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Eco-Nutritional assessment of the knowledge, attitudes and practices of producers, traders and processors in the market gardening sector of greater Lomé

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Abstract: Societal changes in the food sector are presenting the Greater Lomé Autonomous District (DAGL) with major sustainability challenges. However, the socio-economic, health, nutritional and ecological knowledge, attitudes and practices (KAPs) of stakeholders in solving these problems are only partially taken into account, even in the existing scientific literature. As such, the research aims to assess the level of health, socio-economic and environmental sustainability of market garden vegetable production, trade and processing in the Autonomous District of Greater Lomé (DAGL), based on the principles of nutritional ecology. Using a quantitative multi-criteria approach, 147 people were interviewed : 44 producers, 56 traders and 47 processors. Judgemental sampling was used to form the sample. The data collected by Kobocollect was processed using Excel, Arcgis and Google Earth Pro. Average scores and good KAP rates were calculated for stakeholders according to key aspects of sustainable development apprehension. The results show that in the DAGL, the rates for ecological (26.13%), health (33.71%), socio-economic (42.46), technological and innovative (22.93%) knowledge, attitudes and practices are low. They stand at 30.31%. These results are unfavorable to the achievement of the SDGs, and do not meet the principles of nutritional ecology and standard 13 of the Global Reporting Initiative (GRI) 2023. Hence the importance of designing and implementing an integrated, long-term eco-nutritional education program for all stakeholders.
Keywords: *Agri-food systems; cities, Eco-nutritional culture, Sustainability, Vegetable supply chain.*

1. Introduction

The sustainable transformation of urban food systems is, in modern times, one of the essential conditions for achieving sustainable development goals in both developed and low- and middle-income countries (DI, 2017, p. 9-12; A. James and V. Zikankuba, 2017; N. Pingault and al., 2017, p. 41). Lomé, Togo's capital, is no exception in terms of its adherence to this developmental approach, which serves as a benchmark for development policies and actors in sub-Saharan African countries, including urban centers.

Following the example of cities in other West African countries, the market garden supply chain in the Greater Lomé Autonomous District (DAGL) has the potential to contribute to reducing hunger, food insecurity (SDG1 and 2) and youth unemployment through job creation and income generation (SDG 8). Thus, the production, marketing and processing of market garden vegetables influence the balance of natural ecosystems (SDG 12, 14 and 15) and the socio-economic development of local communities (N. Sirdey and al., 2021, p. 1).

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In addition, these activities associated with the aforementioned food chain can provide small and medium-sized industrial units with raw materials, foster innovation and infrastructural development (SDG 9) through sustainable consumption and production patterns (SDG 12) (DI, 2017, p. 10).

However, the production, trade and processing of market garden vegetables are exposed to several socio-economic, health and ecological risks in Greater Lomé (M. Kanda and al., 2009).

Growers in Togo's largest city have limited access to credit, inputs and land. They lack the technical means and skills needed to properly use and control crop irrigation, preserve their produce and even use fertilizers and pesticides (Y. Adjrah and al., 2013; M. Kanda and al., 2014, p. 118-119; M. Kanda and al., 2017; M. Kanda and al., 2009, p. 361).

Soils are then at risk of infertility. Consumers, for their part, are not protected from the dangers of food contamination and poisoning (Y. Adjrah and al., 2011, p. 715-716; L.K. Agboyi and al., 2015; Y. Maehata and al., 2012). This depends on the fact that the latter consume food that contains residues of insecticides, herbicides, fertilizers and is poorly preserved from bacteria, parasites and viruses that can contaminate it. These problems can also be observed in the transportation, sale and processing of vegetables in the markets of Greater Lomé, as well as among street vendors.

To meet these issues, Togo has drawn on existing international, sub-regional and national development visions, as well as on the state of food and nutritional security in the country. Hence the country's involvement in a multitude of programs and projects to transform its food systems on the one hand, and on the other, the development of several policies, strategic plans and documents aimed at transforming its food systems.

Among the most recent and well-known are the Ten-Year Community Program for the Transformation of Agriculture for Food and Nutritional Security in the UEMOA (CCNUD: 2016-2025), the West African Food Systems Resilience Program (FSRP : Food System Resilience Program), the Food and Nutritional Insecurity Resilience Program in the Sahel (P2RS) , the Programme for the transition of agricultural and food systems to local areas (TERSAA), the Program to promote climate-smart agriculture in West Africa (AIC : 2020-2023), Project to support agro-ecological transition in West Africa (2017-2021), the Project to promote integrated school feeding models in West Africa (PPMIA-AO: 2023-2026), the Agroecological program in the Sahel and West Africa (PAAO: 2017-2021), the Programme régional d'investissement agricole et de sécurité alimentaire et nutritionnelle (PRIASAN: 2016-2020) and the Regional agricultural investment and food and nutrition security program (PPAAO: 2017-2021).

