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Supplying Accra with Market Garden Vegetables: An Eco-Sanitary and Socio-Economic Assessment of the Knowledge, Attitudes and Practices of Producers, Traders and Processors

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Abstract

Like other cities in West Africa, Accra's market garden sector faces a number of sustainability challenges. However, the sector's sustainability projects focus less on the knowledge, attitudes and practices (KAP) of the stakeholders in this food system, and more on the other factors that can enhance its socio-economic, health and ecological sustainability. Thus, the research aims to assess the level of health, socio-economic and environmental sustainability of market garden vegetable production, trade and processing in the Accra metropolitan district, based on the knowledge, attitudes and practices of stakeholders. A quantitative multi-criteria evaluation approach was adopted, using a questionnaire survey targeting 156 respondents (50 producers, 63 traders and 43 processors) selected by purposive sampling. The data collected by Kobocollect were processed using Excel, Arcgis and Google Earth. Average scores and good KAP rates were calculated for all players taken together, and particularly in consideration of the key dimensions of sustainable development. The results reveal low rates for ecological (28.24%), health (20.15%), socio-economic (36.15%), technological and innovative (14.25%) knowledge, attitudes and practices, evaluated overall at 26.87%. These results are unfavorable to the achievement of the SDGs, and do not meet either standard 13 of the Global Reporting Initiative (GRI) 2023, or the principles of nutritional ecology. Hence the importance of an integrated, long-term eco-nutritional education program for all stakeholders.

Keywords: *Vegetable Supply Chain, Eco-Nutritional Culture, Sustainability, Agri-Food Systems, Cities.*

Introduction

From primitive to modern societies, urban food production, distribution, processing and consumption have undergone major changes. These changes in urban agrifood systems affect countries in both the North and the Global South(B. Delpeuch and F. Maire, 2004, p. 23-24; B. Hérault and al., 2019; D.J. Hoffman and H. Posluszny, 2023; E. Nyangwile and al., 2022, p. 5-8; B.M. Popkin and al., 2020). These include the preference for intensive production over organic farming, the diversity and plurality of the food supply, the primacy of out-of-home catering over home-made food, the greater distribution and consumption of foods containing high levels of sugars and saturated fatty acids, the rising prevalence of chronic food-borne pathologies, health and climate shocks, and the resulting fear of eating (A. Alengebawy and al., 2021; E.G. Anaduaka and al., 2023; P. Cozma and al., 2017; K. Kpotchou, 2017, 2018a, 2018b; T. Reardon and al., 2021, p. 6; A.-S. Roy and al., 2023). These agri-food changes, which do not exclude Accra's vegetable supply chain, are accompanied by socio-economic, environmental and health problems.

In Ghana's capital, market gardeners generally fail to comply with existing sanitary, hygiene and ecosystem preservation measures. (S. Achio and al., 2015; P. Antwi-Agyei and al., 2016; G. Owusu-Boateng and K.K. Amuzu, 2013; J. Quansah and al., 2020; J.K. Quansah, 2018; I. Yeboah, 2014b). What's more, they have no mastery of the safe use of fertilizers, pesticides and herbicides. (A.W. Arimiyaw and al., 2021; A.W. Arimiyaw and al., 2020; G.K. Danso and al., 2014; E. Obuobie and al., 2006; G. Owusu-Boateng and K.K. Amuzu, 2013; I. Yeboah, 2014b). In this city's food distribution markets, the vegetables on sale are often displayed or stored in environments that are not safe from rodents, dust, humidity, radioactive substances and parasites carrying bacteria and pathogenic germs.(K. Abass and al., 2019, p. 6-9; C. Cătălina and C. Elena, 2019, p. 142-143). Even the effectiveness of treatments carried out on these products by processors

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(restaurateurs or home cooks) to rid them of any toxic products or contamination by parasites or germs before cooking is dubious (K. Abass and al., 2019, p. 7; F. Akabanda and al., 2017, p. 6; P. Antwi-Agyei and al., 2016). The preparation times and sanitary conditions under which food is cooked can reduce its nutritional quality and/or expose the eater to health insecurity (F. Akabanda and al., 2017; C. Cătălina and C. Elena, 2019, p. 142; A. George Amponsah and B. Ekua Anamoaba, 2011; S. Marras and al., 2016; P. Mensah and al., 2002; S. Nanema and al., 2022; S.T. Odonkor and al., 2011; B. Osei-Tutu, 2018).

Faced with the food, health, hygiene and environmental challenges and risks affecting Accra's vegetable sector, the Accra Metropolitan Assembly, in the absence of a metropolitan policy on the resilience of its food systems, relies on Ghana's national food and nutrition security policies, programs and projects (P. Caron and al., 2018, p. 4-6; P.-F.E. Group, 2021; P. Stacey and al., 2021; C. Tuholske and al., 2018; C. Tuholske and al., 2020b). These programs and projects are essentially based on the country's Food and Agricultural Sector Development Policy (FASDEP). They are in line with the vision of the second Sustainable Development Goal (SDG) of the United Nations' 2030 Agenda. The same applies to Pillar 3 of the ECOWAS Vision 2050, and to the second point of the first aspiration of the African Union's Vision 2063. Indeed, the Accra Metropolitan Assembly adopted a specific implementing regulation for Ghana's food safety and hygiene policy on April 19, 2017. This regulation takes into account environmental protection, nutrition, hygiene and the general well-being of producers and consumers, but its application remains difficult (V. Linderhof and al., 2019, p. 2). Moreover, in Ghana's largest city, food systems capacity-building actions have focused more on modernizing agriculture to increase Accra's productive capacity through the popularization of modern production techniques accessible to producers of all categories, as well as the optimal reduction of food loss and waste along the city's supply chains (AMA, 2020, p. 25). To this end, a common vision of what Accra's food system should look like in 2050 has been defined, along with transition paths(V. Linderhof and al., 2023, p. 29-30). These transition paths are generally centered on the establishment of food practices and lifestyles underpinned by endogenous know-how, and the production, processing and green consumption of foodstuffs that are permanently available and accessible to all (V. Linderhof and al., 2023, p. 24-29). An Accra Resilience Strategy was even launched by the city's Metropolitan Assembly on March 29, 2019 to. Nevertheless, these solutions developed for Accra's food and nutrition security do not seem to consider nutrition and urban ecological education as a priority; these frameworks for action seem to be limited to issues relating to gender parity, social protection, increasing small producers' incomes and their technical production capacities (L. Hope and al., 2009; V. Linderhof and al., 2019, p. 2; PAM, 2018, p. 19).

As with policies, programs and projects globally aimed at improving the sustainability of Ghana's food systems, existing research on Accra's vegetable value chain has been more limited to issues related to vegetable productivity, availability and diversity (K. Abass and al., 2019; A. Abu Hatab and al., 2019; F. Akabanda and al., 2017). They also focused on the socio-economic living conditions of producers, their challenges in relation to phytosanitary product use practices (pesticides, fertilizers, herbicides and fungicides) in market gardening, the hygienic, sanitary and environmental challenges facing vegetable horticulture in Accra (R.A. Ayambire and al., 2019; G. Owusu-Boateng and K.K. Amuzu, 2013). Even Accra's 2023 annual action plan focuses only on restaurateurs in the city's food supply chain (AMA, 2022, p. 7). The few studies assessing the effects of levels of agri-food knowledge, attitudes and practices on food safety and hygiene in Accra have been more restricted to the processing stage, without placing greater emphasis on producers and traders. The topics most discussed were the determinants of food market choices and restaurant owners' cooking practices as measured by their knowledge, attitudes and practices on food safety, hygiene and health (F. Akabanda and al., 2017; M.I. Dzudzor and N. Gerber, 2023; A. George Amponsah and B. Ekua Anamoaba, 2011; O.A. Odeyemi and al., 2019). Socio-economic and environmental aspects have only been partially addressed. These observations show that, as in most West African countries, the fight against food and nutritional insecurity for the sustainability of the Accra market garden sector is being steered in a direction that does not prioritize the evaluation of the knowledge, attitudes and agrifood practices of all the key players involved. The same holds true for the development and implementation of urban food policies and strategies. However, an eco-nutritional awareness supported by all players in the food supply chain, and based on behavior-change communications, can have a lasting influence on the norms, values, perceptions, knowledge and risk beliefs associated with the food supply. It

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can also help to change choices, preferences and agri-food practices in the market gardening sector, especially if it is carried out in cities, taking into account the socio-cultural, economic and natural environment realities of each locality (S. Dury and al., 2019, p. 15, 17). Under these conditions, particular attention must be paid to the level of eco-nutritional culture of the actors in Accra's vegetable value chain with regard to its socio-economic, health and environmental sustainability for the development of adequate urban agri-food sustainability policies.

These observations raise the following question: what are the levels of knowledge, perceptions and practices of Accra's vegetable producers, traders and processors with regard to the socio-economic, health and environmental well-being of their activities? Based on existing research data and empirical research exploration, the following hypothesis is formulated: Accra's vegetable supply actors have low levels of knowledge and low rates of good practice in relation to the possible effects of their activities on socio-economic life, health and the preservation of the natural ecosystems that support them. Accordingly, this study aims to assess the level of health, socio-economic and environmental sustainability of market garden vegetable production, marketing and processing, based on the principles of nutritional ecology, the Sustainable Development Goals and Standard 13 of the Global Reporting Initiative 2023 for the agriculture, aquaculture and fisheries sector.

