} Y_i = \gamma_0 + \gamma_1\, gender_i + \gamma_2\, education_i + \gamma_3\, age_i + \gamma_4\, landown_i + \\ \gamma_5 farm\ size_i + \gamma_6 GIC_{it} + \gamma_7 people_i + \gamma_8 area\ type_i + \gamma_9 house\ distance_i + \epsilon_i \end{gathered} \tag{1}$$

where Y_i is whether farmers i used any agricultural inputs or not: Y_1 only organic fertilizers or did not only use organic fertilizers; Y_2 only mineral fertilizer or did not only use mineral fertilizer; Y_3 both mineral and organic fertilizers or did not use both mineral and organic fertilizers; Y_4 pesticides or not.

Model (2) examined the relationship between human diseases and the associated confounding variables, as shown in the following equation:

$$Y_i = \beta_0 + \beta_1 farming\ practices_i + \beta_2 X_i + \varepsilon_i \tag{2}$$

where Y_i is the prevalence of the disease with farmer i. The diseases assessed include: (1) malaria, (2) hydric diseases (typhoid, abdominal pain, diarrhea), (3) skin diseases, (4) headache (after any farming activity), and lastly (5) respiratory diseases (coughing and lung problems).

The full description of the variables used in models (1) and (2) is provided in Appendix A Tables A2 and A3.

3. Results and Discussion

3.1. Demographic Characteristics of Farmers

All sampled farmers responded to the questionnaire, i.e., the response rate was 100%. Of the sampled population, 55.4% were females (Table 1). The predominance of women involved in urban agriculture in four out of the six studied areas runs counter the reports of Kenmogne et al. [32] and Saidou and Pritchard [33], who observed stronger maledominated farmer communities in the Nkolbisson, Mokolo, and Nkolondom areas of Yaoundé, respectively.

Table 1. Farmer's socio-demographic profile (*N* = 130).

Variables	Division (%)						Average (%)
	Emana	Minkoameyos	Mokolo	Nkolbisson	Ekounou	Ekoumdoum	
Male	82	25	35	34	70	36	45
Female	18	75	65	66	30	64	55
Status							
Single	36	19	40	33	15	42	36
Married	46	56	35	58	62	43	46
Widow(er)	18	25	25	9	23	15	18
Education							
None	-	6	-	13	18	4	8
Primary	64	50	15	33	30	58	39
Secondary	27	44	80	54	46	27	47
Higher	9	-	5	-	6	11	5
Motivations							
Unemployment	54	25	10	25	65	33	35
Incomes	45	69	20	58	73	45	62
Family habits	27	25	12	25	31	33	27
Food supply	-	-	60	8	8	18	9

The lower participation of men in urban agriculture nowadays may be explained by the increasing job diversification of male farmers in Africa and beyond. Since women are often more involved in the family food supply, this could improve households' nutrition as vegetables are often produced by women in home gardens [34]. Half of the farmers who participated in our study were married and had completed at least secondary education. Yet, the education level of other respondents was quite low, since only 39% of the respondents had completed primary school and 8% of the respondents were illiterate. This may be the result of the rural exodus that brings youths from the villages to the city. Low education levels may affect the capacity to understand many complex issues regarding the safe management of farming practices, and thus, ultimately affects farming productivity. Such an impact of farmers' education background on farm productivity was also found by Paltasingh and Goyari [35] in their study on farmer education on farm productivity under varying technologies in India.

The main purposes of urban farming are enhancing the income of households (62%), improving food supply (9%), and lowering unemployment (35%). We noted that only a few participants continue farming because of family habits (27%), e.g., inheriting a farm or farmland.

The age of the participants ranged from 18–76 years, with an average of 44 (±15) years, and in all the different study areas, the mean age exceeded 40 years (Table 2). This corroborates findings by Sotamenou and Parrot [14] on the adaptation of compost in urban agriculture in Yaoundé and Bafoussam, Cameroon. A previous study in Yaoundé communities reported that the average age of farmers ranged between 34–36 years [14]. In addition to unemployment and the feeding lifestyles, the level of responsibility of the people aged 18–76 years might be another reason for the high implication of farmers age ranges in vegetable production in Yaoundé. The average farm working experience was 11 (±9) years, with three to five household members involved in farming. This corresponds well with the average number of people living in households in Yaoundé, which ranges from one to more than six persons, with about 40% of households consisting of more than six members [2]. Although farmers usually grow vegetables in more than one plot, the size of the cultivated lands is relatively small, and with increasing urbanization, the size of cultivated land is decreasing even more with time. The average size of a farm in our study was 298 m^2, which is substantially smaller than the previously reported average of 400 m^2 [36].

Table 2. Summary of ages and farm characteristics (± standard deviation), N = 130.

Variables	Divisions						Average
	Emana	Minkoameyos	Mokolo	Nkolbisson	Ekounou	Ekoumdoum	
Age (years)	50 ± 12	43 ± 11	42 ± 15	43 ± 16	46 ± 15	44 ± 16	44 ± 15
Household size (number)	5 ± 4	4 ± 2	3 ± 2	3 ± 3	3 ± 2	4 ± 4	4 ± 3
Farm area (m^2)	245 ± 233	186 ± 155	86 ± 45	275 ± 223	478 ± 496	375 ± 381	298 ± 342
Operational years	7 ± 6	6 ± 7	14 ± 11	11 ± 8	11 ± 6	11 ± 11	11 ± 9

All farmers practiced polyculture, with leafy vegetables as dominant crops, followed by herbs and vegetable fruits, including plants that are botanically classified as fruits, but are used as vegetables for culinary purposes. The primary cultivated species were vegetable food species such as *Amaranthus hybridus* (89%), *Solanum nigrum* (77%), *Corchorus olitorius* (66%), *Lactuca sativa* (49%), and *Vernonia amygdalina* (39%). *Abelmoschus esculentus* (34%) and *Solanum melangera* (28%) are among the most grown vegetable fruits, while *Apium graveolens* (31%), *Ocimum basilicum* (22%), and *Petroselinum crispum* (21%) were the most commonly grown herb species (Table 3).

Table 3. Percentages of land use for vegetable crops grown in the six lowland study sites in Yaoundé.

Land Use	Areas (%)						Average (%)
	Emana	Minkoameyos	Mokolo	Nkolbisson	Ekounou	Ekoumdoum	
A. hybridus	91	85	94	92	88	88	89
S. nigrum	91	69	70	71	77	85	77
C. olitorius	64	25	60	38	57	56	66
L. sativa	5	43	5	37	67	62	49
V. amygdalina	36	37	90	37	23	24	39
A. esculentus	55	31	80	25	15	24	34
A. graveolens	55	44	0	42	27	30	31
S. melangera	45	25	60	21	18	15	28
O. basilicum	55	50	0	29	12	15	22
P. crispum	45	25	0	21	24	19	21

The choice of crop production was based on a combination of farmers' consumption preferences, a preferably short vegetational cycle, and the local market demands. The vast majority of farmers in the six lowlands grew *A. hybridus* and *S. nigrum* primarily for self-consumption, with only the surplus sold at nearby markets. Yet, *L. sativa* was primarily grown for market sale. Such kind of crop choices were also reported by Bopda et al. [23] and Kenmogne et al. [32] in their studies in Nkolondom and Nkolbisson, respectively.

3.2. Irrigation Water

More than half of the farmers (56%) used surface water sources (rivers) for their irrigation needs. Among the participants, 44% relied on groundwater (GW), mainly obtained from shallow dug wells built near the plots for irrigation. Figure 2 shows the percentages of irrigation water sources in all study areas. Farmers from five out of the six studied lowland areas utilized water from different origins. Farmers from Mokolo used only GW to irrigate their fields, while those in Nkolbisson and Minkoameyos mainly utilized surface water (SW) (61%). Ekounou farmers equally used GW and SW. With the irrigation water sector accounting for only 7.3% of water use in Cameroon, farmers rely on potentially polluted water for irrigation because of general water scarcity. The type of irrigation water sources is one of the most critical parameters for the potential contamination of vegetables. Untreated water used for irrigation is the primary source of pathogens and heavy metal contamination in farms [37,38]. This may lead to the deterioration of GW quality, soil structure, and changes in physicochemical properties of lands that significantly reduces their fertility [19].