For the most part, this dynamic underpins the development and implementation of the Country Strategic Plan-Togo (2022-2026), Togo's national multi-sector nutrition strategic plan and, above all, the National Agricultural Investment Program for Food and Nutritional Security (PNIASAN 2017-2023). PNIASAN has enabled the implementation of the Project to support the agricultural sector (PASA) and the Agricultural Development Support Project in Togo (PADAT). The same applies to the Project to develop and rehabilitate 660 hectares of farmland in the Mission-Tové area (PARTAM), the Lower Mono River Valley hydro-agricultural development project (PBVM), the Integrated rural development project for the Mô plain (PDRI-MÔ), the Djagblé plain rural development projec (PDRPD), etc.

PNIASAN aims to increase agricultural productivity by 10% and smallholder incomes by 100% throughout the country. In line with this goal, between 2021 and 2023, Togo has created 222 agricultural development zones (ZAAP) covering 32,230 hectares, enabling the development of a project to promote market gardening in the country's rural and peri-urban centers.

As a continuation of the planned agricultural development under Ordinance no. 78-18 of May 17, 1978, the Agency for the Promotion and Development of Togo's Agropoles (APRODAT) was created by decree no. 2018-036/PR on February 27, 2018. To strengthen agricultural production, processing systems, access to credit and rural entrepreneurship capacities, the 2016-2018 Emergency Community Development Program (PUDC 2016-2018) was established and renewed in 2020, with a lower level of participation and involvement of the market gardening sector. Its realization requires the development of information systems and the improvement of basic socio-economic infrastructures, monitoring and evaluation mechanisms for the transformation of the population's living conditions and the reduction of social inequalities (PAM, 2019, p. 10). This prompted the establishment of the "Mechanism for Incentive Agricultural Finance based on Risk Sharing" (MIFA SA) in support of Togo's National Food Security Agency (ANSAT), the Institute for Technical Advice and Support (ICAT), the Togolese Institute for Agronomic Research (ITRA) and the Institute for Alternative Training for Development (IFAD) associated with the Education Development Agency (AED). As part of its commitment to the social protection of children, the Togolese government introduced an updated national school feeding policy in 2008, with the support of the World Food Program (WFP).

In this way, the country is working to build infrastructure, develop technology, create conditions to improve agro-avico-pastoral production and its viability, and strengthen its manufacturing capacities and human capital. On May 15, 2009, Togo enacted Law n°2009-007 on the Public Health Code of the Togolese Republic. This law prohibits the pollution of air, water and soil in the practice of any activity in the agri-food sector, and insists on hygiene in and around establishments and activities involving the production, sale, preservation, packaging, transport and provision of food-related services. Civil society organizations, for their part, are implementing initiatives such as the multi-sectoral Program for Food and Nutrition Security and Resilience Building (ProSecAl: 2015-2023).

They also stand out for their promotion of local processed and packaged food products (PALTC), and their awareness-raising campaigns on healthy, nutritious, adequate, balanced and varied diets. Nevertheless, most PNIASAN projects have focused on the rural areas bordering Togo's secondary towns, giving priority to the productive links to the detriment of the marketing and processing stages. In addition, the market gardening sector has benefited less from these viabilization initiatives than other sectors. Analysis of the implementation of these projects and programs has also revealed that the knowledge, attitudes and practices (KAP) of DAGL market garden vegetable producers, distributors and processors have been less taken into account during the implementation of these projects and programs with regard to food contamination or poisoning, pollution of aquatic and terrestrial ecosystems, food loss and waste, and the use of environmentally-friendly technologies and tools. Unlike developers and implementers of food system sustainability policies in Togo, several scientists have worked on the Greater Lomé market garden supply chain.