Nutritional ecology is an interdisciplinary scientific approach that studies the sustainability of food systems through their structures, interdependencies and dynamics in relation to their effects (the activities and practices of actors in food supply and value chains) in four dimensions: nutritional health, social life, the economic situation and the natural environment of the actors who interact internally or externally. (C. Leitzmann, 2003; K. Schneider and I. Hoffmann, 2011, p. 1-2).

Materials And Methods

Physical Scope of Research

The assessment of knowledge, attitudes and practices relating to the socio-economic, health and environmental sustainability of Accra's market gardening sector has the Accra Metropolitan Assembly as its target population. (AMA). It is the urban center of the Greater Accra Region of Ghana, the country's capital. It covers an area of 139, 674 km² (GSS, 2014, p. 1) and concentrates Ghana's key administrative, political and economic functions (R.A. Acheampong, 2021, p. 5; GSS, 2014, p. 3-4). The Accra Metropolitan Area (AMA) is bordered to the north by the Ga West Municipal, to the west by the Ga South Municipal, to the south by the Gulf of Guinea and to the east by the La Dadekotopon Municipal. The AMA is made up of 12 districts, presented in the following table with their areas and numbers of inhabitants, according to data from the 2021 Ghana Population and Housing Census (GSS, 2021, p. 80).

Table 1: Districts Making Up the Accra Metropolitan Assembly

Districts	Area (sq. km)	Total number of inhabitants		
		Total	Male	Female
Ablekuma North Municipal	11	159 208	76 782	82 426
Ablekuma West Municipal	10	153 490	73 879	79 611
Ablekuma Central Municipal	9	169 145	82 594	86 551
Ablekuma South (Accra metropolitan)	6	110 158	51 882	58 276
Ashiedu Keteke (Accra metropolitan)	4	88 633	40 423	48 210
Okaikoi South (Accra metropolitan)	11	85 333	41 740	43 593
Korle Klottey	10	68 633	33 108	35 525
Ayawaso Central Municipal	6	94 831	46 488	48 343

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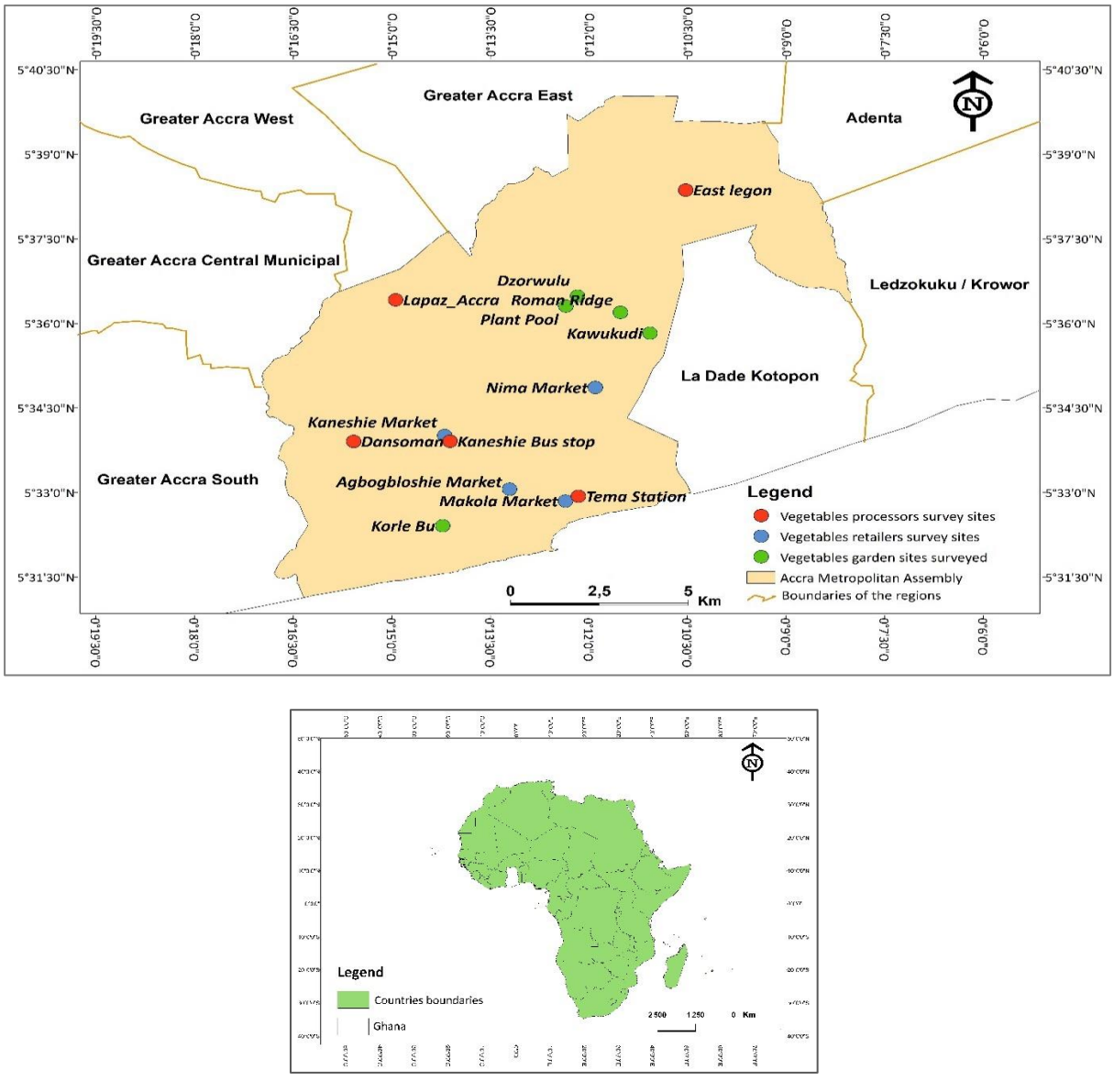
Ayawaso East	3	53 004	25 438	27 566
Ayawaso North Municipal	2	63 386	30 043	33 343
Ayawaso west municipal	31	75 303	38 614	36 689
Okaikoi North	19	160 446	78 421	82 025
Totals	122	1 281 570	619 412	662 158

Source: Ghana Statistical Services (GSS, 2021, p. 80)

Map 1: Data Collection Sites for Vegetable Growers, Traders and Processors in Accra Metropolitan Assembly



Source: K. E. Assinou and K. Kpotchou, 2024

Research Methods, Techniques, Tools and Indicators

The Multicriteria approach was used to assess the sustainability of vegetable production, marketing and processing in Accra. This methodological choice is explained by the multidimensional aspect of the sustainability of agri-food chains (C.C. Esnouf and al., 2011, p. 179-180).To this end, several dimensions

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and principles were identified to assess the sustainability of Accra's vegetable value chain based on the following standards and documents: the consolidated set of Global Reporting Initiative 2023 standards (GRI, 2023); the 2014 SA8000 standard (SAI, 2014); the 2010 ISO26000 standard (AFNOR, 2010); the Indicateurs de Durabilité des Exploitations Agricoles (IDEA4) method (F. Zahm and al., 2023); "The top 100 questions of importance to the future of global agriculture" (J. Pretty and al., 2010); "Cadre d'évaluation de la durabilité adapté à la réalité des secteurs/filières bioalimentaires québécois" (L. Tamini and al., 2020).

The table below provides information on the sustainability dimensions, principles and indicators used, as well as the standards that inspired them.

Table 2: Information On the Choice of Sustainability Indicators Used for The Assessment

Durability dimensions	Guidelines	Standards	Indicators
Socio-economy	Social responsibility: job quality, employer-employee relations, child labor, social life	ISO26000 : 2010	Corporate membership rates (1)
		GRI IDEA4	Treatment of employees in the market gardening sector (2)
		ISO26000 : 2010 IDEA4	Level of consideration for health and well-being and improvement of living conditions for employees (3)
		IDEA4 GRI	Trends in perceptions of the needs adequately met by income from vegetable production, trade or processing (4)
			Trends in perceptions of needs that cannot be adequately met by income from vegetable production, trade or processing (5)
			Trends in perceptions of the needs that income from vegetable production, trade or processing can help to satisfy to some extent (6)
		GRI ISO26000 : 2010	Rate of stakeholders' resilience or survival strategies (7)
			Levels of knowledge about the economic, environmental and social aspects that can be directly influenced by the production, sale and processing of vegetables (8)
			Levels of knowledge about the different dimensions of sustainability that the production, trade and processing of market garden produce may indirectly affect (9)
			Market gardeners', traders' and processors' level of knowledge of the social needs that the production, distribution and processing of market garden vegetables can help to meet (10)
Health of producers, retailers, processors and consumers	Social responsibility: health hazards		Producers', traders' and processors' knowledge of the diseases that can be caused by poorly controlled use of fertilizers and pesticides. (11)
			Market gardeners' level of knowledge about the effects of overdosage of herbicides, pesticides and fungicides on consumer health (12)
			Levels of knowledge about the possible effects of the water used by the players on consumer health (13)