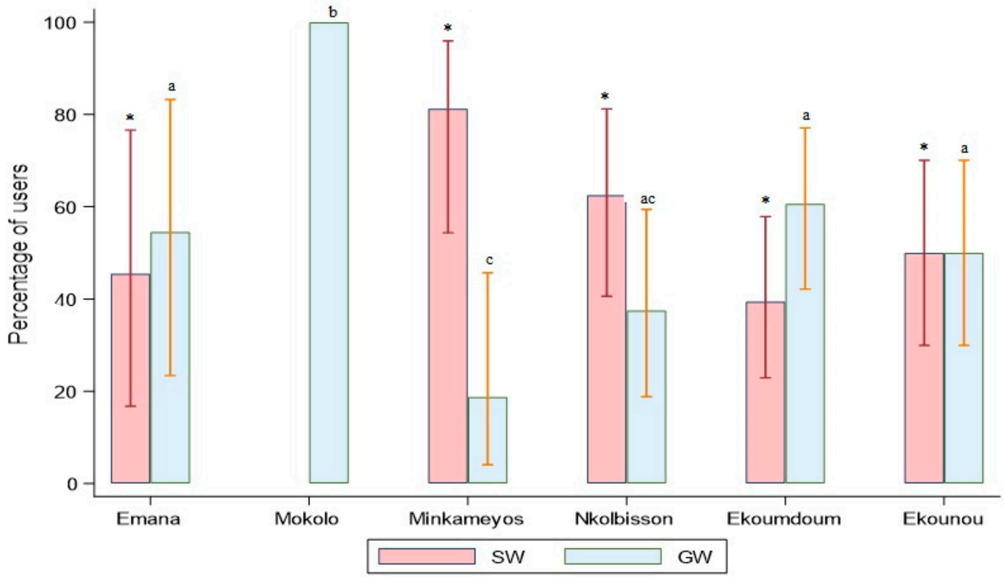

Figure 2. Percentages and types of irrigation water used in the studied areas (SW: surface water; GW: groundwater; same letters for the respective irrigation water type are not significantly different at $p < 0.05$; * not significantly different at 95% exact confidence intervals).

The percentage of Mokolo farmers using GW for irrigation was significantly higher than in the other studied areas of Yaoundé. On the contrary, the percentage of farmers from Minkoameyos using GW for irrigation was significantly lower than those from the Emana, Ekounou, and Ekoumdoum sites.

3.3. Fertilizers

Vegetable production in urban areas requires several external inputs, including mineral or organic fertilizers. Of the surveyed farmers, 84.6% used fertilizers to enhance soil fertility, with the highest use in Nkolbisson (88%) and Emana (73%), yet with no significant differences in fertilizer use among the six studied lowland areas of Yaoundé (Figure 3). Most farms in Nkolbisson belong to the neighboring Cameroonian Institute of Agricultural Research for Development or are owned by former workers of the institute, possibly explaining the relatively higher fertilizer use there compared to the other studied lowland areas. Improper farm fertilizer management can lead to nutrient contamination and other chemical pollutants into water bodies through runoff and soil erosion [19], and such contaminants may negatively affect plants, animals, and humans [39].

The type of fertilizers applied varied among farmers based on their availability and affordability. Of the interviewed farmers, 50% used a combination of mineral and organic fertilizers, while 28.5% utilized only organic and 6.1% only mineral fertilizers in their fields. The three most common organic fertilizers used were chicken manure (65.4%), pig manure (4.6%), and compost (8.5%). The comparison of the organic fertilizers shows that the proportion of farmers using chicken manure was significantly higher. Among the mineral fertilizers, urea was the most used type (27.7%), followed by NPK (22.3%) and ammonium sulfate (6.2%) (Figure 4). The analysis revealed that the proportion of farmers using ammonia was statistically lower. The high popularity of chicken manure, especially compared to mineral fertilizers, such as urea or NPK, can be explained by its better availability and greater affordability. For instance, a 50 kg bag of chicken manure costs approximately Franc CFA 1200–2000 (EUR 2–3), while a 50 kg bag of mineral fertilizers costs around Franc CFA 18,000–25,000 (EUR 27–38), which is often not affordable for many smallholder farmers.

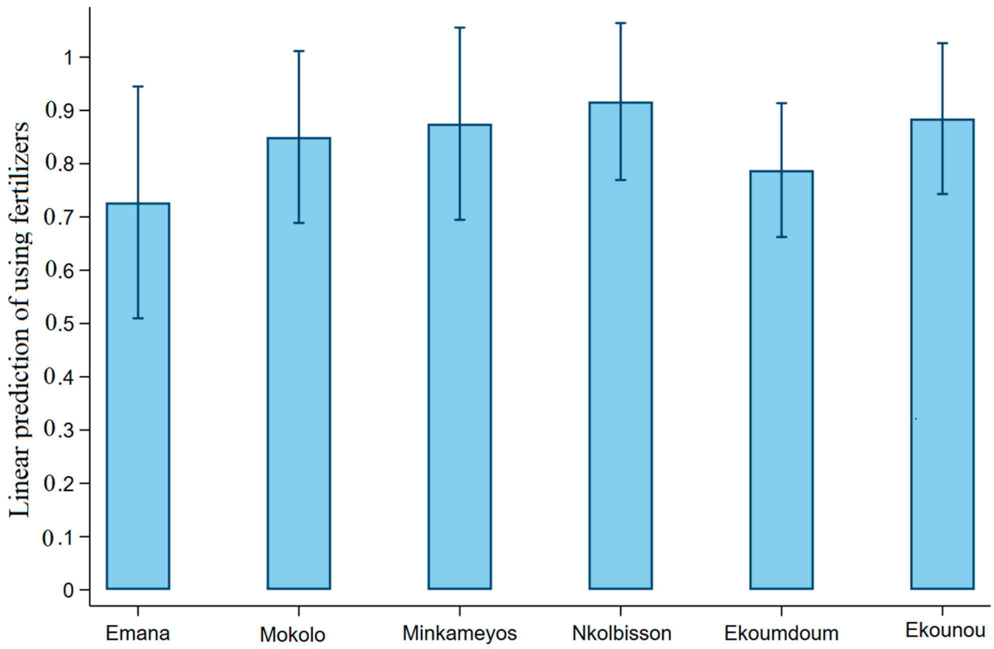

Figure 3. Probability of using fertilizers in the studied lowlands areas (at 95% confidence intervals).

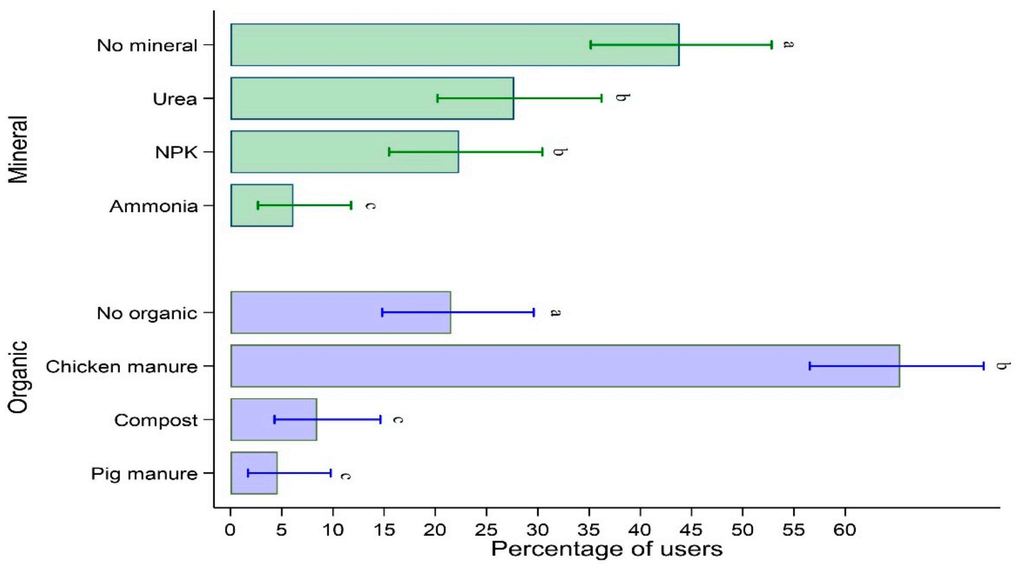

Figure 4. Types of fertilizers used in Yaoundé lowlands (No mineral: farmers use only organic fertilizers; No organic: farmers use only mineral fertilizers; same letter for the respective fertilizer types are not significantly different at $p < 0.05$ at 95% exact confidence intervals).

