

Assessment of Phytosanitary Practices in Peri-Urban Agriculture and Associated Environmental and Health Impacts in Developing Countries: Case of Abengourou City (Côte d'Ivoire)

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Abstract

The use of phytosanitary products remains uncontrolled and abusive in the practice of market gardening in most developing countries. However, it remains one of the potential sources of environmental contamination and public health problems. This study examines the health and environmental risks associated with the use of phytosanitary products in market gardening in the town of Abengourou in Cote d'Ivoire. Field surveys carried out among all (30) market gardener sites housed 150 farmers showed that when the products were spread, no health and safety measures were observed. Approximately 80% of the respondents did not wear gloves or face masks. Some products used were not approved for market gardening. Farmers had itching, dizziness, headaches, colds and vomiting on a regular basis when applying the products. The study also revealed the presence of empty packaging in the surrounding surface water and on the ground. In addition to producers, this type of uncontrolled market gardening likely exposes consumers to high health risks and also contributes to environmental degradation. Raising awareness among stakeholders of good agricultural practices could help promote sustainable market gardening. However, studies of the effects of products in such an environment on the health of consumers deserve to be carried out.

Keywords

Phytosanitary Practices, Market Gardening, Health and Environmental Risks,

1. Introduction

The growth of urban markets in sub-Saharan African countries has led to an expansion of agricultural practices in cities, with the uncontrolled use of phytosanitary products (pesticides) by market gardeners to increase their production [1]. Indeed, if peri-urban agriculture practices improve the living environment and play a positive role in the use of waste (Droppings) [2], the uncontrolled use of pesticides (*i.e.* insecticides, fungicides and herbicides) and various source of organic amendments lead to contamination of soils as well as surface and ground water, thus exposing populations to various pathologies [3] [4] [5] [6] [7].

Several studies carried out in the countries, including those by Cissé *et al.* [8] in Senegal, Kanda *et al.* [9] in Togo, Lawani *et al.* [10] in Benin, Tarnagda *et al.* [11] in Burkina Faso, Tchamadeu *et al.* [12] in Cameroon and Ado *et al.* [13] in Niger, noted very poor management of pesticides on market garden sites in urban areas of these countries. This concerns the reuse, burying and abandonment on sites of empty pesticide packaging as well as the poor storage of phytosanitary products which could constitute a threat to the biodiversity and productivity of natural ecosystems as well as to human health.

Proper pesticide use is crucial to farmers' health and environmental protection. Indeed, long-term pesticide exposure has been linked to the development of Parkinson's disease; asthma; depression and anxiety; attention deficit and hyperactivity disorder (ADHD); and cancer, etc. [14] [15]. Akter *et al.* [16] and Bertrand [17] noted several cases of toxicity symptoms among farmers in Bangladesh and Africa respectively, during the application of pesticides among which eye and skin irritation, nausea, vomiting, and headache were the most frequent symptoms.

In Côte d'Ivoire, the examination of phytosanitary practices by market gardeners and their impact on the sanitary quality of crops grown (carrots, lettuce, vegetables, onions, parsley, tomatoes, etc.) has been the subject of several studies in urban areas of certain regions. These are the regions of the south (Abidjan) [18] [19] [20], the center (Bouaké and Yamoussoukro) [21] [22] [23] and from the north (Korhogo) [24]. These investigations have shown that the phytosanitary products used were fungicides, insecticides and herbicides, generally acquired from non-approved resellers, most of which were not approved for market garden crops. In addition, most market gardeners did not observe any protective measures during phytosanitary treatments of crops. Thus, in order to understand the information relating to the use of phytosanitary products in urban market gardening, on a national scale, it appears necessary to extend these studies to other regions of the country. This would make it possible to develop policies to deal with this phenomenon.

This study aims to examine the practice of market gardening in the town of Abengourou (capital of the “Indénié-Djuablin” region), in eastern Côte d’Ivoire. Specifically, this involves: 1) determining the socio-demographic profile of market gardeners and the types of crops grown; 2) identifying the phytosanitary products used and waste management on market gardening sites; and 3) assess the environmental and health risks associated with the use of phytosanitary products in market gardening.

2. Materials and Methods

Data collection for this study was carried out on market gardening sites in the city of Abengourou and required the use of a survey sheet, addressed to market gardeners, of a Global Position Satellite (GPS) for geo locate the various sites and a digital camera to take pictures of the environment of the market gardening sites.