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			Farmers' willingness to use crop protection products that are less harmful to their health and that of consumers (14)
			Water sources used by vegetable supply chain actors (15)
			Levels of good water treatment practices used by stakeholders in the market garden produce supply chain (16)
		CIRANO (2020) GRI IDEA4	Tendency to take sanitary and self-protection measures in the production, sale or processing of market garden vegetables. (17)
		GRI ISO26000 : 2010 CIRANO (2020)	Trends in the preservation of cooked and raw vegetables by processors, retailers and growers (18)
			Trend in urban farmers' awareness of the risks of using plant protection products in inappropriate conditions (19)
			Extent to which retailers and processors are aware of the possible health effects of their vegetable processing methods on consumer health (20)
Food protection and preservation at the production, processing and marketing stages	Social responsibility	GRI CIRANO (2020) ISO26000 : 2010	Market gardeners' knowledge of the effects of overdosing with herbicides, pesticides and fungicides on crop quality (21)
			Knowledge of the possible effects of the water used by players on the quality of food produced, sold or processed (22)
			Frequency of safety checks on raw and cooked vegetables by retailers and processors (23)
			Trends in the protection of vegetables against contamination and biochemical pollution at the level of each actor during transportation, storage, preparation, display or presentation of vegetables (24)
Environmental pollution	Environmental responsibility	GRI CIRANO (2020) ISO26000 : 2010	Market gardeners' knowledge of the effects of overdosing herbicides, pesticides and fungicides on soil (25)
			Market gardeners' knowledge of the effects of intensive ploughing and weeding on soil quality (26)
			Market gardeners' level of knowledge about the effects of overdosing herbicides and fungicides on water, atmosphere and climate (27)
			Propensity of Accra's urban farmers to use less polluting but more productive plant protection products than fertilizers (28)
Loss and waste	Social responsibility: food usage	IDEA4 CIRANO (2020) GRI ISO26000 : 2010	Vegetable loss levels (29)
			Levels of vegetable waste (30)
Technology and innovations	Environmental responsibility		Digitization and mechanization scope (31)
			Application usage trend (32)
			Social networking propensity (33)

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Governance: technical and financial support, etc.	Social responsibility: public and CSO support		Public support or support from civil society organizations (34)

Sources: K. E. Assinou and K. Kpotchou, 2024

A quantitative analysis method was adopted through the use of a questionnaire survey materialized by three semi-structured questionnaires. The questionnaires were administered to growers, traders and processors of market garden vegetables. In addition to the questionnaire survey, non-participatory direct observation was used through mobile photography, particularly at market garden sites and markets targeted by the research. The Global Positioning System (GPS) was also deployed to capture and geographically represent the various survey sites.

Sampling

Stakeholders in the Accra Metropolitan Assembly vegetable supply chain form the target population for the research, located in Ghana's capital, the Greater Accra region. The population targeted was vegetable growers, traders and processors aged 18 and over, living in Accra for at least one year prior to data collection.

Over 50% of respondents had at least five years' experience in their respective businesses. But those with less than one year's experience are estimated at around 3%. In addition, respondents are interviewed according to whether or not they are self-employed or employ people to assist them in their respective jobs, in order to increase the chances of obtaining information relevant to the research objectives.

Producers are men or women from the target population who, through cultivation processes, produce edible vegetables to be sold to a customer (trader, processor or final consumer) on the growing area, a market or any other place that can host this type of economic exchange.

Traders are men or women from the target population, wholesalers, semi-wholesalers or retailers, who buy and resell vegetables produced by market gardeners, either near the latter, or near a wholesaler or semi-wholesaler.

Processors are the men or women in the target population who transform market garden vegetables into dishes for sale to the final consumer, either as raw vegetables ("salads with vegetables"), or as sauces to be served as accompaniments to cereal, tuber, legume or other dishes. Nevertheless, given that they work in the informal sector and that there is no database from which to select them by probability sampling, purposive sampling was adopted along the lines of V.S. Kwol and al. (2020, p. 2-3) and E. Babbie (2008, p. 203). It is in this sense that J. Curwin and al. (2013, p. 116) confirm that judgmental sampling is not based on chance, but on the researcher's ability to select his or her respondents on the basis of a logic conducive to building a valid sample. E.R. Babbie (2016, p. 187) confirms this assertion, arguing that it is sometimes preferable for the researcher to base his choice of sample on knowledge of the target population and its components, as well as on the objectives of his analysis.

One hundred and fifty-six (156) respondents were interviewed on the assumption of a normal distribution of the data collected. Thus, referring to L. Kish (1965), it is considered that the distribution of attributes lies between 20% and 80%, which gives the possibility of choosing a sample of between thirty (30) and two hundred (200) elements. In addition, this sample is made up of subgroups: fifty (50) market gardeners, sixty-three (63) traders in vegetables from the Accra market garden and forty-three (43) women who process vegetables into dishes (salads or vegetable sauces). The size of these sub-groups is defined according to S. Sudman (1976) assertion, taken up by D.I. Glenn (1992) concerning the comparative analysis of subgroups : the author has shown that in a comparative situation, 20 to 50 observations per subgroup are sufficient to extend the results to the total population.

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The snowball technique was also used to reach respondents, particularly market gardeners who cannot be found on market garden sites at any time of day.

Data Collection

The Kobokollect v2023.2.4 application was installed and used for data collection via tablets.

A team of seven (7) enumerators, supported by two controllers including the researcher was instructed in the objectives of the research, the constitution of the sample, the structure of the three questionnaires designed and the use of the Kobokollect v2023.2.4 application. This activity enabled the interviewers to familiarize themselves with all the sites, people, activities and objects targeted by the research. In order to facilitate data collection in the field, an initial visit to the survey sites was carried out for the three categories of respondents; this took place from May 15 to 20, 2023 with the entire data collection team. This first field visit in the data collection process was preceded by an exploration of the market garden sites and other sites using the Google earth Pro application, version 7.3.6.9345 and digital documentation. Then, the pre-survey was carried out to enable the interviewers to become more familiar with the forms, especially as regards their administration in "Twi", "Ewe" or English. In addition to the authorization received from the heads of the market gardeners' associations before the start of each interview, the consent of potential respondents was a prerequisite for the start of any discussion. They were guaranteed confidentiality and the right to stop if the questions did not suit them. The administration of each questionnaire lasted between twenty (20) and thirty (30) minutes.

Five (5) vegetable production sites were selected (Djorwulu, Kawukudi, Korle Bu, Plant Pool, Roman Ridge). During the field visit, initial contacts were made with the market gardeners. This was an opportunity to introduce them to the interviewers, explain the aim of the research and obtain their agreement to the interviews, any photo-taking and to find out the days and times when they would be available. These market-gardening sites were chosen because they are key market-gardening production areas in the center of metropolitan Accra. They play a significant role in the city's economy, food supply and nutrition, and provide a minimum income for market gardeners (S. Assibey-Yeboah and I. Koomen, 2019; R.K. Bannor and al., 2022).

Traders answered the interviewers' questions in four (4) markets: Agbogbloshie market, Makola market, Kaneshie market, Nima market. Internet browsing was used to identify the markets in advance, before the list was finalized after some fifteen exploratory interviews with pre-survey market gardeners from whom they obtain their supplies.

The vegetable processors interviewed were street vendors who agreed to be interviewed by the data collection team in four (4) localities: Lapaz, Kaneshie Bus stop, Tema station, East Legon. At this level, restaurant and hotel processors were excluded from the sample, as their knowledge, attitudes and hygiene practices were taken into account in the research (F. Akabanda and al., 2017; J. Azanaw and al., 2019). What's more, their food is less available to a large majority of the population than that of the street food restaurants that sell food to a large number of Accra's population on a daily basis, due to the evolution of eating out in the cities. (R.K. Bannor and J. Amponsah, 2023; S.E. Hiamey and G.A. Hiamey, 2018; S. Stevano and al., 2020; C. Tuholske and al., 2020a). These areas are part of Accra's business centers, which during working hours and days concentrate a large number of men and women with heterogeneous socio-demographic characteristics. (B. Doe and al., 2022, p. 7; E. Gaisie and al., 2019).

The vegetables taken into account by the research are defined by the FAO (F. Beed and al., 2021, p. 2; FAO, 2021, p. 5) as "...the edible parts of plants cultivated or harvested in the wild, found in their raw state or in a minimally processed form". Based on this definition, the following table shows the categories of vegetables targeted and excluded by the research.

Table 3: Categories Of Vegetables Targeted by The Research

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Targeted vegetable categories	Examples	Excluded vegetable categories	Examples
Fruit vegetables	Tomatoes, chillies, peppers, eggplants, cucumbers, zucchinis, etc.	Starchy roots and tubers	Cassava, potato, sweet potato, yam, etc.
Leafy vegetables	Vegetable coretes, cabbage lettuce, spinach, etc.	Pulses or dried vegetables	Dry beans, soybeans, chickpeas, split peas, lentils, etc.
Bulbous vegetables	Garlic, spring onions, shallots, leeks, etc.	Cereals	Corn, rice, millet, sorghum, fonio, etc.
Root vegetables	Carrots, beet, etc.	Medicinal plants	
Stalk vegetables	Celery, fennel, kohlrabi, pear, asparagus, rhubarb, etc.	Processed and ultra-processed vegetable products	Fruit juices, Ketchup, etc.
Blossom and budding vegetables	Cauliflower, broccoli, artichokes, etc.	Stimulating agents	Tea, coffee, cocoa, etc.

Data Processing And Analysis

The data collected was imported from the Kobotoolbox platform and processed in Microsoft Office Excel 2019 spreadsheet software for the three respondent categories. GPS data were processed in Google Earth Pro software, version 7.3.6.9345, to create landmarks corresponding to the research sites for each respondent category. The landmarks created were then exported to arcGIS Destop 10.8.2 to obtain point layers and place them on maps of the administrative contours of Ghana, the Greater Accra region and the Accra metropolis.

The data was processed in accordance with the sustainability indicators, divided into socio-economic, health, environmental, technological, innovative and governance dimensions of the sector.Pour le calcul des données, le tableur Excel a été utilisé.