Previous studies reported that mineral fertilizer prices in different parts of Africa were not affordable for smallholder farmers (35, 36). Such farmers often revert to poultry manure to replenish soil fertility [33]. Because of its low moisture content, chicken manure is easy to dry, thus requiring less labor, and can substantially improve the nutrient availability in the soil. It also contains less toxic and nonessential elements than mineral fertilizers [33]. In addition, it has a higher concentration of N, P, and K per unit compared to other types of animal manure [40,41]. However, chicken manure application has also been reported to have some undesirable effects, such as phosphorus (P) reduction and extended stockpiling period [42]. In some of the study areas, e.g., Nkolbisson, Emana, and Mokolo, farmers grow maize intercropped with leguminous vegetables. This practice helps to provide additional nitrogen as an environmentally friendly and more sustainable way of improving soil fertility. Nonetheless, intercropping was absent in the other three study areas, leading to higher (mostly mineral) fertilizer inputs into the environment.

3.3.1. Organic Fertilizer Use per Square Meter

The on-farm quantity of fertilizer used per m^2 varied widely among farmers and areas studied. On average, farmers applied 2.14 (±2.16 SD) kg/m^2 organic fertilizers, ranging from 0.05–12.5 kg/m^2. Figure 5 summarizes the amount of organic fertilizer (in kg) used per m^2 of the farm size. In the study area, the average amounts of fertilizers applied were 1.61 kg/m^2, 3.60 kg/m^2, 1.05 kg/m^2, 1.42 kg/m^2, 2.98 kg/m^2, and 1.99 kg/m^2 for Emana, Mokolo, Minkoameyos, Nkolbisson, Ekoumdoum and Ekounou, respectively.

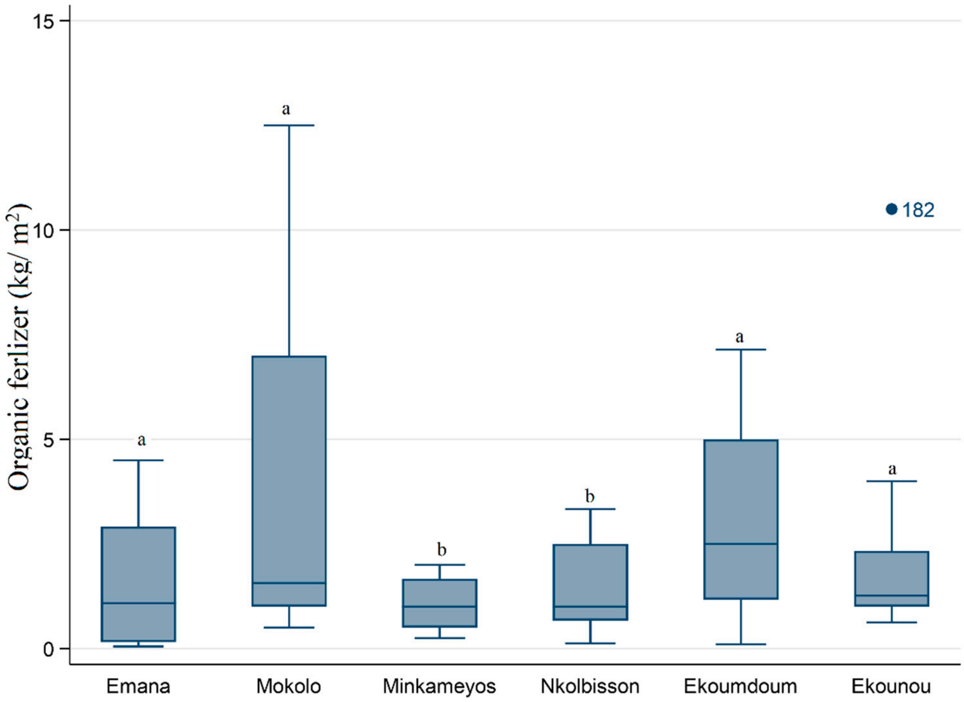

Figure 5. Box plot showing the distribution of the amount of organic fertilizer used per m^2 in the studied areas. (Same letters indicate no significant differences at $p < 0.05$; data are shown using box whisker plot to reveal the heteroscedasticity; the significance indicator refers to a robust generalized linear model).

The on-farm use of organic fertilizers in each area was evaluated using regression analysis and pairwise comparison. The results showed that the amount of organic fertilizer used per m^2 in farms in the Mokolo, Emana, and Ekoumdoum areas was significantly higher than in Minkoameyos, Nkolbisson, and Ekounou.

3.3.2. Mineral Fertilizer Use per Square Meter

The use of mineral fertilizers varies from 0.01–0.50 kg/m^2, with an average of 0.08 ± 0.09 kg/m^2 (Figure 6). In the different locations, the average quantity of fertilizers applied were 0.07 kg/m^2, 0.17 kg/m^2, 0.10 kg/m^2, 0.05 kg/m^2, 0.07 kg/m^2 and 0.05 kg/m^2 for Emana, Mokolo, Minkameyos, Nkolbisson, Ekoumdoum and Ekounou.

The results of the analysis revealed that the amounts of mineral fertilizer were significantly higher in the farms of Mokolo compared to those in the Ekounou, Nkolbisson, Emana, and Ekoumdoum areas, though there was no difference in mineral fertilizer use between farms in the Mokolo and Minkoameyos areas.

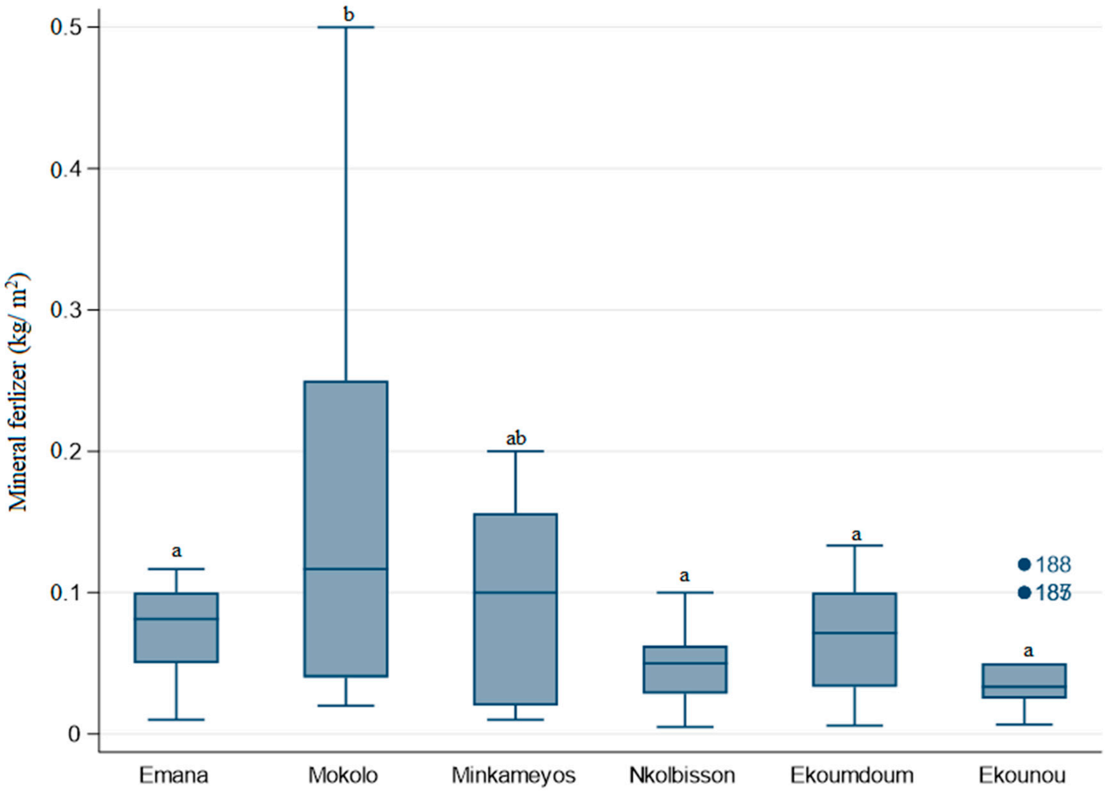

Figure 6. Box plot showing the distribution of the amount of mineral fertilizer used per m^2 in the study sites (same letters indicate no significant differences at $p < 0.05$; data are shown using box whisker plot to reveal the heteroscedasticity; the significance indicator refers to a robust generalized linear model).