2.1. Study Area

The city of Abengourou is located in the administrative region of Indénié-Djuablin of which it is the capital and is located between $6^{\circ}43'47''\text{N}$ and $3^{\circ}29'47''\text{W}$. It covers an area of 5744 km². The city is located in the east of the country (**Figure 1**), precisely 210 km from Abidjan, on the Abidjan-Bondoukou axis. The climate

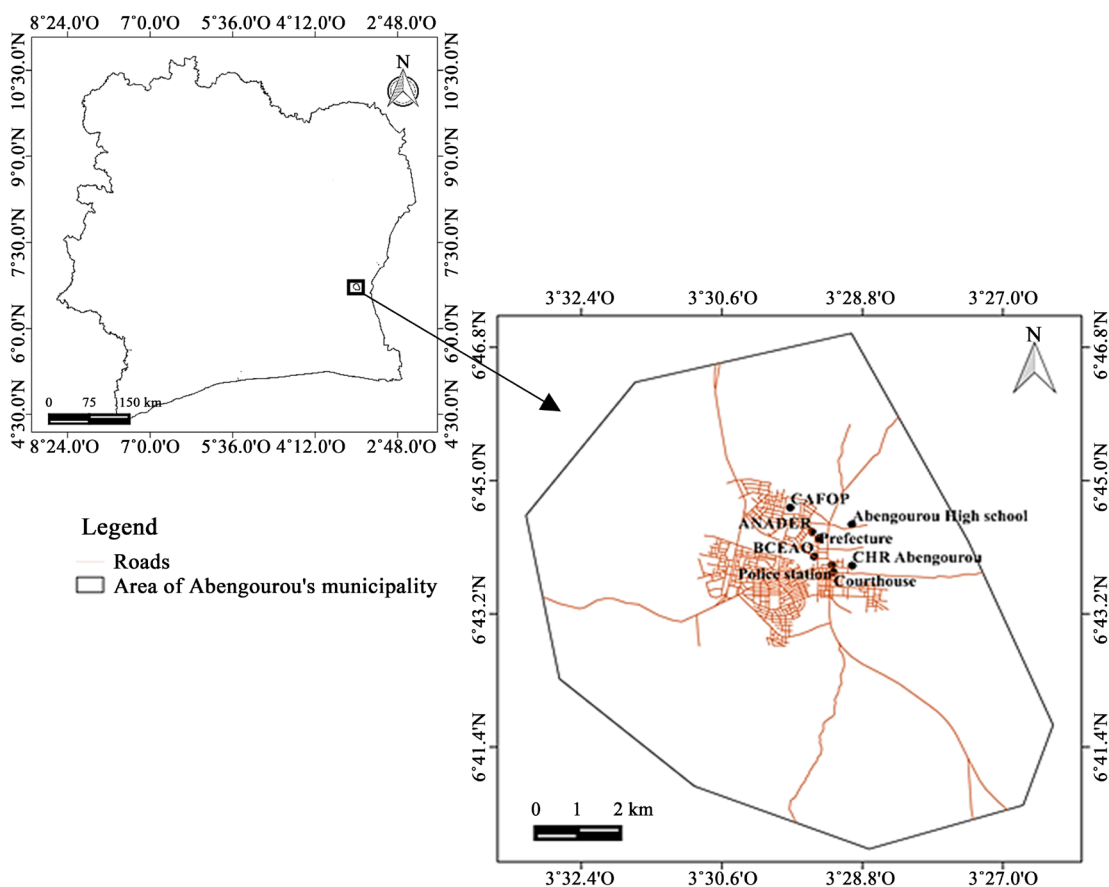


Figure 1. Location of the municipality of Abengourou.

of the region comprises four (4) seasons divided into a large rainy season extending from April to July, a small dry season from July to September, a small rainy season from September to November and a large and very marked dry season from December to March. In this equatorial transition regime, the annual precipitation levels vary from 1400 to 2500 mm [25]. The city of Abengourou has a total of four (04) main types of soil, in particular weakly ferrallitic soils in the North, moderately saturated soils in the South, weakly ferrallitic soils on granite and alluvial soils in the lowlands and swamps which remain favourable to the practice of market gardening [26].