They have mainly focused on the following aspects of the market garden supply chain: productivity and diversity of vegetables (M. Kanda and al., 2014) ; producers' incomes, their access to funding (H.E. Julien and al., 2021), their socio-demographic characteristics, their practices in the use of phytosanitary products (M. Kanda and al., 2014); land tenure dynamics in productive areas (M. Kanda and al., 2017); hygiene, health and environmental challenges for producers, traders and street vendors alike (Y. Adjrah and al., 2013, p. 715-716; Y. Adjrah and al., 2011; L.K. Agboyi and al., 2015; K. Anani and al., 2013; A. Diallo and al., 2020; M. Kanda and al., 2012; M. Kanda and al., 2013; Y. Maehata and al., 2012). Other works have addressed the following issues: the trend dialectic of food transformations and permanencies (K. Kpotchou, 2018a) in Greater Lomé; eating out, food innovation, people's growing interest in soy consumption in Togo's main cities (K. Kpotchou, 2018b, 2020, 2021); cultural mixing relating to eating (K. Kpotchou, 2017); the use of social networks and food fears (K. Kpotchou, 2018a) ; the evolution of social values and symbols linked to food was also questioned on the basis of cynophagy (K. Kpotchou, 2013); representations of eating well in Greater Lomé (K.E. Assinou, 2020). But this last series of issues addressed focused more on questions relating to the behaviors of the final food consumer that Jean-Pierre Poulain calls the eater (2017).

In particular, the nutritional, health, innovative or technological knowledge, attitudes and practices of all members of the supply chain, excluding the consumer, have not been tackled at the same level as the challenges mentioned above. Nor have they been included in the implementation of projects and programs aimed at making this food system sustainable (DAGL's market garden sector). A good nutritional and ecological culture among producers, traders and processors in the Greater Lomé Autonomous District's market garden sector can have a lasting influence on values, knowledge and beliefs, and in turn, on changes in attitudes and risky behaviours linked to the food supply. It can help reduce food contamination along the Greater Lomé market garden supply chain, safeguard the health of all stakeholders, avoid food waste and the degradation of aquatic and terrestrial ecosystems, and make urban agriculture viable for the market gardeners of the cities in question (C.C. Tranchant and al., 2009).

From this perspective, nutritional ecology is an interdisciplinary scientific approach that studies food systems, focusing on the nutritional, health, socio-economic and environmental effects of the activities and practices of the actors who interact with them through their practices (C. Leitzmann, 2003; K. Schneider and I. Hoffmann, 2011, p. 1-2).

This leads to the following question: what is the level of knowledge, perceptions and practices of market garden vegetable producers, traders and processors in Greater Lomé with regard to the socio-economic, health and environmental well-being of their activities? In view of the exploratory data collected for this research, the following hypothesis is formulated: the actors supplying Greater Lomé with vegetables have low levels of knowledge and low rates of good practice in relation to the possible influences of their activities on socio-economic life, consumer health and the preservation of the natural ecosystems that support them.

On this basis, the aim of this paper is to assess the degree of social, environmental, economic and health sustainability of the production, sale and processing of market garden vegetables in Greater Lomé, in the light of the knowledge, attitudes and practices of the people involved, based on the principles of nutritional ecology, the Sustainable Development Goals and Standard 13 of the Global Reporting Initiative 2023 on the agriculture, aquaculture and fisheries sector.

2. Materials and Methods

2.1. Greater Lomé Autonomous District

The population base considered for the research is the Autonomous District of Greater Lomé (DAGL), a special territorial entity with legal personality and financial autonomy whose territorial jurisdictions, attributions and functioning are defined by Decree No. 2017-131/PR of November 15, 2017 in Togo. The DAGL covers a territory of 425.6 Km2 and includes thirteen (13) communes according to the aforementioned decree.

Two million seven hundred and sixty-seven thousand four hundred and sixteen (2,767,416) people, including one million sixty thousand five hundred and fifty-four (1,060,554) men and one million seven hundred and six thousand eight hundred and sixty-two (1,706,862) women inhabit the district (INSEED, 2022, p. 19, 22-30).

It is geographically framed by the Zio prefecture to the north, Ghana to the west, the Lacs prefecture to the east and the Gulf of Guinea to the south. Greater Lomé is Togo's main urban center, concentrating more of its population and providing the country's administrative, political and economic backbone (K.A. Biakouye, 2014, p. 69, 77-79). The DAGL is the result of the application of law no. 2022-011 of July 4, 2022, amending law no. 2007-011 of March 13, 2007 on decentralization and local government, amended by law no. 2018-003 of January 31, 2018, law no. 2019-006 of June 26, 2019 and law no. 2021-020 of October 11, 2021.

The table below shows the gender breakdown of DAGL residents by commune.

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Table 1.
Les communes du Grand Lomé.