The differences in fertilizer usage between the different areas studied might have been influenced by the differences in the price of fertilizer in the respective surrounding markets of these areas. Farmers involved in animal husbandry have a greater access to comparatively less expensive organic fertilizer and are thus more likely to use comparatively larger quantities of such fertilizer on their fields. A recent study in Yaoundé reported that poultry manure was the cheapest source of N to purchase, although a larger volume was required [33]. The authors highlighted that the application of 200 kg chicken manure would supply 7.8 kg N/ha/pa, which is lower than the Kenya Agricultural Research Institute recommended rate of 50 kg of DAP (diammonium phosphate) and 60 kg of calcium ammonium nitrate (CAN) in sub-Saharan Africa [43,44]. In comparison, 150 kg/ha of NPK and 50 kg/ha of urea (46% N) provide a total N loading of 53 kg/ha/pa [33]. Our study found the highest amount of organic and mineral fertilizers was applied on farms in the Mokolo area, even though these farms tended to be smaller than those in the other study areas. This comparatively higher fertilizer use in Mokolo was probably due to the longer duration of cultivation and the soil typology there. On smaller farms, farmers often tend to overuse soil amendments to increase their productivity with little awareness of potential health and environmental effects. In addition, because of a lack of information and training on occupational health and safety, farmers often apply fertilizers with their bare hands, a practice that potentially increases long-term health hazards.

3.4. Pesticides

Pesticides, just as fertilizer applications, are common in urban agriculture in the Yaoundé lowlands. Sixty-four percent (64%) of farmers applied pesticides to control pests, weeds, and diseases that reduce yields, and only 36% did not utilize chemical pest control. The proportions of pesticides users were 91%, 70%, 19%, 67%, 72%, and 62% for the

Emana, Mokolo, Minkoameyos, Nkolbisson, Ekoumdoum, and Ekounou sites, respectively (Figure 7). The highest proportion of farmers using pesticides in their farms was found in the Emana and the lowest in the Minkoameyos area.

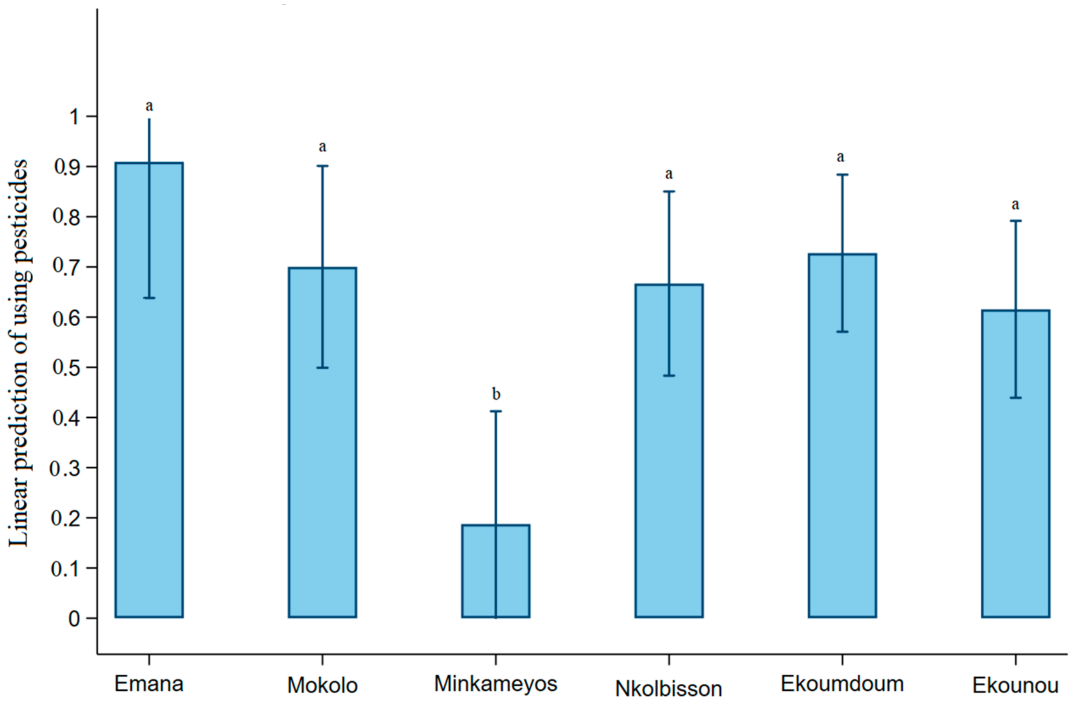

Figure 7. Probability of using pesticides in the studied areas of Yaoundé (same letter indicates no significant differences at $p < 0.05$ at 95% confidence intervals).

Compared to all studied areas, the proportion of farmers using pesticides in the Minkoameyos area was significantly lower.

Farmers involved in urban lowland agriculture in Yaoundé apply different types of pesticides. The most commonly used pesticides, including six fungicides, two insecticides, one nematicide, and one herbicide, were classified according to the type and commercial brand name, active ingredient(s), and WHO classification (Table 4). Fungicides were most frequently used (76%), followed by insecticides (66%) and nematicides (14%). Only 9% of farmers applied herbicides in their fields.

Table 4. Types of pesticides used in the lowland farms in Yaoundé.

Active Substances and Classification	Formulations	WHO Classification	Proportion (%)
Cypermethrin (I)	Cypercal 12 EC	II	48
	Cypercot 25EC	II	
	Cyperplant 50 EC	II	
	Cigone 12 EC	II	
Lambda-cyhalothrin (I)	Lamida Gold 90 EC	II	18
Chlorothalonil 550 g/l +Carbendazime 100 g/l (F)	Banko Plus	III	27
Maneb 80% (F)	Plantineb 80 WP	III	4
Metalaxyl 80 g/kg + Mancozeb 640 g/Kg (F)	Mancoxyl plus 720 wp	III	10
Mancozeb 800 g/kg (F)	Penncozeb 80 WP	III	4

Table 4. *Cont.*

Active Substances and Classification	Formulations	WHO Classification	Proportion (%)
Metalaxyl-M 6%+ Copper Oxide 60% (F)	Rodomil gold plus 66 wp	III	25
	Callomil plus 66 WP		
Glyphosate 360 g/l (H)	Herbi-star 360 SL	III	9
	Roundup 360 SL [a]	III	
Chlorothalonil 720 g/l (F)	Balear 720 Sc SL	III	6
-	Beauchamps [b]	-	12
Oxamyl 50 g/kg (N)	Bastion Super	Ia	14

Notes: Ia = Extremely hazardous; II = moderately hazardous; III = slightly hazardous [45]; [a] = obsolete, [b] = unclassified; I = insecticide, F = fungicide, H = herbicide and N = nematicide.