With regard to the questions corresponding to the targeted indicators, following the example of (M.N. Islam and al., 2023) and (N.A. Moreb and al., 2017), each knowledge, attitude or correct practice selected by a respondent is scored at one (1) point. But the score is zero (0) for incorrect knowledge, attitudes and practices. Percentages of correct answers were calculated for all variable modalities, as the questions were essentially multiple-choice. The "passing score" or "acceptable sustainability score" corresponds to fifty percent (50%) or more correct answers for each variable modality, variable and indicator. Furthermore, for the verification of sustainability in terms of its dimensions considered by scale, it is qualified as good if the rate of correct responses is greater than or equal to seventy (70) percent. Sustainability is fairly good if this rate is between fifty-one (50) and sixty-nine (69) percent; it is poor if the rate of correct answers is below fifty (50) percent. In the results data tables, the percentage cells calculated for correct answers are colored red if their value is less than fifty (50) percent; they are yellow if the proportions are between fifty-one (50) and sixty-nine (69) percent. These cells are colored green if the values are greater than or equal to seventy (70) percent.

Regardless of knowledge, attitudes and practices, the arithmetic averages of the percentages of correct responses in relation to the various aspects of sustainability (socio-economics, health of stakeholders, food protection and conservation, environmental pollution, losses and wastage, technologies and innovations, governance) mentioned in Table 2 were calculated for each variable from the values of the variable modalities, for each category of stakeholder and for all stakeholders according to the following formulae:

General Formulae

$$\bar{x} = \bar{x}_{pct} = \sum x / n = \bar{x}_p + \bar{x}_c + \bar{x}_t / 3$$

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$\bar{x}_{pct} = \bar{x}_{pct1} + \bar{x}_{pct2} + \bar{x}_{pct3} + \bar{x}_{pct4} + \bar{x}_{pct5} + \bar{x}_{pct6} + \bar{x}_{pct7} + \bar{x}_{pct8} / 8$

Other Formulas

$\bar{x}_{p} = \bar{x}_{p1} + \bar{x}_{p2} + \bar{x}_{p3} + \bar{x}_{p4} + \bar{x}_{p5} + \bar{x}_{p6} + \bar{x}_{p7} + \bar{x}_{p8} / 8$

$\bar{x}_{c} = \bar{x}_{c1} + \bar{x}_{c2} + \bar{x}_{c3} + \bar{x}_{c4} + \bar{x}_{c5} + \bar{x}_{c6} + \bar{x}_{c7} + \bar{x}_{c8} / 8$

$\bar{x}_{t} = \bar{x}_{t1} + \bar{x}_{t2} + \bar{x}_{t3} + \bar{x}_{t4} + \bar{x}_{t5} + \bar{x}_{t6} + \bar{x}_{t7} + \bar{x}_{t8} / 8$

$\bar{x}_{pct1} = \bar{x}_{p1} + \bar{x}_{c1} + \bar{x}_{t1} / 3$

$\bar{x}_{pct2} = \bar{x}_{p2} + \bar{x}_{c2} + \bar{x}_{t2} / 3$

$\bar{x}_{pct3} = \bar{x}_{p3} + \bar{x}_{c3} + \bar{x}_{t3} / 3$

$\bar{x}_{pct4} = \bar{x}_{p4} + \bar{x}_{c4} + \bar{x}_{t4} / 3$

$\bar{x}_{pct5} = \bar{x}_{p5} + \bar{x}_{c5} + \bar{x}_{t5} / 3$

$\bar{x}_{pct6} = \bar{x}_{p6} + \bar{x}_{c6} + \bar{x}_{t6} / 3$

$\bar{x}_{pct7} = \bar{x}_{p7} + \bar{x}_{c7} + \bar{x}_{t7} / 3$

$\bar{x}_{pct8} = \bar{x}_{p8} + \bar{x}_{c8} + \bar{x}_{t8} / 3$

$\bar{x}p1$, $\bar{x}p2$, $\bar{x}p3$, $\bar{x}p4$, $\bar{x}p5$, $\bar{x}p6$, $\bar{x}p7$, $\bar{x}p8$, $\bar{x}c1$, $\bar{x}c2$, $\bar{x}c3$, $\bar{x}c4$, $\bar{x}c5$, $\bar{x}c6$, $\bar{x}c7$, $\bar{x}c8$, $\bar{x}t1$, $\bar{x}t2$, $\bar{x}t3$, $\bar{x}t4$, $\bar{x}t5$, $\bar{x}t6$, $\bar{x}t7$ and $\bar{x}t8$ are also calculated using the same formula : $\bar{x} = \sum x / n$.

$\bar{x}$ or $\bar{x}_{pct}$ corresponds to the overall average of the proportions of sustainable knowledge, attitudes and practices of producers, traders and processors in the Accra market garden supply chain from socio-economic, environmental, health, technological and governance points of view;

$\sum x$ represents the sum of the different values averaged;

n, is the number of values averaged;

$\bar{x}_{p}$, $\bar{x}_{c}$ and $\bar{x}_{t}$ are the averages of the proportions of socio-economic, environmental, health, technological and participatory governance knowledge, attitudes and practices (KAPs) considered for vegetable growers, traders and Vegetable Processors respectively;

$\bar{x}_{p1}$, $\bar{x}_{p2}$, $\bar{x}_{p3}$, $\bar{x}_{p4}$, $\bar{x}_{p5}$, $\bar{x}_{p6}$, $\bar{x}_{p7}$, $\bar{x}_{p8}$, $\bar{x}_{c1}$, $\bar{x}_{c2}$, $\bar{x}_{c3}$, $\bar{x}_{c4}$, $\bar{x}_{c5}$, $\bar{x}_{c6}$, $\bar{x}_{c7}$, $\bar{x}_{c8}$, $\bar{x}_{t1}$, $\bar{x}_{t2}$, $\bar{x}_{t3}$, $\bar{x}_{t4}$, $\bar{x}_{t5}$, $\bar{x}_{t6}$, $\bar{x}_{t7}$, $\bar{x}_{t8}$ are obtained from the average percentages of sustainability rates calculated for the seven sustainability variables considered for the research according to each stakeholder category. In doing so, p, c and t represent vegetable producers, traders and processors respectively in the Accra Metropolitan Assembly vegetable value chain;

$\bar{x}_{pct1}$, $\bar{x}_{pct2}$, $\bar{x}_{pct3}$, $\bar{x}_{pct4}$, $\bar{x}_{pct5}$, $\bar{x}_{pct6}$, $\bar{x}_{pct7}$, $\bar{x}_{pct8}$ are the overall averages of sustainability rates calculated from the knowledge, attitudes and practices of market garden vegetable producers, traders and processors according to the following seven (7) sustainability aspects: degree of awareness of the sustainability of the activity, socio-economics, health of stakeholders, food protection and preservation, losses and wastage, environmental pollution and waste management, technologies and innovations, Governance;

$\bar{x}_{p1}$, $\bar{x}_{c1}$ and $\bar{x}_{t1}$ are the respective average rates of producers', traders' and processors' knowledge of the sustainability criteria that their activities directly or indirectly influence;

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$\bar{x}_{p2}$, $\bar{x}_{c2}$ and $\bar{x}_{t2}$, respectively represent the average proportions of socioeconomic sustainability of the market gardening activity, trade and vegetable processing ;

$\bar{x}_{p3}$, $\bar{x}_{c3}$ and $\bar{x}_{t3}$, respectively indicate the average percentages of knowledge and practices of producers, traders and processors on the health risks of their activities ;

$\bar{x}_{p4}$, $\bar{x}_{c4}$ and $\bar{x}_{t4}$ are the average rates of respective knowledge, attitudes and practices of producers, traders and processors on the protection and conservation of their products;

$\bar{x}_{p5}$, $\bar{x}_{c5}$ and $\bar{x}_{t5}$, are the average levels of sustainability linked, respectively, to the rates of good practices by producers, traders and processors concerning losses and wastage;

$\bar{x}_{p6}$, $\bar{x}_{c6}$ and $\bar{x}_{t6}$ are the average sustainability proportions related respectively to producers', traders' and processors' knowledge of environmental pollution and waste management;

$\bar{x}_{p7}$, $\bar{x}_{c7}$ et $\bar{x}_{t7}$ are the variables that, respectively, indicate the average rates of adoption of innovative and technological practices by producers, traders and processors;

$\bar{x}_{p8}$, $\bar{x}_{c8}$ et $\bar{x}_{t8}$ are the mean sustainability rates calculated respectively for the inclusive and participatory governance of the activities of producers, traders and processors in the Accra market garden supply chain.

The research findings were confronted with socio-economic, health and ecological realities based on the principles of nutrition ecology, the themes of Standard 13 of the Global Reporting Initiative 2023 and the Sustainable Development Goals of the United Nations 2030 Agenda.Research findings and discussion

Results

Socio-Demographic Profiles of The Target Population

The following table essentially illustrates the distribution of interviewees according to gender, age, level of education, length of experience in the activity, marital status, basic professional training field and membership of a corporate organization.