2.2. Survey for Data Collection

The survey was carried out from August to September 2019, on all of the city's market gardening sites (30), located in the plateau district, in particular in the lowlands of the Pedagogical Project in the Centers of Animation and Educational Training (CAFOP) and that of the Central Bank of West African States (BCEAO) in the city of Abengourou (**Figure 2**). The lowland of CAFOP has an area of 16 hectares and that of BCEAO is 6 hectares. There are a variety of cultural practices there (cucumber, lettuce, onion, parsley, tomato, etc.).

The survey consisted of collecting information relating to the socio-demographic profile of farmers, market gardening practices, waste management and environmental and health risks related to the activities carried out. Knowledge relating to market gardening practices concerned the types of crops grown, the types of phytosanitary products used, the methods of using phytosanitary products and the means of protection used by farmers. A total of 150 farmers were identified across all the market gardening sites and interviewed as part of the survey. Field observations consisted of assessing the state of the lowland environment in order to illustrate the types of crops and the impacts of activities on

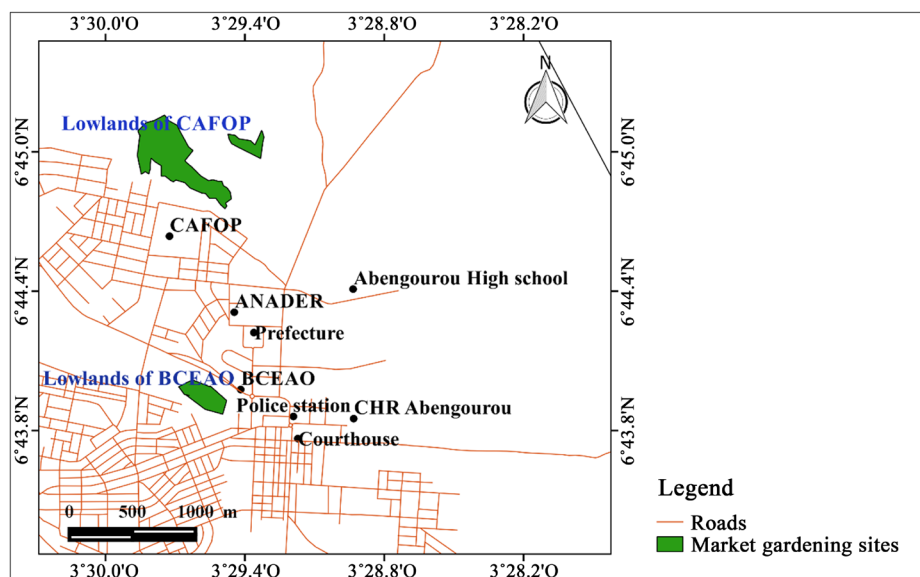


Figure 2. Location of market gardening sites in Abengourou.

the environment through the management of phytosanitary waste (plastic, packaging of products already used, jars, etc.).

2.3. Calcul and Statistics

The data collected from the questionnaire were codified and then grouped by variables (socio-demographic profile, market gardening practices, waste management and environmental and health risks). The frequency of each variable was calculated in relation to the number of market gardeners questioned according to relation (1):

$$F = \frac{X}{Y} \times 100 \quad (1)$$

where:

F : Frequency (%);

X : Number of the modality considered;

Y : Total workforce of the modality considered.

The arithmetic mean made it possible to estimate the mean value of the size of the plots, calculated from the relation (2):

$$\bar{X} = \frac{1}{n} \times \sum_{i=1}^n X_i \quad (2)$$

where;

\bar{X} : Average value of the size of plots;

n = Total number of market gardeners surveyed;

X_i = Plot size

3. Results and Discussion

3.1. Socio Demographic Characteristics of Market Gardeners

Amount the total of 30 market gardening sites housing 150 farmers encountered in the lowlands of the city of Abengourou, the workforce was made up of 53.3% women and 46.7% men (**Table 1**). This result is contrary to those of most similar

Table 1. Socio demographic characteristics of market gardeners.