The low proportions of farmers applying herbicides in their farms can be explained by the high cost of these products, their only partial availability, and the low labor costs, with the vast majority of farmers thus preferring to manually weed their farms. A high proportion of farmers using fungicides was also reported by Tambe et al. [46] in their study on pesticide use by smallholder's tomato farmers in Cameroon. They reported that fungicides were the most common pesticides used among urban farmers and that most farmers apply these pesticides rather indiscriminately without using any protective gear. Moreover, another Cameroon study revealed that pesticides usage is responsible for 78% of accidental poisoning cases, 12% of suicide attempts, and 4% of criminals (thieves arrested are injected with Gramoxone or Paraquat) [47]. Furthermore, the potential human health risk from pesticides residues in drinking water in many countries has been reported by El-Nahhal and El-Nahhal [48].

Most farmers in our study lacked training in farming practices and knowledge on safe occupational practices. Thus, only 34% of the farmers wear personal protective clothing during irrigation, fertilizer, and pesticide applications. Even though the farmers are aware of the occupational health risks, none wear complete protective clothing, such as boots, gloves, and masks. Most farmers use only one or two pieces of personal protective gear, such as boots, raincoats, or gloves. In addition, most farmers are exposed to wastewater and often ingest some soil particles during farm work, leading to health risks [49,50].

More than half of the farmers generally walk in the irrigation water or wet their clothes during the irrigation process. Although 60% of farmers reported no feeling of inconvenience related to the untreated water, 40% noticed skin itching, burning, and the wretched water smell. These findings are probably due to the lack of awareness of occupational health risks and the low level of education of most of the encountered farmers. Yet, appropriate education is key to understanding safe working procedures and health risks related to certain behaviors. Asongwe et al. [51], working with vegetable farmers in the Bamenda wetlands of Cameroon, reported that wearing personal protective gear can significantly reduce work-related threats.

3.5. Farming Practices and Explanatory Variables

A logistic model was used to understand the factors influencing the use of agricultural inputs. Four independent variables, i.e., education, land ownership, farm size, and the number of years the farm has been cultivated, significantly affected the use of fertilizers and pesticides (Table 5).

Table 5. Factors influencing the use of various agrochemicals (fertilizers and pesticides) in smallholder farms in Yaoundé lowlands.

Variables	No Fertilizers	Organic Fertilizers Only	Organic and Mineral Fertilizers	Mineral Fertilizers Only	Pesticides
Gender	0.0004	−0.0564	0.0363	−0.0390	0.0867
	(0.0475)	(0.0848)	(0.0916)	(0.0470)	(0.0875)
Education	0.0156	−0.2120 **	0.1510	0.1090	−0.0216
	(0.0507)	(0.0719)	(0.0838)	(0.0610)	(0.0823)
Age (years)	0.0005	−0.0038	0.0045	−0.0018	−0.0022
	(0.0021)	(0.0027)	(0.0030)	(0.0021)	(0.0028)
Land ownership	−0.2110 **	0.0856	0.1330	0.0050	−0.2910 **
	(0.0572)	(0.0852)	(0.0920)	(0.0451)	(0.0766)
Years of Cultivation	0.0026	0.0010	0.0028	−0.0070 *	0.0096 *
	(0.0040)	(0.0043)	(0.0049)	(0.0033)	(0.0047)
Farm area (m^2)	−0.0018 **	0.0000	0.0004 *	0.0000	−0.0002
	(0.0005)	(0.0001)	(0.0001)	(0.0000)	(0.0001)
CIG [a] membership	−0.0413	−0.0853	0.0771	−0.0201	−0.1470
	(0.0656)	(0.1190)	(0.1190)	(0.0563)	(0.1100)
Number of people	−0.0030	−0.0122	0.0235	−0.0131	−0.0142
	(0.0073)	(0.0135)	(0.0143)	(0.0132)	(0.0131)
Area type [b]	−0.0699 *	−0.0253	0.0847	0.0311	−0.0923
	(0.0300)	(0.0531)	(0.0613)	(0.0312)	(0.0598)
House distance (m)	−0.0001	0.0001	0.0000	0.0000	0.0000
	(0.0001)	(0.0001)	(0.0000)	(0.0000)	(0.0000)

Notes: the dependent variable is the use of agrochemicals (fertilizers and pesticides). Coefficient estimates are reported with robust standard errors in parentheses. Other variables controlled for include gender and level of education of farmers, age, land ownership and size, number of the household member involved in farm activities and distance between farm and house. [a] Common initiative grouping (CIG) membership and [b] Area type (temporary flooded or permanently flooded) were also controlled. ** $p < 0.01$, * $p < 0.05$ represent statistical significance at 1% and 5%, respectively.

Education is significant in negatively affecting the use of organic fertilizers. Possibly even (better) educated farmers are not sufficiently aware of the benefits of nutrient management on their farms or lack training on environmentally friendly farming techniques. Thus, there is a need to better inform and train farmers via agricultural extension agents. Cameroon's Ministry of Agriculture often grants expenditures for organic fertilizers through NGOs or farmers' associations. Therefore, educated farmers opt to use both types of fertilizers instead of only mineral fertilizers. Using only the latter might cause harm to environmental and human health. The integrated use of both organic and mineral fertilizers requires higher managerial skills, such as combining the two inputs in the correct proportions. Sotamenou and Parrot [14], in their study on sustainable urban agriculture and the adoption of composts in Cameroon, found that education favors combined fertilizer use on farms.

The use of pesticides is significantly negatively associated with land ownership (Table 5). Farmers that own the land are more interested in long-term investments, such as sustainable farming techniques and are thus less likely to use pesticides. The use of pesticides has been widely regarded as an unsustainable practice in Yaoundé because of its effect on soil, water, and human health [47,52]. Those who do not own the land, as many farmers living in the lowlands of Yaoundé, who often face eviction from the land, are more interested in short-term profits rather than the sustainable maintenance of soil health and thus are more prone to use pesticides. There is also an issue of awareness whereby the majority of these farmers, irrespective of land ownership, are aware that pesticides usage is harmful to soil health because of consumer organizations that sensitize them on the health risks linked to improper management of pesticides. These consumer organizations frequently hold informal debates with communities about human and environmental health issues from pesticide and other agrochemical use in farming systems.

The number of years the farm has been under cultivation (years of cultivation) has mixed effects on externality use. It is significantly negatively and positively associated with mineral fertilizer and pesticide use, respectively (Table 5). Possibly farmers are aware that the long-term use of mineral fertilizers leads to diminishing productivity and soil fertility, resulting in low crop production. Yet, long-term cultivation of crops on the same piece of land leads to a build-up of pests and diseases, negatively affecting crop productivity and soil health. Therefore, farmers probably tend to address these problems through the increased use of pesticides.

There is a significant positive association between farm size and the use of a combination of organic and mineral fertilizers (Table 5). Our findings suggest that the smaller the farm, the higher the likelihood of using higher rates of fertilizers to increase crop yield and productivity. Previous studies have also demonstrated that farm size influences the use of fertilizers. For instance, a study on fertilizer adoption in Ghana indicated that farmers were more likely not to adopt fertilizer as the farm size increased [53]. Nkamleu [54] reported that farm size was significantly negatively related to adopting mineral fertilizer, organic fertilizer, and integrated use of combined organic–mineral fertilizers. In this study, farmers with larger farms usually have ownership of this land and hence were interested in long-term farm management strategies, including applying combined mineral and organic fertilizers to maintain soil fertility. On the contrary, in smaller farms, where the owners do not own the land, there is a focus on producing as much as possible in the short term and to make money quickly and hence the tendency to use more inputs, in this case, fertilizers.

3.6. Farming Practices and Disease Prevalence

Our findings from the self-reported disease data show that farmers in Mokolo and Nkolbisson have the highest (95%) case of disease prevalence compared to the other studied areas. The result of the logistic regression model is reported in Table 6.