Table 1: Overview of Respondents' Socio-Demographic Characteristics

Breakdown of respondents by gender	Producers		Traders		Street caterers		All stakeholders	
	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)
Male	50	100,0	5	7,9	6	14,0	61	39,10
Female	0	0,0	58	92,1	37	86,0	95	60,90
Total	50	100,0	63	100,0	43	100,0	156	100,00

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Breakdown of respondents by age	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)
18-25	8	16,0	4	6,3	8	18,6	20	12,82
26-35	11	22,7	9	14,3	13	30,2	33	21,37
36-45	14	28,0	24	38,1	12	27,9	50	32,05
46-55	12	24,0	18	28,6	7	16,3	37	23,72
56 and more	5	9,3	8	12,7	3	7,0	16	10,04
Total	50	100,0	63	100,0	43	100,0	156	100,00
Breakdown of respondents by time spent in their field of business experience	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)
1-2 years	6	12,0	7	11,1	12	27,9	25	16,03
3-4 years	4	8,0	6	9,5	5	11,6	15	9,62
5 years and more	39	78,7	50	79,3	26	60,5	115	55,34
Total	50	100,0	63	100,0	43	100	156	100,00
Breakdown of respondents by education level	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)
Not instructed	13	26,7	19	30,2	3	7,0	35	22,65

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Primary	15	29,3	22	34,9	6	14,0	43	27,35
Secondary school	18	36,0	20	31,7	28	65,1	66	42,31
high school	4	8,0	2	3,2	6	14,0	12	7,69
Total	50	100,0	63	100,0	43	100,0	156	100,00
Breakdown of respondents by Marital status	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)
Single	18	36,0	14	22,2	16	37,2	48	30,77
Cohabiting partner	0	0,0	0	0,0	0	0,0	0	0,00
Divorced	1	2,7	4	6,3	3	7,0	8	5,34
Engaged	1	2,7	1	1,6	1	2,3	3	2,14
Maried	29	58,7	39	61,9	20	46,5	88	56,62
Widower	0	0,0	5	7,9	3	7,0	8	5,13
Total	50	100,0	63	100,0	43	100,0	156	100,00
Number of dependents	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)
0	16	32,0	3	4,8	12	27,9	31	19,87
1-2	9	18,7	17	27,0	10	23,3	36	23,29
3-4	13	25,3	25	39,7	13	30,2	51	32,48

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5 and more	12	24,0	18	28,6	8	18,6	38	24,36
Total	50	100,0	63	100,0	43	100,0	156	100,00
Distribution of respondents according to their membership of farmer/trader /processor organizations	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)
Membership to one (1) organization	33	66,7	19	30,2	8	18,6	60	38,68
Belonging to 2 organizations	0	0,0	7	11,1	1	2,3	8	5,13
Aucune	17	33,3	37	58,7	34	79,1	88	56,20
Total	50	100,0	63	100,0	43	100,0	156	100,00
Respondent distribution by professional training field	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)
Business and marketing	2	4,0	33	52,4	16	37,2	51	32,69
Agro-pastoral	17	33,3	0	0,0	1	2,3	18	11,32
Craft	12	24,0	6	9,5	9	20,9	27	17,31
Food service	0	0,0	0	0,0	0	0,0	0	0,00
Healthcare	0	0,0	0	0,0	0	0,0	0	0,00

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Others	19	38,0	24	38,1	17	39,5	60	38,46
Total	50	100,0	63	100,0	43	100,0	156	100,00

Source: K. E. Assinou and K. Kpotchou 2024

The majority of workers in Accra's vegetable supply chain are women (61%), divided between trading and processing. In terms of numbers, they make up 92.1% of vegetable traders and 86% of processors. Men make up only 39.10% of all supply chain actors, but at the production stage, they make up the entire workforce (100%). Respondents aged between 36 and 55 represent around 56% of the headcount, compared with 34% for the youth (18 to 35) and 16% for the oldest (55 and over). The majority of respondents (73.72%) had at least 5 years' experience in their respective fields: 78% of producers, distributors and 60% of processors. In view of this age distribution and degree of professional experience, it can be validly asserted that the data is collected from mostly experienced and mature stakeholders. While 77.35% of actors are well-educated, the majority have between an primary and secondary level of education (69.66%). This could make it difficult for them to have the proven knowledge and adopt the practices needed to preserve ecological resources, adopt a good lifestyle and improve their socio-economic conditions.

Lack of knowledge about sustainability principles among vegetable growers, traders and processors in Accra

Table 5: Producers', Processors' and Traders' Awareness of The Socio-Economic, Environmental And Health Aspects Of Their Activities

Stakeholders	Producers		Traders/retailers		Street food vendors		All stakeholders	
Scores	Scores for right answers	Total score	Scores for right answers	Total score	Scores for right answers	Total score	Over all score for right answers	Overall total score
Right answers / Rate	Number of right answers	Rate (%)	Score	Rate (%)	Score	Rate (%)	Score global	Global rate (%)
Trends in stakeholders' knowledge of the sustainability principles their activities directly influence	215	450	185	567	130	387	530	1404
	9	47,70	9	32,63	9	33,59	9	37,73
Trends in stakeholders' knowledge of the sustainability principles indirectly influenced by their activities	81	200	30	252	47	172	158	624
	4	40,33	4	12,04	4	27,33	4	25,32
$\bar{x}_{p1}$ / $\bar{x}_{c1}$ / $\bar{x}_{t1}$ / $\bar{x}_{pct1}$	$\bar{x}p1$	44,02	$\bar{x}c1$	22,34	$\bar{x}t1$	30,46	$\bar{x}pct1$	31,53

Source : K. E. Assinou et K. Kpotchou 2024

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The data in Table n°5 reveal that the respondents, taken in their respective corporations or as a whole, have a low level of knowledge ($\bar{x}$pct1= 31.53%) of the elements of socio-economic, health, ecological and food safety sustainability that their activities can influence directly (37.73%) or indirectly (25.32%). At growers' level, the average ($\bar{x}$p1) is 44.02%; it is lower at the stage of vegetable processors ($\bar{x}$t1= 30.46%) and traders ($\bar{x}$c1=22.34%). Of the three categories of stakeholders surveyed, if we refer to the data on variable modalities, only 5.13% of them are aware that their activities can have effects on terrestrial, aquatic and ambient air ecosystems. As for their knowledge of the direct effects of their practices on the reduction or increase of GDP, consumer health and their own health, the rates are equally low, at 35.26, 41.88 and 13.03 percent respectively. These low rates undervalue those of the strong awareness that these actors have of the influence of their activities on the fight against hunger (70.73%), food security (68.80) and their income (60.26). This may be reflected in their propensity to adopt practices unfavorable to the viability of the Accra market garden supply chain, and to compromise the socio-economic and health well-being of stakeholders, accompanied by practices of pollution and degradation of natural ecosystems.

Fair Awareness of Social Responsibility in Accra's Vegetable Supply Chain

Table 6: Actors' Awareness of Their Social Responsibility in Their Relations with Their Employees

Stakeholders	Producers		Traders/retailers		Street food vendors		All stakeholders	
Scores	Scores for right answers	Total score	Scores for right answers	Total score	Scores	Scores for right answers	Total score	Scores for right answers
Right answers / Rate	Number of right answers	Rate (%)	Score	Rate (%)	Right answers / Rate	Number of right answers	Rate (%)	Score
Stakeholders' average awareness of their contribution to the national economy through their IGAs	50	150,0	60	189,0	42	189,0	152	528
	3	33,33	3	31,75	3	22,22	3	28,79
Average level of social responsibility awareness of actors in their working relationship with their employees	93	350,0	99	441,0	78	301,0	270	1092
	7	26,67	7	22,45	7	25,91	7	24,76
Level of respondents' average awareness concerning their social responsibility for the health and well-being of their employees.	36	100,0	55	126,0	38	86,0	129	312
	2	36,00	2	43,65	2	44,19	2	41,35
Average level of awareness among stakeholders of the social needs that market gardening/vegetable sales/vegetable catering can help to meet	113	250	106	315	24	215	243	780
	5	45,33	5	33,65	5	11,05	5	31,16
Proportion of employees adopting best practices to improve working and living conditions	80	300,0	95	378,0	81	258,0	256	936
	6	26,67	6	25,13	6	31,40	6	27,35
$\bar{x}_{p2}$ / $\bar{x}_{c2}$ / $\bar{x}_{t2}$ / $\bar{x}_{pct2}$	$\bar{x}$p2	38,93	$\bar{x}$c2	36,35	$\bar{x}$t2	33,23	$\bar{x}$pct2	36,15

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Sources: K. E. Assinou et K. Kpotchou 2024

Table n°6 highlights a low level of social responsibility for the three categories of market garden vegetable supply actors in Accra ($\bar{x}$pct2=36.15%). For producers, this rate stands at 38.93% ($\bar{x}$p2); it slightly exceeds that of traders ($\bar{x}$c2= 36.35%) and supplants the level of social responsibility of processors ($\bar{x}$t2=33.23%). Even though the average rate of child labor among 10- to 14-year-olds is low (16.67%) compared to that of young people of working age (63.47% of people aged 15 to 35) in Accra's vegetable industry, the majority (58.65%) of respondents don't believe they are responsible for the health well-being and improved living and working conditions of their employees. In fact, only 36% of producers acknowledge this responsibility, 43.65% of retailers and 44.19% of restaurateurs. This is confirmed by the fact that only 28.79% of players know that they contribute to the national economy. And an average of only 27.35% are thinking about adopting good practices to improve their working and living conditions. This insouciance and ignorance on the part of players regarding their socio-economic responsibility can affect the sector's socio-economic development through the significant existence of social gaps, inequalities of treatment and injustices, without ignoring the associated risks of impoverishment.