Municipalities	Overall population		
	Total	**Male**	**Female**
Golfe 1 (Bè Est)	351 600	171 372	180 228
Golfe 2 (Bè Centre)	136 153	65 558	70 595
Golfe 3 (Bè Ouest)	52 769	26 480	26 289
Golfe 4 (Amoutivé)	155 842	76 501	79 341
Golfe 5 (Aflao Gakli)	169 993	80 221	89 772
Golfe 6 (Baguida)	181 561	88 390	93 171
Golfe 7 (Aflao Sagbado)	257 813	123 095	134 718
Agoè-Nyivé 1 (Agoè-Nyivé)	317 255	152 354	164 901
Agoè-Nyivé 2 (Légbassito)	128 164	62 263	65 901
Agoè-Nyivé 3 (Vakpossito)	47 554	22 621	24 933
Agoè-Nyivé 4 (Togblekopé)	154 431	77 024	77 407
Agoè-Nyivé 5 (Zanguéra)	704 087	60 765	643 322
Agoè-Nyivé 6 (Adétikopé)	110 194	53 910	56 284
Totals	2 767 416	1 060 554	1 706 862

Source: (INSEED, 2022).

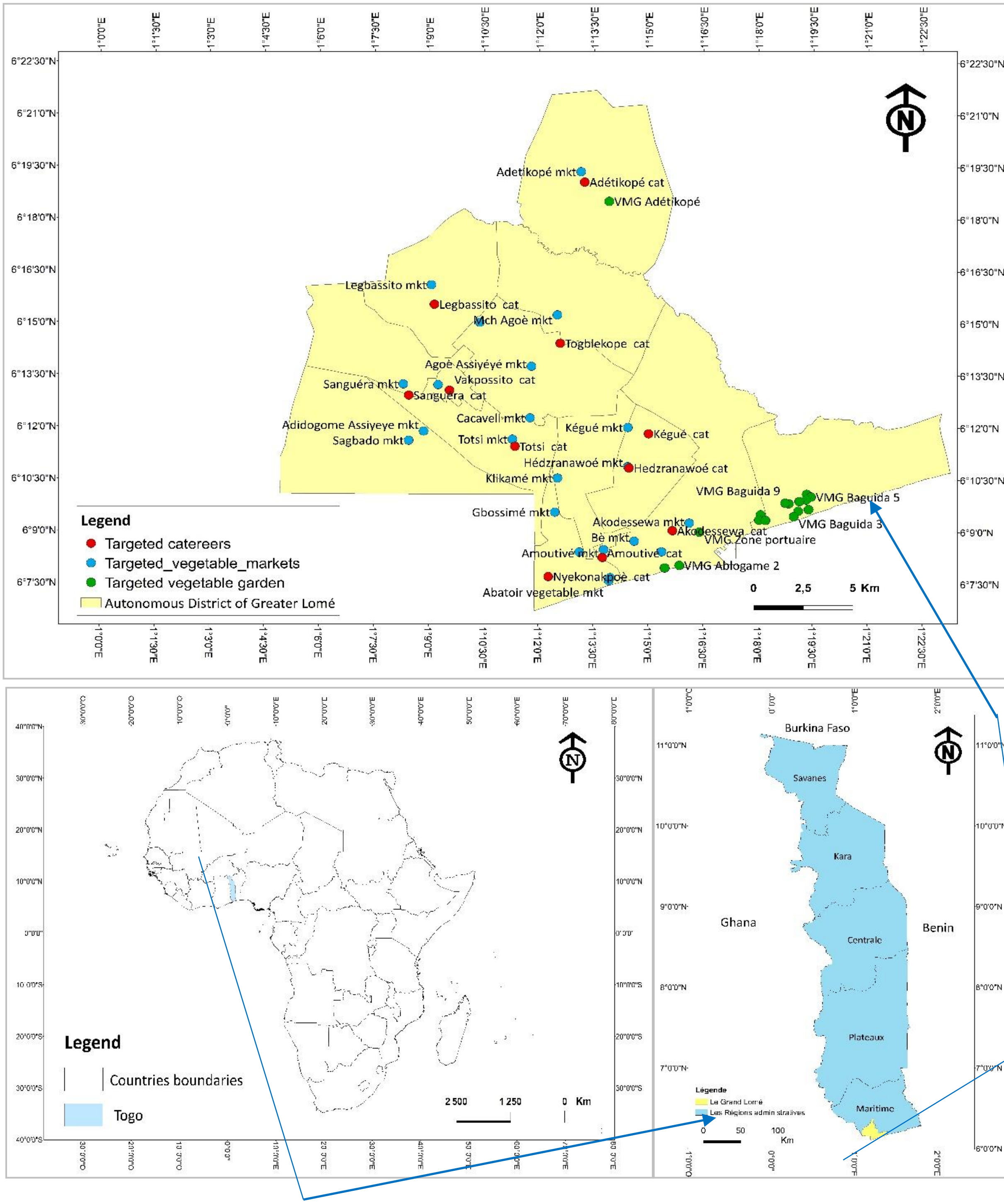

Figure 1.
Sites for collecting data from market gardeners, traders and vegetable processors in the DAGL.
Source: K. E. Assinou et K. Kpotchou 2024.

2.2. Research Methods, Techniques, Tools and Indicators

A multi-criteria analysis approach was used to assess the sustainability of vegetable production, commercialization and processing in Lomé, based on the knowledge, attitudes and practices of the stakeholders involved. This method was chosen because of the complex, multidimensional nature of agri-food chains in general, and the vegetable chain in particular (C.C. Esnouf and al., 2011, p. 179-180). This depends mainly on the fact that several actors interact in the Greater Lomé market garden supply chain. What's more, while they are producing, selling and processing vegetables for profit, their activities influence or are influenced by the agri-food environment (availability, physical and economic accessibility, food quality and safety) and consumer behaviour (purchasing choices, preservation, cooking, ingestion). These factors interact with natural ecosystems, socio-economic and political contexts, infrastructures, health conditions, technology and innovation.

A multitude of dimensions and principles were then taken into account in assessing the viability of the DAGL market garden supply chain. The following standards were used as references:

The consolidated set of Global Reporting Initiative 2023 standards (GSSB, 2023) ; the SA8000 standard of 2014 (SAI, 2014) ; 2010 ISO26000 standard (AFNOR, 2010) the Farm Sustainability Indicators method (la méthode Indicateurs de Durabilité des Exploitations Agricoles : IDEA4) (F. Zahm and al., 2023) ; Sustainability assessment framework adapted to the reality of Quebec biofood sectors/industries". (L. Tamini and al., 2020); the document « The top 100 questions of importance to the future of global agriculture » (J. Pretty and al., 2010).