It shows that educated farmers (above primary school level) are significantly less likely to report having malaria. This finding corroborated those reported by Spjeldnæs et al. [55] in their study on education and knowledge that helps to combat malaria in Tanzania. These authors found that a high education status was significantly associated with high knowledge and less likelihood of contracting malaria. According to Ricci [56], women tend to be less educated than men and thus have limited knowledge on the causes, transmission, and further appropriated treatment of malaria as the information might be available only in English or French and not in any local language. Additionally, farmers from Emana, Minkoameyos, Nkolbisson Ekoumdoum, and Ekounou are, respectively, 62%, 55%, 55%, 63%, and 48% significantly less likely to report having malaria than those in the Mokolo area. This result might be explained by the location of the Mokolo area in a slum community and the type of housing prevalent there, as poorly constructed houses facilitate the entrance of mosquito vectors and, thus, increase the risk of infection among the household members [57].

Additionally, when farmers put on masks and gloves and are older, they are 41%, 38%, and 0.75%, respectively, significantly less likely to report contracting waterborne diseases, including typhoid, skin diseases, diarrhea, and abdominal pain. Nose masks might reduce the accidental ingestion of irrigation water. Similarly, wearing gloves might protect their hands from contacting the irrigation water and, thus, decreases the likelihood of contracting waterborne diseases. Using fertilizers significantly increases the likelihood of contracting waterborne diseases by 21%. Fertilizers, especially organic fertilizers, such as animal manure, are often stored outside. Subsequently, farmers applied the organic fertilizer using their bare hands when it was still wet, increasing the risk of infection.

Table 6. Factors associated with the incidence of common diseases (self-reported diseases) among farmers.

	Malaria	Waterborne Diseases	Headache	Respiratory Diseases
Education level	−0.164 *	−0.089	0.105	0.017
	(0.079)	(0.078)	(0.068)	(0.081)
Marital status	−0.085	−0.031	0.019	−0.084
	(0.080)	(0.073)	(0.066)	(0.074)
Age (years)	0.003	−0.008 **	0.0001	−0.003
	(0.003)	(0.003)	(0.002)	(0.003)
Gender	0.147	0.107	−0.001	0.051
	(0.086)	(0.072)	(0.071)	(0.083)
Use gloves	−0.058	−0.383 *	0.082	−0.024
	(0.142)	(0.156)	(0.109)	(0.160)
Use raincoats	0.133	0.138	0.150	−0.045
	(0.181)	(0.208)	(0.132)	(0.188)
Use masks	−0.113	−0.410 *	0.0108	−0.086
	(0.173)	(0.171)	(0.152)	(0.202)
Use boots	−0.150	0.274	0.090	0.148
	(0.141)	(0.165)	(0.100)	(0.139)
Use glasses	0.290	0.202	−	0.185
	(0.357)	(0.323)		(0.339)
Hand cleaning	0.143	0.224	−0.047	−0.003
	(0.172)	(0.187)	(0.137)	(0.180)
Use fertilizers	0.071	0.206 *	−0.112	−0.052
	(0.108)	(0.085)	(0.080)	(0.104)
Use pesticides	0.076	−0.041	0.0345	−0.122
	(0.088)	(0.074)	(0.076)	(0.081)
Knowledge risks	−0.024	0.0734	0.079	0.165
	(0.110)	(0.104)	(0.092)	(0.117)
Type water	−0.072	−0.069	0.100	0.075
	(0.087)	(0.084)	(0.072)	(0.089)
Inconvenience	0.177 *	0.143 *	−0.080	0.083
	(0.081)	(0.071)	(0.068)	(0.074)
Getting wet	0.170	0.331 *	−0.054	0.048
	(0.145)	(0.157)	(0.107)	(0.163)
Emana	−0.621 **	−0.099	0.213	−0.143
	(0.229)	(0.177)	(0.170)	(0.215)
Minkoameyos	−0.548 *	0.124	0.331 *	0.152
	(0.222)	(0.188)	(0.162)	(0.165)
Nkolbisson	−0.547 **	0.019	0.191	0.135
	(0.202)	(0.138)	(0.150)	(0.144)
Ekoumdoum	−0.633 **	−0.083	0.145	−0.064
	(0.187)	(0.102)	(0.141)	(0.129)
Ekounou	−0.475 *	0.033	0.202	0.094
	(0.202)	(0.118)	(0.144)	(0.135)
Number of observations	130	130	127	130

Notes: All the areas were compared to Mokolo because the estimation of categorical variables is always comparable with the unmuted variables. The dependent variable is the self-reported diseases: malaria, waterborne diseases (typhoid, skin diseases, diarrhea, and abdominal pain), headache, and respiratory diseases (coughing and lung problems). Coefficient estimates are reported with robust standard errors in parentheses. ** $p < 0.01$, * $p < 0.05$ represent statistical significance at 1% and 5%, respectively.

Furthermore, farmers who reported facing some inconvenience, such as skin burning and itching, and are exposed to irrigation water are 14% and 33%, respectively, significantly more likely to report contracting hydric diseases. Farmers in Minkoameyos have a 33% higher risk of reporting to have headaches compared to those from Mokolo. Farmers in Minkoameyos have a 33% significantly higher risk of reporting to have headaches compared to those from Mokolo.

4. Conclusions

This study assessed the factors that influence farming practices and the prevalence of diseases in vegetable producers in the lowlands of Yaoundé. Towards this objective, we found that often associated with hygiene and sanitation, most of the reported health problems were largely the result of the farmers' general lack of appropriate protective gear for applying fertilizers and pesticides and their exposure to untreated and wastewater used for irrigation purposes. Despite these health risks, vegetable farming provides crucial food for domestic consumption, employment, and income to farmers, contributing to their well-being. Importantly, the study shows that most of the health problems could possibly be avoided by stricter adherence of farmers to basic occupational health and safety measures. Effective extension services, which provide improved training on the safe application of agrochemicals and sound production techniques, as well as regular monitoring of water, soil, and product quality, will also reduce health risks to farmers and consumers.

Author Contributions: A.S.N.: conceptualization, data curation, writing original draft, review, and editing; A.A. (Annet Adong), P.N. and A.A. (Anne Ayo): software, writing, review, and editing; T.F., A.R. and C.B.: supervision, project administration, funding acquisition, writing, review, and editing. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the Schlumberger Foundation under its Faculty for The Future (FFTF) initiative.

Institutional Review Board Statement: The study was approved by the ethics committee of the Center for Development Research, University of Bonn (Germany), and the National Ethics Committee for Human Health Research -NECHHR, Yaoundé (Cameroon).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data are available from the authors with the permission of collaborators at a reasonable request.

Acknowledgments: The authors would like to thank the funding organization of this research project, the Schlumberger Foundation Faculty for the Future (FFTF), Ives Kengne (In memorium), and Guido Luechters for his statistical advice and the farmer's participants.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Key information and different components of farmers' questionnaire.

Demographics Information	Area/Crops	Agricultural Inputs	Water, Sanitation, and Hygiene	Health
Gender	Farm size	Seeds	Origin of irrigation water	Main diseases
Marital status	Ownership	Amendment	Other use of watering water	Symptoms
Education level	Operating years	Fertilizers	Drinking water source	Long term/chronic disease
Region	Types of crops	Pesticides	Toilet facility	Type of medication
Main occupation	Irrigation		OHS	
Motivation	Machinery		Contact water/ soil	Farming constraints
Weight	Purpose of the growing		Post-work behaviors Disease occurrence	

Table A2. Description of variables used in the first model.

Variable	Description	Hypothesis
$gender_i$	Gender of the farmers	Female farmers are more likely to adopt organic fertilizers because they can use kitchen residues and home livestock waste
age_i	The age of the farmers in years	Younger farmers may be more inclined towards experimenting or trying out the use of old and new agricultural inputs
$education_i$	The education level of the farmers	More educated farmers are more likely to comprehend better the agronomic and environmental advantages related to the use of organic fertilizer; educated farmers are therefore more likely to adopt organic fertilizers
$landown_i$	The land ownership	-
GIC_i	The membership of the farmer to an association	-
$farm\ size$	The farm's area	The area of the farm is likely to affect negatively the use of mineral farm inputs because they are costly
$people_i$	The number of family households involved in farming activities	Large number of people are a source of labor and will act positively with the use of any agricultural inputs to increase the farm productivity
$Area\ type_i$	Whether the farm is permanently or temporarily flooded	The rationale is that farmers whose farms are frequently flooded possibly refrain from using farm inputs, such as fertilizers, as the flood water will transport nutrients from nearby waste depots to their plots
$house\ distance_i$	The distance between the house of the farmer and his land use for cultivation	Cultivated land far away from the household may be given less application of agriculture inputs [31]
ε_i	The error term that explains other unobserved confounding factors	

Table A3. Description of variables used in the second model.