Characteristics of market gardeners (Farmers)		Percentage (%)
Gender of farmers	Male	53.3
	Female	46.7
Female farmers	Wives of farmers	87.5
	Daughter heirs of farmers	12.5
Education level of farmers	Secondary school education	20
	Primary school education	13.3
	No formal education	66.7
Market gardening training	No training received	60
	Trained in market gardening	40

studies carried out in certain regions of Côte d'Ivoire [18] [20], Togo [27] [28], Burkina Faso [29] and Cameroon [12], who reported a low rate of involvement of women in market gardening. Indeed, in Abengourou, we noticed the presence of rice fields upstream of market gardening sites, the owners of which were mostly by men who were mostly husbands of women working on market gardening sites located downstream. In fact, the women met at all of the sites (80) were mainly (87.5%) wives of self-employed market gardeners and 12.5% of heiress daughters, as observed in **Table 1**.

Analysis of the education level of market gardeners showed that the schooling rate of market gardeners was low (**Table 1**). The rate of educated market gardeners was 33.3% against 66.7% of out-of-school. However, among that in school, 13.3% had limited primary school education and 20% had secondary education. This could be due to the cost of primary school enrolment at the time of the latter, unlike the free education nowadays, in the country. The result corroborates that of Kpan *et al.* [20] carried out in the municipality of Port-Bouët (Abidjan). Moreover, these authors believed that the lack of employment and the harsh selection forced non-graduates to practice market gardening in order to meet their needs. From local point of view, the low level of industrialization of the city of Abengourou will have reduced the chances of employability of the population whose level of study was mainly primary school. These results confirm with those of Banjo *et al.* [30], Congo [31], Diop [32] and Tarnadga *et al.* [11], performed in certain sub-Saharan African countries, in which, the farmers had no training in market gardening for the most part like those in the present study. Indeed, only 40% of farmers had received training before market gardening, against 60% (**Table 1**).

3.2. Market Gardening Practice

The average number of farmers in each market gardening site was 5 farmers. However, three (3) classes were distinguished (**Table 2**), in particular the market gardening plots which house 1 to 3 farmers, the most numerous (43.3%), then come the plots housing 3 to 5 farmers, the proportion of which was 33.3% of market gardening sites. Finally, those which housed more than 5 farmers represented 23.4%. We noted in the same table that market gardening activities have been practiced on most of the plots (88%) for more than 5 years. On the other hand, 12% of market garden sites are less than 5 years old.

The crops grown at the sites consist of eggplant, cucumber, lettuce, mint, onion, parsley and tomato. However, lettuce was grown on all plots. It is followed by onion, parsley and mint, which are practiced on 66.7%, 60% and 40% of sites, respectively. Eggplant remains the least practiced by market gardeners (16%). This production system characterized by a plurality of crops is similar to those observed by Kouakou *et al.* [18], Obuodi *et al.* [33], Fondio *et al.* [21], Tano *et al.* [22] and Kanda *et al.* [9]. The diversity of market garden species is attributed by these authors to short crop cycles, ranging from 30 to 45 days and to

the high demand for these crops by consumers. In fact, these are vegetable species necessary for a balanced diet, rich in nutrients (*i.e.* carotene, vitamin B and C, proteins, etc.) [34] [35]. This same observation has been made by several authors, notably Diao [2] in Senegal, Dongmo *et al.* [36] in Cameroon, Tallaki [37] in Togo and Kouakou *et al.* [18] in Côte d'Ivoire. **Figure 3** illustrates the most dominant crops (lettuce, onion, parsley, mint) on the market gardening sites visited.

3.3. Use of Phytosanitary Products in Market Gardening

Farmers use chemical fertilizers (NPK and urea fertilizers), organic fertilizers (poultry droppings) and phytosanitary products in their market gardening activities (**Figure 4**). The most widely used phytosanitary products consist of 45% herbicides followed by fungicides (30%) and insecticides (25%) (**Table 3**). According to Cissé *et al.* [8] and Kouakou *et al.* [18], market gardeners use these products to fight against hazards, ensure soil fertility, and protect crops against pests, rot and weeds. Indeed, the major constraints of vegetable production are linked to the attack of weeds and the proliferation of pest macro invertebrates, made favourable by the soil of the lowlands [38]. In addition, the lack of fallow

Table 2. Market gardening practice on the plots.

Market gardening sites	Percentage (%)
Number of farmers per market gardening plot	[1; 3[
	43.3
	[3; 5[
Types of crops grown	[5; plus[
	23.4
	Eggplant
	16.7
	Cucumber
	26.7
	Lettuce
Duration of cultivation practice	100
	Mint
	40
	Onion
	66.7
	Parsley
	60
	<5 years
	12
	>5 years
	88



Figure 3. View of the most cultivated crops in the study area. (a) Lettuce crop; (b) Onion crop; (c) Parsley crop; (d) Tomato crop.