The sustainability dimensions considered in the assessment, and the principles and indicators associated with them, are presented in the table below, in correspondence with the standards that underpinned them.

Table 1.
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

Durability dimensions	Guidelines	Standards	Indicators
			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)
			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

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

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

The questionnaire survey was used to collect the data required for the evaluation from market garden vegetable producers, traders and processors. Non-participatory direct observation was combined with the questionnaire survey. The same applies to the Global Positioning System (GPS).

2.3. Sampling

People working in the Greater Lomé vegetable supply chain constitute the basic research population. Vegetable growers, traders and processors who are at least 18 years old and who, in the DAGL, live in the Gulf or Agoè-Nyivé prefectures at least twelve (12) months prior to data collection are the statistical units targeted by the evaluation. More than 50% of respondents have five (5) years' experience in their respective activities. Those targeted by the research, who have less than one year's experience in the exercise of their activities, make up less than three (3) percent of the sample. Respondents are also questioned on the basis of their self-employed status, whether or not other people work for them, in order to gather reliable and relevant data in terms of results.

Producers are the male and female people composing the target population, who produce vegetables to be exchanged for money from a customer (trader, processor or final consumer), either on the production area, at the market, or at any other place where this economic exchange can take place.

Traders are the persons who buy and resell vegetables produced by market gardeners on a wholesale, semi-wholesale or retail basis, either near the farmers or near a wholesaler or semi-wholesaler.

Processors produce and sell dishes to the final consumer from vegetables purchased from producers or merchants of these products, either in raw form (vegetable salads), or as sauces to serve as accompaniments to dishes of cereals, tubers, legumes, etc.