Variables	Descriptions
$farming\ practices_i$	Relates to the use of occupational health and safety practices, including boots, gloves, glasses, cleaning of hands, fertilizers, and pesticides
X_i	Are confounding variables including age, gender of the farmer, education level, use of personal protective equipment (PPE), hand cleaning after the application of pesticides and fertilizers, type of irrigation water used, being wet when conducting farming activities, area location and feeling inconvenient when using the irrigation
ε_i	Is the error term that explains other unobserved confounding factors

References

1. INS. *Annuaire Statistique De La Région Du Centre*; INS: Yaoundé, Cameroon, 2017. Available online: www.statistics-cameroon.org (accessed on 20 February 2021).
2. BUCREP. *Troisieme Recencement Générale de la Population et de l ´Habitat*; BUCREP: Yaoundé, Cameroon, 2010; Volume II.
3. World Bank. *Cameroon Inclusive and Resilient Cities Development Project*; World Bank: Washington, DC, USA, 2017; Volume 102.
4. Wang, Y.S. The challenges and strategies of food security under rapid urbanization in China. *Sustainability* **2019**, *11*, 542. [CrossRef]
5. Orsini, F.; Kahane, R.; Nono-Womdim, R.; Gianquinto, G. Urban agriculture in the developing world: A review. *Agron. Sustain. Dev.* **2013**, *33*, 695–720. [CrossRef]
6. FAO. Food Security and Nutrition in the World the State of Transforming Food Systems for Affordable Healthy Diets. The State of the World. 2020, p. 320. Available online: https://doi.org/10.4060/ca9692en (accessed on 15 November 2021).
7. FAO. *Fruit and Vegetables—Your Dietary Essentials*; The International Year of Fruits and Vegetables, 2021, Background Paper, 2020th edition; FAO, Ed.; FAO: Rome, Italy, 2020.

8. FAO. *Public Food Procurement for Sustainable Food Systems and Healthy Diets*; FAO, Swensson, A.L.F., Hunter, D., Schneider, S., Tartanac, F., Eds.; FAO: Rome, Italy, 2021; Volume 1, Alliance of Bioversity International and CIAT and Editora da UFRGS. Available online: https://doi.org/10.4060/cb7960en (accessed on 15 November 2021).
9. CHP. Non-Communicable Diseases Watch Eat More Fruit and Vegetables Eat More Fruit and Vegetables. Wan Chai. 2021. Available online: http://www.chp.gov.hk (accessed on 15 November 2021).
10. WHO. *Fruit and Vegetable Promotion Initiative*; WHO: Geneva, Switzerland, 2003.
11. UN-Habitat. *Working for a Better Urban Future: Annual Progress Report 2018*; Mohd, M., Ed.; UN-Habitat: Nairobi, Kenya, 2018. Available online: www.unhabitat.org (accessed on 15 November 2021).
12. FAO. *Growing Greener Cities in Latin America and the Caribbean*; FAO, Ed.; FAO: Rome, Italy, 2014. Available online: www.fao.org (accessed on 15 November 2021).
13. Hinson, A.V.; Mbaduet, Y.; Djouaka, R.; Zeukeng, F.; Gounongbe, F.; Adjobime, M.; Fayomi, B. Health hazards linked to the quality of the irrigation water and to the consumption of the vegetables grown in the market gardening site of Nkolondom, (Yaounde-Cameroon). *IJRDO-J. Agric. Res.* **2018**, *4*, 35–52.
14. Sotamenou, J.; Parrot, L. Sustainability Sustainable urban agriculture and the adoption of composts in Cameroon. *Int. J. Agric. Sustain.* **2013**, *11*, 37–41. [CrossRef]
15. Nkwemoh, C.A.; Tchindjang, M. Urban sprawl and agriculture: A case study of the Yaounde metropolis (Cameroon). *Rev. Sci Tech. Forêt Environ. Bassin Congo* **2018**, *10*, 45–58.
16. Schreinemachers, P.; Simmons, E.B.; Wopereis, M.C.S. Tapping the economic and nutritional power of vegetables. *Glob. Food Sec.* **2018**, *16*, 36–45. [CrossRef]
17. Richter, C.H.; Custer, B.; Steele, J.A.; Wilcox, B.A.; Xu, J. Intensified food production and correlated risks to human health in the Greater Mekong Subregion: A systematic review. *Environ. Health A Glob. Access Sci. Source* **2015**, *14*, 1–13. [CrossRef]
18. Abossolo, S.A.; Amougou, J.A.; Tchindjang, M.; Silvère, M.; Armand, R.; Batha, S. Analyse des précipitations annuelles à la station de Yaoundé de 1895 à 2006. *Afrique Sci. Rev. Int. Sci. Technol.* **2015**, *11*, 183–194.
19. Mfopou, Y.C.M.; Traore, M.; Kenmogne, P.P.N.; Aboubakar, A.; Manguele, G.S.F.; Maboune, S.A.T.; Ndam, J.R.N.; Gnankambary, Z.; Nacro, H.B. Structure of Vegetables Farming and Farmer's Perception of Soil and Water Degradation in Two Periurban Areas in Yaounde Cameroon. *Open J. Soil Sci.* **2017**, *7*, 333–346. [CrossRef]
20. BUCREP. *Caractéristiques des Ménages et Des Enquêtés*; BUCREP: Yaoundé, Cameroon, 2015.
21. INS. *Second Survey on Employment and the Informal Sector (EESI 2) Phase 1: Survey on Employment Main Report*; INS: Yaoundé, Cameroon, 2011.
22. Roubaud, F.; Torelli, C. Employment, Unemployment, and Working Conditions in the Urban Labor Markets of Sub-Saharan Africa: Main Stylized Facts. In *Urban Labor Markets in Sub-Saharan Africa*; Africa Development Forum Series; De Vreyer, P., Roubaud, F., Eds.; World Bank: Washington, DC, USA, 2013; pp. 37–79.
23. Bopda, A.P.; Brummett, R.; Dury, S.; Elong, P.; Foto, S. Urban Farming Systems in Yaoundé—Building a Mosaic. In *African Urban Harvest Agriculture in the Cities of Cameroon, Kenya and Uganda*; Prain, G., Karanja, N., Lee-Smith, D., Eds.; Urban Harvest CIP: Lima, Peru, 2011; pp. 39–61.
24. Falkenberg, T. Wastewater-Irrigated Urban Agriculture in the Context of WASH in Ahmedabad, India. ULB Libr. 2016. Available online: http://hss.ulb.uni-bonn.de/2017/4656/4656.htm (accessed on 21 December 2021).
25. UNHCR. *Libya: How to use KoBo for UNHCR—Led Sectors*; UNHCR: Geneva, Switzerland, 2016.
26. Ruel, M.T.; Arimond, M. Spot-check observational method for assessing hygiene practices: Review of experience and implications for programmes. *J. Health Popul. Nutr.* **2002**, *20*, 65–76.
27. Moore, D.S.; Notz, W.I.; Fligner, M. *The Basic Practice of Statistics*; Freeman, W.H. & Company: New York, NY, USA, 2018; p. 1016.
28. Rothman, K. Using regression models in epidemiologic analysis. In *Epidemiology—An Introduction Predictive Causal Sample Size Score*; Oxford University Press: New York, NY, USA, 2012; pp. 212–254.
29. Cameron, C.; Trivedi, P.K. *Microeconometrics Using Stata, Revised Edition*, 2010th ed.; Stata Press: College Station, TX, USA, 2010; p. 706.
30. Tukey, J.W. *Exploring Data Analysis*; Pearson: New York, NY, USA, 1974.
31. Nkamleu, G.B.; Adesina, A.A. Determinants of chemical input use in peri-urban lowland systems: Bivariate probit analysis in Cameroon. *Agric. Syst.* **2000**, *63*, 111–121. [CrossRef]
32. Kenmogne, G.R.K.; Rosillon, F.; Mpakam, H.G.; Nono, A. Enjeux Sanitaires, Socio-Économiques Et Environnementaux Liées À La Réutilisation Des Eaux Usées Dans Le Maraîchage Urabia: Cas Du Bassin Versant De l'Abiergué (Yaoundé-Cameroun). VertigO–La Rev Électronique En Sci L'environnement. 2010, 14. Available online: http://www.researchgate.net/profile/Traore_Salifou/publication/264557583_Effet_du_za_amlior_sur_la_productivit_du_sorgho_en_zone_sahlienne/links/53f0721b0cf2711e0c430b0f.pdf (accessed on 21 December 2021).
33. Saidou, I.; Pritchard, D. Soil Constraints to Urban Agriculture in Valley Beds of. *J. Environ. Sci. Allied Res. Vol.* **2019**, *2*, 1–8.
34. Tshwene, C.; Oladele, I. Water use productivity and food security among smallholder homestead food gardening and irrigation crop farmers in North West province, South Africa. *J. Agric. Environ. Int. Dev.* **2016**, *110*, 73–86.
35. Paltasingh, K.R.; Goyari, P. Impact of farmer education on farm productivity under varying technologies: Case of paddy growers in India. *Agric. Food Econ.* **2018**, *6*, 1–19. [CrossRef]