Figure 4. View of the empty packaging of the products used in market gardening activities. (a) = Mancomax 80 WP; (b) = Mon jardinier 80 WP; (c) = Ivory 80 WP; (d) = Mancotop 800 WP; (e) = Padimax 432 EC; (f) = Cigogne 50 EC.

Table 3. Characteristics of phytosanitary products used by market gardeners.

Trade name	Active substances and concentration	Registration number	Recommended use	Targets
Cigogne 50 EC	Cyperméthrine: 50 g/L	04 0652 In	Vegetables and food crops	Insect pests
Cyplam 50 EC	Cyperméthrine: 50 g/L	00 0494 In	Vegetables, food crops and corn	
Décis 12,5 EC	Deltaméthrine: 12.5 g/L	90 0075 In	Avocado, citrus fruits, bananas, cocoa, coffee, vegetables and food crops	
K optimal 35 EC	Lambda-cyhalothrine: 15 g/L	09 0877 In	Vegetables and food crops	
Pyriforce 480 EC	Chlorpyrifos-ethyl: 480 g/L	97 0364 In	Pineapple and mango	
Dufeu 480 SL	Glyphosate (ammonium salt)	15 1675 He	All crops, fallows	Weeds
Glyphader 360 SL	Glyphosate: 360 g/L	98 0428 He	Fallow, plantation	
Lamachette 480 SL	Glyphosate: 360 g/L	13 1345 He	Fallow, plantation	
Surplace 480 SL	Glyphosate isopropylamine salt 410 g/L	16 1756 He	All crops, fallows	
Tasman 360 SL	Glyphosate: 360 g/L	09 0871 He	Fallow, plantation	
Topstar 400 SC	Oxadiargyl: 400 g/L	99 0451 He	Rice	Cryptogamic diseases
Tout brûlé 410 SL	Glyphosate isopropylamine salt: 410 g/L	14 1457 He	All crops, fallows	
Padimax 432 EC	Propanil: 360 g/l; Triclopyr: 72 g/L	10 0913 He	Rice	
Mancotop 800 WP	Mancozèbe: 800 g/kg	15 1626 Fo	Lettuce	
Zébra 800 WP	Mancozèbe: 800 g/kg	15 1706 Fo	Market gardeners	
Mon jardinier 80 WP	Mancozèbe: 800 g/kg	10 1455 Fo	Market gardeners	Cryptogamic diseases
Manco 80 WP	Mancozèbe: 80 g/kg	15 1704 Fo	Market gardeners	
Mancomax 80 WP	Mancozèbe: 800 g/kg	14 1464 Fo	Market gardeners	
Ivoir 80% WP	Mancozèbe: 800 g/L	01 0557 Fo	Vegetables and food crops	

in market gardening due to insufficient cultivable land contributes to further depleting these soils [38].

However, during the investigation, the use of non-approved products for market gardening was recorded. This is the case with agrochemicals such as Pyriforce 480 EC, Padimax 432 EC, Décis 12.5 EC and Topstar 400 SC (**Table 3**), registered for crops of pineapple, avocado, citrus, banana, mango and rice, but unfortunately used in market gardening in the city of Abengourou. This situation could be related to the costs, probably less expensive, of these agrochemical specialties. Doumbia and Kwadjo [19] and Kpan *et al.* [20] noted the use of approved products for growing cotton (*i.e.* Stater 350 EC, Calfos 720 EC, Curacron 500 EC and Polytrine 186 EC) by market gardeners in Abidjan and its suburbs (*eg.* Portbouët, Dabou and Anyama). Indeed, these products were sold at low prices thanks to a subsidy which benefited cotton farmers [19].

In addition, the use of phytosanitary products in high proportions of herbicides followed by fungicides and insecticides is similar in Côte d'Ivoire [20] [22] [38] and in the sub-region [8] [11] [32] [39]. According to Kouakou *et al.* [38], this situation could be explained by the major constraint of market gardening sites due to the strong pressure from adventitious plants and pest parasites.