The absence of a database led to the use of purposive sampling, in line with the approach of V.S. Kwol and al. (2020, p. 2-3) et de E. Babbie (2008, p. 203). According to J. Curwin and al. (2013, p. 116), judgmental sampling is not based on chance, but on the researcher's ability to select respondents on the basis of a logic conducive to building a valid sample. As stated by E.R. Babbie (2016, p. 187), it is hardly surprising that knowledge of the target population and its components, as well as the research objectives, underpin the composition of the sample under conditions similar to those described above.
One hundred and forty-seven (147) respondents were interviewed on the basis of the hypothetical normal distribution of sample values around the true value. The confidence level is therefore considered to be 95% and the accuracy level around 5%, with a degree of variability (P) of 0.5. This degree of variability reflects the fairly good homogeneity of the sample's sub-groups. Thus, referring to L. Kish (1965), the distribution of attributes around the mean is between 20% and 80%, allowing us to select a sample of between thirty (30) and two hundred (200) items. The one hundred and forty-seven respondents were distributed as follows: forty-four (44) market gardeners, fifty-six (56) vegetable traders and forty-seven (47) restaurant owners. The size of these sub-groups is defined with reference to S. Sudman (1976) et D.I. Glenn (1992) on comparative analysis. They proved that with observation numbers between twenty (20) and fifty (50) for each subgroup, extension of the results to the total population is possible. In this case, the number of sub-groups in the sample is over 80% of the maximum (50). The snowball technique was also used to reach respondents, enabling us to move from one market gardener to another, and to detect vegetable sales markets.

2.4. Data Collecting

The Kobokollect v2023.2.4 application was installed and used for data collection via tablets. A support team made up of seven (7) enumerators and two controllers was trained on 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. The aim of this training was to provide the data collection assistants with the tools they needed to master the questionnaires, and to familiarize them with all the sites, objects, actors and activities covered by the research. A pre-survey was then carried out to enable interviewers to become more familiar with data collection tools, particularly in local languages (Mina, Ewé, Kabyè). The right of respondents to refuse to be interviewed or to stop if the questions do not suit them was respected, as was the principle of confidentiality. The protection and security of data relating to their declarations and the exclusive use of information for research purposes were rigorously applied. Discussions with interviewees lasted between twenty (20) and thirty (30) minutes.

The targeted production sites are located on Lomé's Ablogamé-plage, Kangnikopé, Baguida and in the harbour area. These sites were chosen because they are the main places of market gardening activity in Greater Lomé. They contribute to strengthening urban capacities for food self-sufficiency and play a significant role in the economy and income generation for farmers in Togo's capital (S. Assibey-Yeboah and I. Koomen, 2019; R.K. Bannor and al., 2022).

The following markets are targeted : Hanoukopé market, Abattoir market, Atikpodzi market, Dekawowosime market, Akodessewa market, Gbossimé market, Klikamé market, Totsi market, Bè market, Amoutivé market, Kégué market, Hedzranawoé market, Agoè "Assiyéyé" market, Totsi market, Kélégougan market and Vakpossito, Legbassito, Sogbossito and Sagbado markets.

The vegetable processors interviewed were street food operators who agreed to give interviews to the data collection team in all areas where cooked vegetables are marketed. The sample did not include restaurant and hotel processors; this depends on the fact that the dishes served in these food places reach less of the majority of the population than those served by street food restaurants. It was also noted that in Greater Lomé, in relation to purchasing power, restaurants and hotels are less frequented by people from the middle and lower social classes (the majority of city dwellers) than those from the upper class (the minority in terms of numbers).

The research definition of vegetables is taken from the FAO (F. Beed and al., 2021, p. 2; FAO, 2021, p. 5). This international organization defines vegetables as "...the edible parts of plants grown or harvested in the wild, in their raw or minimally processed state". The table below outlines the categories of vegetables included and those excluded.

Table 2.
Categories of vegetables targeted by the research.

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.

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

2.5. Data Processing and Analysis

The information collected for the DAGL vegetable supply chain sustainability assessment was processed in Microsoft Office Excel 2019 spreadsheet software for producers, traders and processors. The Google Earth Pro application, version 7.3.6.9345, was used to convert GPS coordinates into landmarks for the areas covered by the data collection for each stakeholder category. The landmarks created, bearing the Keyhole Markup Language (kml) extension, were then converted into point layers in arcGIS Destop 10.8.2. These points were illustrated on the DAGL map. The data was processed according to the indicators defined for the research in relation to the sustainability dimensions considered (socio-economic, health, environmental, technological, innovative and governance aspects of the sector).

Drawing on M.N. Islam and al. (2023) et de N.A. Moreb and al. (2017), each correct knowledge, attitude or practice selected by a respondent is scored one (1) point. But the score is zero (0) for incorrect knowledge, attitudes and practices. Percentages of the right answers were calculated for all variable modalities, as the questions were essentially multiple-choice. Sustainability rates reaching fifty percent (50%) correspond to "acceptable sustainability scores" for each variable modality, variable and indicator. Sustainability is good if the percentage of valid answers is greater than or equal to seventy (70) percent; it is fairly good if this percentage is between fifty-one (50) and sixty-nine (69) percent. It is low or insufficient if the rate of correct answers is less than fifty (50) percent. In the research product tables, the percentage cells calculated for "correct" answers are colored red, yellow or green. Red refers to values below fifty (50) percent; yellow indicates proportions between fifty-one (51) and sixty-nine (69) percent and green shows that they are greater than or equal to seventy (70) percent.