36. Bopda, A.P.; Brummett, R.; Dury, S.; Elong, P.; Foto-menbohan, S.; Gockowski, J.; Kana, C.; Kengue, J.; Ngonthe, R.; Nolte, C.; et al. *Urban Farming Systems in Yaoundé – Building a Mosaic: African Urban Harvest*; Springer: New York, NY, USA, 2010; pp. 39–59.
37. Clarisse, Y.; Mewouo, M.; Vivien, O.; Rémy, J.; Ngoupayo, N.; Ekodeck, G.; Hubert, S.; Togouet, Z.; Bilong, P.; Mfopou, C. Microbiological Quality of Shallow Irrigation Water at Nkolbisson a Sub-Urban Area of Yaounde (Cameroon): Influence of Some Physicochemical Properties. *Int. J. Res.* **2014**, *2*, 8–17.
38. Khan, M.M.; Akram, M.T.; Janke, R.; Qadri, R.W.K.; Al-Sadi, A.M.; Farooque, A.A. Urban horticulture for food secure cities through and beyond COVID-19. *Sustainability* **2020**, *12*, 9592. [CrossRef]
39. Soro, G.; Kone, B.; Kouakou, Y.E.; M'Bra, K.R.; Soro, P.D.; Soro, N. Utilisation de produits phytosanitaires dans le maraîchage autour du barrage d'alimentation en eau potable de la ville de Korhogo (nord de la Côte d'Ivoire): Risques pour la santé publique. *Env. Risque Sante.* **2018**, *17*, 155–163.
40. Hass, A.; Gonzalez, J.M.; Lima, I.M.; Godwin, H.W.; Halvorson, J.J.; Boyer, D.G. Chicken Manure Biochar as Liming and Nutrient Source for Acid Appalachian Soil. *J. Environ. Qual.* **2012**, *41*, 1096–1106. [CrossRef]
41. Yang, Z.; Han, L. Analysis and comparison of nutrient contents in different animal manures from Beijing suburbs. *Agric. Sci.* **2013**, *4*, 50–55. [CrossRef]
42. Hoover, N.L.; Yeow, J.; Ann, L.; Long, M.; Kanwar, R.S.; Soupir, M.L. Long-term impact of poultry manure on crop yield, soil and water quality, and crop revenue. *J. Environ. Manag.* **2019**, *252*, 109582.
43. Olwande, J.; Sikei, G.; Mathenge, M. *Agricultural Technology Adoption: A Panel Analysis of Smallholder Farmers' Fertilizer use in Kenya John Olwande*; University of California: Berkeley, CA, USA, 2009.
44. Vanlauwe, B.; Kihara, J.; Chivenge, P.; Pypers, P.; Coe, R.; Six, J. Agronomic use efficiency of N fertilizer in maize-based systems in sub-Saharan Africa within the context of integrated soil fertility management. *Plant Soil.* **2011**, *339*, 35–50. [CrossRef]
45. WHO. *The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification 2019*, 2019th ed.; World Health Organization: Geneva, Switzerland, 2020. Available online: http://www.who.int/about/licensing (accessed on 12 January 2022).
46. Tambe, A.B.; Mbanga, B.M.R.; Nzefa, D.L.; Nama, M.G. Pesticide usage and occupational hazards among farmers working in small-scale tomato farms in Cameroon. *J. Egypt Public Health Assoc.* **2019**, *94*, 1–7. [CrossRef] [PubMed]
47. Pouokam, G.B.; Album, W.L.; Ndikontar, A.S.; Sidatt, M.E.H. A pilot study in cameroon to understand safe uses of pesticides in agriculture, risk factors for farmers' exposure and management of accidental cases. *Toxics* **2017**, *5*, 30. [CrossRef] [PubMed]
48. El-nahhal, I.; El-nahhal, Y. Pesticide residues in drinking water, their potential risk to human health and removal options. *J. Environ. Manag.* **2021**, *299*, 113611. [CrossRef]
49. Baltas, H.; Sirin, M.; Gökbayrak, E.; Ozcelik, A.E. A case study on pollution and a human health risk assessment of heavy metals in agricultural soils around Sinop province, Turkey. *Chemosphere* **2020**, *241*, 125015. [CrossRef]
50. Keshavarzi, A.; Kumar, V. Spatial distribution and potential ecological risk assessment of heavy metals in agricultural soils of Northeastern Iran. *Geol. Ecol. Landsc.* **2020**, *4*, 87–103. [CrossRef]
51. Asongwe, G.A.; Yerima, B.P.K.; Tening, A.S. Vegetable production and the livelihood of farmers in Bamenda Municipality, Cameroon. *Int. J. Curr. Microbiol. Appl. Sci.* **2014**, *3*, 682–700.
52. Branchet, P.; Cadot, E.; Fenet, H.; Sebag, D.; Ngatcha, B.N.; Borrell-Estupina, V.; Ngoupayou, J.R.N.; Kengne, I.; Braun, J.; Gonzalez, C. Polar pesticide contamination of an urban and peri-urban tropical watershed affected by agricultural activities (Yaoundé, Center Region, Cameroon). *Environ. Sci. Pollut. Res.* **2018**, *25*, 17690–17715. [CrossRef]
53. Edward, M.; Nimo, W.A.; Etwire Prince, M.; Mathias, F.; Buah, S.S.J.; John, B.; Ahiabor Benjamin, D.K.; Francis, K. Fertilizer Adoption and Use Intensity Among Smallholder Farmers in Northern Ghana: A Case Study of the AGRA Soil Health Project. *Sustain. Agric. Res.* **2013**, *3*, 24.
54. Nkamleu, G.B. Modeling farmers' decisions on integrated soil nutrient management in sub-Saharan Africa: A multinomial Logit analysis in Cameroon. In *Advances in Integrated Soil Fertility Management in Sub-Saharan Africa: Challenges and Opportunities*; Springer: Dordrecht, The Netherlands, 2007; Volume 237, pp. 891–904.
55. Spjeldnæs, A.O.; Kitua, A.Y.; Blomberg, B. Education and knowledge helps combating malaria, but not degedege: A cross-sectional study in Rufiji, Tanzania. *Malar J.* **2014**, *13*, 2–11. [CrossRef]
56. Ricci, F. Social implications of malaria and their relationships with poverty. *Mediterr J. Hematol Infect. Dis.* **2012**, 4. [CrossRef] [PubMed]
57. Lindsay, S.W.; Jawara, M.; Paine, K.; Pinder, M.; Walraven, G.E.L.; Emerson, P.M. Changes in house design reduce exposure to malaria mosquitoes. *Trop. Med. Int. Health* **2003**, *8*, 512–517. [CrossRef] [PubMed]