Insufficient knowledge on the part of producers, traders and processors of the health risks associated with their practices

Table 7: Trends of knowledge and good practices of the actors on sanitary risks in the market garden sector

Stakeholders	Producers		Traders/retailers		Street food vendors		All stakeholders	
Scores	Scores for right answers	Total score	Scores for right answers	Total score	Scores	Scores for right answers	Total score	Scores for right answers
Right answers / Rate	Number of right answers	Rate (%)	Score	Rate (%)	Right answers / Rate	Number of right answers	Rate (%)	Score
Stakeholders' knowledge of the diseases that can be contracted by consumers through the consumption of food containing pesticide or fertilizer residues.	125	450,0	43	567,0	29	387,0	197	1404
	9	27,78	9	7,58	9	7,49	9	14,03
Trend in use of main source of crop irrigation water by growers	100	250,0	80	315,0	36	215,0	216	780
	5	40,00	5	25,40	5	16,74	5	27,69
Trends in growers', traders' and processors' knowledge of the possible effects of the water they use to treat vegetables on the health of the final consumer.	7	200,0	3	252,0	2	172,0	12	624
	4	3,50	4	1,19	4	1,16	4	1,92
Trends in water treatments used by the various players involved in vegetable handling	12	150,0	3	189,0	16	129,0	19	468
	3	0,00	3	1,59	3	12,40	4	4,06
Trends in self-protection provisions for vegetable handling by stakeholders	82	250,0	52	315,0	44	215,0	178	780
	5	32,80	5	16,51	5	20,47	4	22,82

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Frequency with which growers are encouraged to use phytosanitary products that are less harmful to their health and that of consumers / Frequency with which retailers and processors check the safety of vegetables and foodstuffs.	39	200,0	61	252,0	43	172,0	143	624
	4	19,50	4	24,21	4	25,00	4	22,92
Frequency of washing, cleaning and disinfection of storage and display equipment for market garden vegetables / cooking and presentation of dishes by the players	0	150,0	49	189,0	39	129,0	88	318
	3	0,00	3	25,93	3	30,23	4	27,67
Tools used to wash, clean and disinfect storage and display areas for vegetables sold/ Cooking and serving	0	300,0	131	378,0	124	258,0	255	636
	6	0,00	6	34,66	6	48,06	6	40,09
$\bar{x}_{p3}$ / $\bar{x}_{c3}$ / $\bar{x}_{t3}$ / $\bar{x}_{pct3}$	$\bar{x}$p3	20,60	$\bar{x}$c3	17,13	$\bar{x}$t3	20,19	$\bar{x}$pct3	20,15

Source: K. E. Assinou and K. Kpotchou 2024

In contrast to the fairly good social responsibility awareness of market garden vegetable producers, traders and processors in Accra, the overall average of their degree of knowledge about the health risks carried by non-recommended practices in their processes is low ($\bar{x}$pct3= 20.15%). This average rate is 20.60% ($\bar{x}$p3) for market gardeners, 17.13% ($\bar{x}$c3) for traders and 20.19% ($\bar{x}$t3) for processors. In fact, only 14.03% of players are aware that fertilizer and pesticide residues contained in vegetables can cause cancer, cardiovascular disease, gastrointestinal pathologies, even nervous disorders, etc. Similarly, the level of self-protection is low among all players (22.82%): protective overalls (16%), boots (5.77%), mufflers (39.53%), gloves (48.08%). Furthermore, 4.06% do not treat the water they use, either for cultivation (0%), or for vegetables sold (1.59%) or processed (12.40%). Even the level of manual control of the safety of vegetables sold (24.21%) or processed is low (25%); at the same time, market gardeners think very little about using phytosanitary products that are less dangerous to their own health and that of consumers (19.50%). In addition, the frequency of washing, cleaning and disinfecting vegetable storage and display equipment is as low as that of cooking and food presentation equipment (25.93% versus 30.23%). If the rates of good practice and knowledge of Accra's vegetable supply chain actors about protecting their own and consumers' health are below average, it is clear that this poses a significant public health problem. As for food protection and preservation, the rate of good practice is no more encouraging.

Insecure Food Protection in Accra's Vegetable Supply Chain

Table 8: Safeguarding And Preserving Foodstuffs at The Production, Processing and Distribution Stages

Stakeholders	Producers		Traders/retailers		Street food vendors		All stakeholders	
Scores	Scores for right answers	Total score	Scores for right answers	Total score	Scores	Scores for right answers	Total score	Scores for right answers

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Right answers / Rate	Number of right answers	Rate (%)	Score	Rate (%)	Right answers / Rate	Number of right answers	Rate (%)	Score
Trends in vegetable conservation techniques that do not quickly find buyers among the three categories of players	37	200,0	94	252,0	34	172,0	165	624
	4	18,50	4	37,30	4	19,77	4	26,44
Storage and protection practices for vegetables for sale	0	350,0	151	441,0	0	301,0	151	441
	7	0,00	7	34,24	7	0,00	7	34,24
Growers' knowledge of the possible effects of fertilizer and pesticide misuse on crops	58	300,0	0	378,0	0	258,0	58	300
	6	19,33	6	0,00	6	0,00	6	19,33
Producers' perceptions of the possible effects of the water they use on food quality	4	50,0	0	63,0	0	43,0	4	113
	1	8,00	1	0,00	1	0,00	1	3,54
$\bar{x}_{p4}$ / $\bar{x}_{c4}$ / $\bar{x}_{t4}$ / $\bar{x}_{pct4}$	$\bar{x}p4$	15,22	$\bar{x}c4$	25,96	$\bar{x}t4$	19,77	$\bar{x}pct4$	20,89

Source: K. E. Assinou and K. Kpotchou 2024

A reading of Table 8 shows that the average proportion of vegetable protection, despite its importance for consumer health, is also low in the Accra market garden supply chain in terms of good practices, knowledge and perceptions for all three categories of actor ($\bar{x}pct4$= 20.89%). This average proportion is 15.22% ($\bar{x}p4$) at the producer level, 25.96% ($\bar{x}c4$) at the sales stage and 19.77% ($\bar{x}t4$) among processors. In this way, the adoption of good preservation practices for raw vegetables that do not quickly find buyers or cooked vegetables that are not sold is at a rate as low as that of the other indicator modalities (26.44%): drying (16.45%), placing under humidity (29, 49%), refrigeration or freezing (26.28%). Meanwhile, growers' knowledge of the effects of pesticide and fertilizer abuse on crops is particularly low (19.33%): traces of fertilizer in vegetables (33.3%); excess minerals (18.7%); contamination of foodstuffs by irrigation water sources (7.08%). In view of these results, it is clear that market garden vegetables are exposed to a number of contamination risks, as the practices and knowledge of those involved do not provide sufficient protection. In addition, food loss and waste are another challenge facing Accra's vegetable supply chain.

Contrasts Between Levels of Protection Practices and Food Losses in Accra's Vegetable Supply Chain

Table 9: Risks Of Loss and Waste

Stakeholders	Producers		Traders/retailers		Street food vendors		All stakeholders	
Scores	Scores for right answers	Total score	Scores for right answers	Total score	Scores	Scores for right answers	Total score	Scores for right answers
Right answers / Rate	Number of right answers	Rate (%)	Score	Rate (%)	Right answers / Rate	Number of right answers	Rate (%)	Score
Reasons why retailers prefer their vegetables to be more resistant to the effects of decomposition / Reasons why processors check the safety of the dishes they produce	0	200,0	186	252,0	128	172,0	314	424
	4	0,00	4	73,81	4	74,42	4	74,06

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Level of recommended Protecting vegetables from contact with chemicals or pathogenic microorganisms during transport (retailers)	0	100,0	83	126,0	0	172,0	83	126
	2	0,00	2	65,87	4	0,00	2	65,87
Level of recommended measures taken by retailers to protect vegetables from microbes and toxic products during display	0	300,0	117	378,0	0	258,0	117	378
	6	0,00	6	30,95	6	0,00	6	30,95
Level of Recommended practices for protecting vegetables from chemical products or pathogenic microorganisms during processing	0	250,0	0	315,0	122	215,0	122	215
	5	0,00	5	0,00	5	56,74	6	56,74
Level of Recommended Practices to protect food from toxic products and microbes when served to consumers by processors	0	200,0	0	252,0	100	172,0	100	172
	4	0,00	4	0,00	4	58,14	4	58,14
Levels of good practice in the treatment of vegetables in the early stages of putrefaction by traders	0	150,0	66	189,0	0	129,0	66	189
	3	0,00	3	34,92	3	0,00	3	34,92
Levels of good practices in handling rotten, moldy and/or decaying vegetables (retailers)	0	150,0	60	189,0	0	129,0	60	189
	3	0,00	3	31,75	3	0,00	3	31,75
Levels of good practice for treating vegetables at the start of mildew, rot or decline (growers)	5	50,0	0	63,0	0	43,0	5	50
	1	10,00	1	0,00	1	0,00	1	10,00
Rate of good handling practices for rotted, withered or moldy vegetables (growers)	48	150,0	0	189,0	0	129,0	48	150
	3	32,00	3	0,00	3	0,00	3	32,00
Rate of good practice in the treatment and stewardship of leftovers from meals served and/or prepared (processors)	0	200,0	0	252,0	17	172,0	17	172
	4	0,00	4	0,00	4	9,88	4	9,88
Throwing frequency of cooked and raw food by stakeholders	4	50,0	4	63,0	36	43,0	36	43
	1	8,00	1	6,35	1	83,72	1	83,72
$\bar{x}_{p5}$ / $\bar{x}_{c5}$ / $\bar{x}_{t5}$ / $\bar{x}_{pct5}$	$\bar{x}$p5	21,00	$\bar{x}$c5	47,46	$\bar{x}$t5	56,58	$\bar{x}$pct5	44,37

Source: K. E. Assinou and K. Kpotchou 2024

Following the same trend as the indicators whose results are presented in the preceding tables, the overall average level of good practices contributing to loss avoidance or reduction is insufficient in Accra's vegetable supply chain ($\bar{x}$pct5 = 44.37%). Nevertheless, this average rate is acceptable at the vegetable processing stage ($\bar{x}$t5 = 56.58) and is very low among growers ($\bar{x}$p5=21%) while it approaches the average at the merchant level ($\bar{x}$c5=47.46%). More striking here is the fact that the rates associated with the measures taken by the various players to protect vegetables from contamination vectors, viruses, parasites, pathogenic bacteria or toxic products that could accelerate putrefaction and loss are almost all above 50% (56.74 to 4.06%), in contrast to good practices for treating vegetables at the start of putrefaction or in a state of total rot (9.88 to 34.92%). These results clearly show that the risk of food loss and waste is high in

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Accra's vegetable supply chain. This also represents a loss of earnings for the players involved, and does not improve their standard of living.