3.4. Waste Management on Market Gardening Sites

The waste encountered on market gardening sites consists of empty packaging of phytosanitary products (*i.e.* cans and sachets), ordinary sachets used to transport the products, leftover poultry droppings used as fertilizer and used working equipment [*i.e.* watering cans, cans, sprayers, etc.] (**Figure 5**). This waste was dominated by empty packaging of (97%) at the various sites. The remains of droppings, used working equipment and ordinary sachets are very little encountered at the respective proportions of 1.5%, 1% and 0.5% (**Table 4**). These wastes were mostly abandoned by the majority of market gardeners (60%) on the sites, both on land and in the water points used for watering crops. Waste management on the sites can be attributed to the low level of education of market gardeners, who do not generally consult the labels of product packaging [8] [40]. Similar results were obtained by Son *et al.* [41] in Burkina, where the identified waste believed to be the source of soil and water contamination of the study sites.

3.5. Health Impact

All market gardeners interviewed were aware of the risks associated with the use of phytosanitary products, both for their health and for the environment. However, 80% of market gardeners did not protect themselves during phytosanitary treatments and only washed their hands (87.5%) after treating the plots (**Table 4**). Akter *et al.* [16] attribute this to the low educational level, the lack of knowledge, insufficient training and the pursuit of high profits of market gardeners. This would justify the pathologies (*i.e.* headaches, body itching, colds, vomiting



Figure 5. View of the waste encountered on the market gardening sites. (a) = Damaged sprayer; (b) = Damaged watering cans; (c) = Manure; (d) = Empty packaging in water; (e); (f) = Empty packaging of sachet and canister products on land.

Table 4. Waste production and management on market gardening sites and safety measures.

Waste on market gardening sites		Percentage (%)
Types of waste produced per market gardening sites	Empty packaging of phytosanitary products	97
	Ordinary sachets	1
	Poultry droppings	1.5
	Worn work equipment	0.5
Disposal of waste on market gardening sites	Landfill of packaging on site	40
	Abandonment on site	60
Health and safety measures	No use of protective equipment	80
	Gloves	6.7
	Face masks	13.3
Behavior after application of phytosanitary products	Hands only washed	87.5
	Body entirely washed	12.5

and dizziness) manifested by market gardeners on the various sites [42]. In fact, 93.3% of them indicated having suffered or still suffered from headaches, 90% from body itching. Then come colds, vomiting and dizziness, manifested respectively in 83.3%, 80% and 76.7% of market gardeners (Figure 6). These same pathologies have been reported by Doumbia and Kwadjo [19], Banjo *et al.* [30], Ngom *et al.* [39], Congo [31], Diop [32] and Kpan *et al.* [20], on market garden sites.

4. Conclusion

The agricultural practices observed by market gardeners in Abengourou city did

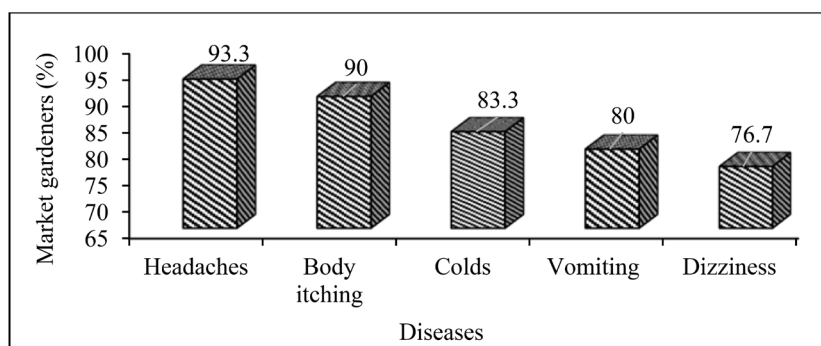


Figure 6. Diseases commonly contracted by the market gardeners on plots.

not comply with good phytosanitary practices. Some of the phytosanitary products used were not suitable for market gardening. Farmers ensured the production of food at the cost of their health because they applied phytosanitary products without proper protection. All the practices observed led to improper management of empty pesticide packaging on production sites. Indeed, this can lead to the risk of diseases identified in market gardeners and also pollute the surrounding ecosystem. To remedy this situation, support measures such as financing funds, training and monitoring must be applied to stakeholders in order to promote sustainable market gardening that takes into account the health of stakeholders and the environmental protection in the city of Abengourou. In addition, studies related to the quality of cultivated soils, surrounding surface water and that of products obtained from market gardening crops would further contribute to much better protection of the environment and the health of the populations.

Conflicts of Interest

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

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