For each variable, the arithmetic averages of the proportions of correct answers relating to the different aspects of sustainability (socio-economics, stakeholder health, food protection and preservation, environmental pollution, losses and wastage, technologies and innovations, governance) mentioned in Table 2 were calculated. These calculations considered the values of the variable modalities associated with each stakeholder category and with all of them. The following formulas were applied:

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- General formula : $\bar{x} = \bar{x}_{pct} = \sum x / n = \bar{x}_{p} + \bar{x}_{c} + \bar{x}_{t} / 3$
- Other formulas :
- $\bar{x}_{pct} = \bar{x}_{pct1} + \bar{x}_{pct2} + \bar{x}_{pct3} + \bar{x}_{pct4} + \bar{x}_{pct5} + \bar{x}_{pct6} + \bar{x}_{pct7} + \bar{x}_{p8} / 8$
- $\bar{x}_{p} = \bar{x}_{p1} + \bar{x}_{p2} + \bar{x}_{p3} + \bar{x}_{p4} + \bar{x}_{p5} + \bar{x}_{p6} + \bar{x}_{p7} + \bar{x}_{p8} / 8$
- $\bar{x}_{c} = \bar{x}_{c1} + \bar{x}_{c2} + \bar{x}_{c3} + \bar{x}_{c4} + \bar{x}_{c5} + \bar{x}_{c6} + \bar{x}_{c7} + \bar{x}_{p8} / 8$
- $\bar{x}_{t} = \bar{x}_{t1} + \bar{x}_{t2} + \bar{x}_{t3} + \bar{x}_{t4} + \bar{x}_{t5} + \bar{x}_{t6} + \bar{x}_{t7} + \bar{x}_{p8} / 8$
- $\bar{x}_{pct1} = \bar{x}_{p1} + \bar{x}_{c1} + \bar{x}_{t1} / 3$
- $\bar{x}_{pct2} = \bar{x}_{p2} + \bar{x}_{c2} + \bar{x}_{t2} / 3$
- $\bar{x}_{pct3} = \bar{x}_{p3} + \bar{x}_{c3} + \bar{x}_{t3} / 3$
- $\bar{x}_{pct4} = \bar{x}_{p4} + \bar{x}_{c4} + \bar{x}_{t4} / 3$
- $\bar{x}_{pct5} = \bar{x}_{p5} + \bar{x}_{c5} + \bar{x}_{t5} / 3$
- $\bar{x}_{pct6} = \bar{x}_{p6} + \bar{x}_{c6} + \bar{x}_{t6} / 3$
- $\bar{x}_{pct7} = \bar{x}_{p7} + \bar{x}_{c7} + \bar{x}_{t7} / 3$
- $\bar{x}_{pct8} = \bar{x}_{p8} + \bar{x}_{c8} + \bar{x}_{t8} / 3$

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

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

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

n, is the size of the averaged values;

$\bar{x}_{p}$, $\bar{x}_{c}$ et $\bar{x}_{t}$ 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 DAGL 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 eight (8) sustainability aspects : degree of awareness to the sustainability of the activity, socio-economics, health of the actors, food protection and preservation, losses and wastage, environmental pollution and waste management, technologies and innovations, Governance.

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

$\bar{x}_{p2}$, $\bar{x}_{c2}$ et $\bar{x}_{t2}$ are respectively the average proportions of socio-economic sustainability of vegetable activity, trade and processing ;

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

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

$\bar{x}_{p5}$, $\bar{x}_{c5}$ et $\bar{x}_{t5}$ are the average levels of sustainability linked, respectively, to the rates of producers', traders' and processors' good practices regarding agri-food losses and wastage;

$\bar{x}_{p6}$, $\bar{x}_{c6}$ et $\bar{x}_{t6}$ are the average proportions of sustainability linked 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 $\bar{x}_{t8}$ represent the average sustainability rates calculated respectively for the inclusive and participatory governance of the activities of producers, traders and processors in the DAGL 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 2022 and the Sustainable Development Goals of the United Nations 2030 Agenda.Findings and discussion

3. Results

3.1. Socio-Demographic Profiles of the Target Population

The following table basically breaks down the respondents by gender, age, level of education, length of experience in the activity, marital status, membership of a corporate organization and main field of vocational training.