Table 10: Environmental Pollution and Waste Management

Stakeholders	Producers		Traders/retailers		Street food vendors		All stakeholders	
Scores	Scores for right answers	Total score	Scores for right answers	Total score	Scores	Scores for right answers	Total score	Scores for right answers
Right answers / Rate	Number of right answers	Rate (%)	Score	Rate (%)	Right answers / Rate	Number of right answers	Rate (%)	Score
Growers' knowledge of the effects that high doses of fertilizers, herbicides and fungicides can have on the soil	88	200,0	0	252,0	0	172,0	88	200
	4	44,00	4	0,00	4	0,00	4	44,00
Producer knowledge of the effects of intensive ploughing and weeding on soil quality	89	200,0	0	252,0	0	172,0	89	200
	4	44,50	4	0,00	4	0,00	4	44,50
Producers' knowledge of the effects of overuse of fertilizers, herbicides and fungicides on water, atmosphere and climate	35	150,0	0	189,0	0	129,0	35	150
	3	23,33	3	0,00	3	0,00	3	23,33
Producers' idea of using less polluting but more productive phytosanitary products than chemical fertilizers	34	150,0	0	189,0	0	129,0	34	150
	3	22,67	3	0,00	3	0,00	3	22,67

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Management practices for organic waste from market gardening among three categories of stakeholders	47	200,0	50	252,0	10	172,0	107	624
	4	23,50	4	19,84	4	5,81	4	17,15
Treatment of inorganic waste (paper, plastics, metals, textiles, etc.) from market gardening activities by the three categories of stakeholders	34	200,0	42	252,0	35	172,0	111	624
	4	17,00	4	16,67	4	20,35	4	17,79
$\bar{x}_{p6}$ / $\bar{x}_{c6}$ / $\bar{x}_{t6}$ / $\bar{x}_{pct6}$	$\bar{x}p6$	29,17	$\bar{x}c6$	20,25	$\bar{x}t6$	18,26	$\bar{x}pct6$	28,24

Source: K. E. Assinou and K. Kpotchou 2024

From an ecological point of view, the levels of knowledge and good practices of producers, traders and restaurateurs in Accra's market garden supply chain are not such as to preserve the ecosystemic balance of natural environments, since the overall average rate calculated for this sustainability dimension addressed by the research is very low ($\bar{x}pct6$=28.24%). In the production process, the average rate is 29.17% ($\bar{x}p6$); it is lower among traders ($\bar{x}c6$=20.25) and processors ($\bar{x}t6$=18.26). In this respect, only 23.33% of growers are aware that the excessive application of fertilizers and pesticides can inevitably have damaging effects on water resources, pollute the air, and even affect soil quality in terms of fertility. Even those who have already had the idea of using less polluting and more profitable inputs make up only 22.67% of the workforce. Furthermore, the rate of good waste management practices by all players is very low, between 17.15 and 17.79%. For example, very few of the players surveyed believe that organic waste can be recycled by selling it to breeders (6.41%), recyclers (2.78%) or composting (11.38%). More people, however, choose to throw it in the garbage can (31.41%), even though this is a less wasteful solution that can be a source of greenhouse gas emissions. The ecological weaknesses of the Accra market-growing sector can also be seen from a technical, social and cooperative angle.

Table 11: Levels Of Technological Sustainability, Innovation and Participatory Management in Accra's Vegetable Value Chain

Stakeholders	Producers		Traders/retailers		Street food vendors		All stakeholders	
Scores	Scores for right answers	Total score	Scores for right answers	Total score	Scores	Scores for right answers	Total score	Scores for right answers
Right answers / Rate	Number of right answers	Rate (%)	Score	Rate (%)	Right answers / Rate	Number of right answers	Rate (%)	Score
Rate of mechanized tasks in the production system	40	400,0	0	504,0	0	344,0	40	400
	8	10,00	8	0,00	8	0,00	8	10,00
Rate of digitized activities in the production system	0	400,0	0	504,0	0	344,0	0	400
	8	0,00	8	0,00	8	0,00	8	0,00
Rate of digitized activities in the marketing system	0	400,0	11	504,0	0	344,0	11	400
	8	0,00	8	2,18	8	0,00	8	2,75

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Rate of digitized tasks in the foodservice system	0	350,0	0	441,0	14	304,0	14	350
	7	0,00	7	0,00	7	4,61	7	4,00
Rate of use of applications by stakeholders in the production, sale or processing of raw or cooked vegetables	19	550,0	13	693,0	6	473,0	38	1716
	11	3,45	11	1,88	11	1,27	11	2,21
Percentage of actors using social networks in the production, sale and processing of raw and cooked vegetables	24	100,0	10	126,0	40	86,0	74	312
	2	24,00	2	7,94	2	46,51	2	23,72
Rate of positive reasons for using social networks or applications in the production, sale or processing of raw or cooked vegetables	50	350,0	33	441,0	14	301,0	97	1092
	7	14,29	7	7,48	7	4,65	7	8,88
Rate of equipment use in the foodservice offering process	0	200,0	0	126,0	107	172,0	107	172
	4	0,00	2	0,00	4	62,21	4	62,21
$\bar{x}_{p7}$ / $\bar{x}_{c7}$ / $\bar{x}_{t7}$ / $\bar{x}_{pct7}$	$\bar{x}p7$	10,35	$\bar{x}c7$	4,87	$\bar{x}t7$	23,85	$\bar{x}pct7$	14,25
Stakeholders	Producers		Traders/retailers		Street food vendors		All stakeholders	
Scores	Scores for right answers	Total score	Scores for right answers	Total score	Scores	Scores for right answers	Total score	Scores for right answers
Right answers / Rate	Number of right answers	Rate (%)	Score	Rate (%)	Right answers / Rate	Number of right answers	Rate (%)	Score
Level of implication of producers, traders and processors in public support projects dedicated to them	31	100,0	24	126,0	19	86,0	74	312
	2	31,00	2	19,05	2	22,09	2	23,72
Level of involvement of producers, traders and processors in NGO and association projects initiated to support their functional and organizational capacities, by corporation	22	100,0	18	126,0	7	86,0	47	312
	2	22,00	2	14,29	2	8,14	2	15,06
$\bar{x}_{p8}$ / $\bar{x}_{c8}$ / $\bar{x}_{t8}$ / $\bar{x}_{pct8}$	$\bar{x}p8$	26,50	$\bar{x}c8$	16,67	$\bar{x}t8$	15,12	$\bar{x}pct8$	19,39

Source: K. E. Assinou and K. Kpotchou 2024

Furthermore, the rate of good waste management practices by all players is very low, between 17.15 and 17.79%. For example, very few of the players surveyed believe that organic waste can be recycled by selling it to breeders (6.41%), recyclers (2.78%) or composting (11.38%). More people, however, choose to throw it in the garbage can (31.41%), even though this is a less wasteful solution that can be a source of greenhouse gas emissions. The ecological weaknesses of the Accra market-growing sector can also be seen from a technical, social and cooperative angle. This innovative and technological weakness of the supply chain

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evaluated can severely hamper productivity and profitability, by affecting the purchasing power of the people involved, and thus limiting their access to a decent minimum standard of living.

In the second part of this table, when it comes to sustainability linked to the participatory operation and organization of the market garden supply chain, we also see an overall average rate well below the average, at 19.39% ($\bar{x}$pct8). Thus, producers ($\bar{x}$p8=26.5%), traders ($\bar{x}$c8=16.67%) and processors ($\bar{x}$t8=15.12%) are sparsely involved in public or civil society organization-led projects dedicated to strengthening their functional, organizational, technical and economic capacities. These figures suggest that, taken as a whole or even according to their categories, actors work in isolation at a general average rate of around 80.61%. In so doing, they may face numerous difficulties in gaining access to new techniques and systems of action that could enable them to maximize their profits while preserving their health well-being, that of their potential customers and the balance of natural ecosystems. This corroborates their propensity to make low-rate use of social networks, applications and digital technologies that can boost their productivity and profitability and change their standard of living. These data also reveal how stakeholders can face financing difficulties without forming cooperatives, since financial institutions, over and above the individual material or financial guarantees that underpin the possibilities of financial support, make use of the co-responsibility of economic operators in income-generating micro and meso activities.

Discussion

In view of the research findings, the socio-economic, health (food and nutrition) and environmental sustainability of Accra's market garden supply chain weakly meets sustainability criteria and principles ($\bar{x}$pct=30, 35%) based on the recommendations of Standard 13 of the Global Reporting Initiative 2023 for the agriculture, aquaculture and fisheries sector, as well as the Sustainable Development Goals (SDGs) of the United Nations Agenda 2030, considering the principle of nutrition ecology theory defined above (GRI, 2023; C. Leitzmann, 2003; K. Schneider and I. Hoffmann, 2011; UN, 2017).

The discussion revolves around the results related to the key dimensions of sustainability. The first result is based on a multiple-choice question highlighting the essential aspects of sustainability considered for the research, but the correct answers were only chosen at an average proportion of 31.53% of the scores ($\bar{x}$pct1: table n°5). This reveals the unawareness of the majority of respondents (68.47%) as to the direct influence of practices relating to their activities on natural ecosystems, biodiversity, their incomes, food and nutritional security, Gross Domestic Product (GDP), their own health as well as that of consumers. This implies a high risk that the chain's vegetable production, marketing and processing practices are neither GRI 13 compliant, nor conducive to achieving the 17 Sustainable Development Goals.

The findings also indicate that the degree of responsibility or socio-economic conscientiousness of key actors in the Accra value chain is low ($\bar{x}$pct2 = 36.15%); they are not conducive to the sustainability of the sector through poverty reduction as R. Vos and A. Cattaneo (2021) have mentioned in their work. This level of responsibility contrasts with the promotion of economic inclusion in public policies designed to improve food systems in sub-Saharan Africa. It does not meet the recommendations of themes 13.12, 13.21 and 13.22 of the GRI standard. In fact, only 28.79% of respondents know that their IGAs contribute to the national economy. Similarly, only 41.35% of respondents affirmed that improving the health, living and working conditions of their employees concerned them. Interviewees who had thought about improving their own working and living conditions were only in the minority (27.35%), compared with the scores for correct answers. Under these conditions, it is unlikely that the eradication of social inequalities as targeted by SDG10 will be achieved in the AMA by 2030. The same applies to SDG 8, which promotes sustained economic growth, full and productive employment and decent work for all.

This trend in the results is confirmed in Table 7 by the low level of the average rate of players' knowledge of the health risks associated with their activities ($\bar{x}$pct3=20, 15%). In fact, only 14.03% are aware that the consumption of food containing pesticide residues exposes the consumer to cancerous, nervous, cardiovascular and even genital pathologies, as demonstrated in the existing literature (D.P. Abrol and U. Shankar, 2014; A. Aggrawal, 2006; A. Ahamad and J. Kumar, 2023; U. Bajwa and K.S. Sandhu, 2014; I.

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Baldi and al., 2013; I. Baldi and al., 2021; P. Biswas and al., 2023; D. Bourguet and T. Guillemaud, 2016; R. Calderon and al., 2022; K. Farswan, 2021; A. Inobeme and al., 2020; M. Khan and al., 2023; W. Lai, 2017; B. Le Huy and al., 2022; A.K. Mohiuddin, 2019). Similarly, only around 22% of all those questioned were aware of the need to wear protective clothing to protect themselves or their food from contamination. Even good practices for washing, cleaning and disinfecting tools used for storing, displaying, cooking or presenting vegetables were chosen by only 22.92%. Protecting vegetables at the production, marketing and processing stages is of very low importance, as Table 8 shows ($\bar{x}$pct4=20, 89%). Thus, the choice of correct answers concerning preservation practices for vegetables that don't quickly find a buyer is limited to 26.44% for all actors, compared with 34.24% when it comes to recommendable practices linked to storage and protection of vegetables sold against dust, rodents, toxic products, etc. This is still a health issue. This indicates that the stakeholders in this sector are exposing themselves and endangering the health of consumers of their vegetables due to the risks of contamination by parasites, viruses or pathogenic bacteria that they face in this situation, as some research has shown (G.N. Murthy and P.B.S. Yadav, 2024; V.M. Pathak and al., 2022; H. Ping and al., 2022; W.V.D.S. Poornima and al., 2024; S. Saggu and al., 2016; G.A. Santarelli and al., 2018; N. Sharma and R. Singhvi, 2017; N.S. Singh and al., 2018; I. Yeboah, 2014a). Clearly, this is not likely to "enable all people to live in good health and promote the well-being of all people at all ages" as targeted by SDG3 and demonstrated by T. Marsden and R. Sonnino (2012), P. Sood (2023), C. Su and al. (2023), J.H. Syed and al. (2014), et M. Varol and al. (2022). Furthermore, this result is inconsistent with the preservation of food safety (theme 13.9), the guarantee of food safety against contamination, disease, intoxication and pollution (theme 13.10) and the preservation of occupational health and safety (theme 13.19) as recommended by GRI standard 13. The analysis of this result is in line with that of G.I. Balali and al. (2020) and J. Waage and al. (2022) on microbial contamination and the growth of health threats associated with fruit and vegetable consumption.

The risk of loss and spoilage is also high, due to the low rate of good practice in the treatment of vegetables at the start of putrefaction (10% among producers and 34.92% among traders) or in the processing of rotten vegetables (31.75% among traders and 32% among producers). These results from Table 9 show that losses and wastage in Accra's vegetable supply chain represent a loss of earnings for producers, traders and processors alike, since the proper preservation of produce prevents it from rotting. But in the event of putrefaction, even if sold at a low price for processing, the stakeholders will see their losses reduced and their environment preserved from pollution and greenhouse gas emissions by organic waste. This would serve to protect their income by minimizing losses ("SDG8") and reinforcing sustainable consumption ("SDG12"). This issue is widely addressed by C. Chauhan and al. (2021), M. Kummu and al. (2012), S.D. Porter and al. (2016), M. Sheahan and C.B. Barrett (2017), E. Surucu-Balci and O. Tuna (2021) et S.M. Wunderlich and N.M. Martinez (2018) in their work on loss and waste in food supply chains.

With regard to the knowledge, attitudes and positive practices of stakeholders in the supply of market garden vegetables in Accra, the overall average rate is not significant ($\bar{x}$pct6=28, 24%). On the one hand, it shows that few market gardeners are aware that excessive use of pesticides and fertilizers (44%) or intensive ploughing (44.5%) can degrade the mineral constitution and fertility of the soil. On the other hand, waste management practices, both organic and inorganic, are also in practically insignificant proportions (17.15% for the former and 17.79% for the latter). This suggests that the natural environment is exposed to air and water pollution, soil degradation and biodiversity loss in Accra's vegetable supply chain. This is a major obstacle to achieving SDG 6, which calls for reasonable use of water resources and sustainable management of sanitation. Achieving SDGs 14 and 15 may also be difficult under these conditions, as aquatic and terrestrial ecosystems are adversely affected by chemical and organic waste from fertilizers and pesticides used, or from poorly processed rotting vegetables traités (I. Ansari and al., 2021; F.P. Carvalho, 2017; R.L. Chaney, 2012; J.L. Gallego and J. Olivero-Verbel, 2021; C. Kouame and al., 2013; B. Mariana Furio Franco and al., 2015; N. Mazlan and al., 2017; N.D. Mu'azu and al., 2020; S. Nayak and al., 2020; P. Rajak and al., 2023; N. Sharma and R. Singhvi, 2017; A.L. Srivastav, 2020; S. Tripathi and al., 2020; M. Tudi and al., 2021; V.L. Zikankuba and al., 2019). These results are also contrary to standard 13 of the GRI 2023, which disapproves and discourages harmful greenhouse gas emissions (theme 13.1), the destruction of biodiversity (theme 13.3), the degradation of natural ecosystems (theme 13.4) and soil health (theme 13.5), the abusive

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or uncontrolled use of pesticides (theme 13.6), water pollution (theme 13.7) and inappropriate waste management (theme 13.8).

The situation is worse when it comes to practices involving innovative ideas, the digitization and mechanization of tasks, or the use of social networks in various processes by producers, traders and market gardeners: the overall average rate is the lowest ($\bar{x}$pct7=14.25%). In a world where new information and communication technologies are more useful than ever in all sectors of activity, it's understandable that Accra's vegetable supply chain is lagging far behind, putting all three categories of supply actors at a disadvantage in terms of productivity, profitability and improved working and living conditions. This being the case, the players are undoubtedly closed to the rest of the world and content with conventional processes, which is unfavorable to the achievement of SDGs 9 and 8. Finally, the fact that these players are closed to the rest of the world and to opportunities for socio-economic inclusion is confirmed by the second part of Table 11, which confirms that they participate at a reduced rate in public or NGO projects designed to strengthen their socio-technical capacities and access to financial assets ($\bar{x}$pct8=19.39%).

From the above, the preservation of socio-economic well-being, along with decent incomes and economic inclusion cannot be guaranteed for vegetable producers, traders or processors as themes 13.12, 13.21 and 13.22 of the GRI standard stipulate.

Conclusion

The eco-nutritional knowledge, attitudes and practices of producers, traders and processors in Accra's market-garden sector are evaluated at an overall average rate of 26.87% ($\bar{x}$pct) with regard to the socio-economic, health, ecological, technological and innovative dimensions of their activities taken together or singularly. In Ghana's first city, the sustainability gap to be bridged is 73.13% of knowledge and good practice to hope to achieve the sustainable development objectives in this sector by 2030. This poses a crucial problem, focusing on the implementation of an integrated, long-term eco-nutritional education program for all players in Accra's market garden supply chain, in order to make the sustainability efforts of Ghana's urban food systems more profitable.

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Authors' contributions

ASSINOU Kokou Elom: Project administration; Conceptualization; Methodology, software, investigation, Data curation, writing—original draft, analysis, validation

KPOTCHOU Koffi: Supervision, Conceptualization, writing—review, validation

All authors have read and agreed to published this version of the manuscript.

Conflicts of Interest

The authors declare that there is no conflict of interest

Institutional review board statement

The study was conducted in accordance with the guidelines of the Declaration of Helsinki and the provisions of the Research and Innovation Charter of the University of Lomé of June 9, 2020.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study. The principles of anonymity, confidentiality and the liberty to refuse or stop an interview in progress were respected.

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