According to the table above, in the Autonomous District of Greater Lomé (DAGL) vegetable supply chain, 72% of stakeholders at every step in the chain are women, while men account for just 28%. This high number of women in the DAGL vegetable supply chain is due to their representativeness in the "trade" (91%) and "catering" (85%) activities, where the presence of men is estimated at only 9 and 18% respectively. At the production stage, men outnumber women 65.7% to 35%. This can be understood as a gendered distribution of actors by type of activity, where the productive activity is dedicated to the male sex, while the trade and processing of what men produce is essentially carried out by women.

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Table 2.
Overview of respondents' socio-demographic characteristics.

	Producers		**Traders**		**Street caterers**		**All stakeholders**	
Breakdown of respondents by gender	**Headcount**	**Rate (%)**	**Headcount**	**Rate (%)**	**Headcount**	**Rate (%)**	**Headcount**	**Rate (%)**
Male	15	34,8	51	91,1	40	85,1	106,3	72,3
Female	29	65,2	5	8,9	7	14,9	40,7	27,7
Total	44	100,0	56	100,0	47	100,0	147,0	100,0
Breakdown of respondents by age	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)
18-25 years	4	9,1	9	16,1	10	21,3	23,0	15,6
26-35 years	11	25,8	15	26,8	13	27,7	39,3	26,8
36-45 years	12	27,3	17	30,4	15	31,9	44,0	29,9
46-55 years	11	24,2	10	17,9	5	10,6	25,7	17,5
56 years and more	6	13,6	5	8,9	4	8,5	15,0	10,2
Total	44	100,0	56	100,0	47	100,0	147,0	100,0
Breakdown of respondents by time spent in their field of business experience	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)
1 à 2 years	4	9,1	11	19,6	15	31,9	30,0	20,4
2 à 3 years	3	7,6	7	12,5	9	19,1	19,3	13,2
4 à 5 years	1	3,0	6	10,7	5	10,6	12,3	8,4
5 years and more	31	71,2	32	57,1	18	38,3	81,3	55,3
Total	44	100,0	56	100,0	47	100,0	147,0	100,0
Breakdown of respondents by education level	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)
Not instructed	13	30,3	15	26,8	8	17,0	36,3	24,7
Primary	7	15,2	17	30,4	7	14,9	30,7	20,9
Secondary school	21	47,7	18	32,1	28	59,6	67,0	45,6
High school	3	6,8	6	10,7	4	8,5	13,0	8,8
Total	44	100,0	56	100,0	47	100,0	147,0	100,0
Breakdown of respondents by Marital status	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)
Single	13	28,8	11	19,6	22	46,8	45,7	31,1
Cohabiting partner	3	7,6	5	8,9	3	6,4	11,3	7,7

Divorced	0	0,0	1	1,8	1	2,1	2,0	1,4
Engaged	0	0,0	1	1,8	1	2,1	2,0	1,4
Maried	21	47,0	36	64,3	16	34,0	72,7	49,4
Widower	7	16,7	2	3,6	4	8,5	13,3	9,1
Total	44	100,0	56	100,0	47	100,0	147,0	100,0
Number of dependents	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)
0	7	15,2	7	12,5	13	27,7	26,7	18,1
1-2	11	25,8	20	35,7	10	21,3	41,3	28,1
3-4	15	33,3	16	28,6	17	36,2	47,7	32,4
5 and more	11	25,8	13	23,2	7	14,9	31,3	21,3
Total	44	100,0	56	100,0	47	100,0	147,0	100,0
Breakdown of interviewees by membership of farmers' organizations	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)
1	11	25,8	12	21,4	2	4,3	25,3	17,2
2	0	4,5	1	1,8	3	6,4	4,0	2,7
3	0	0,0	1	1,8	0	0,0	1,0	0,7
4	2	69,7	0	0	0	0	2,0	1,4
5 and more	0	0,0	1	1,8	0	0,0	1,0	0,7
None	31	0,0	41	73,2	42	89,4	113,7	77,3
Total	44	100,0	56	100,0	47	100,0	147,0	100,0
Respondent distribution by professional training field	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)	Headcount	Rate (%)
Business and marketing	2	4,5	19	33,9	2	4,3	23,0	15,6
Agro-pastoral	12	27,3	1	1,8	1	2,1	14,0	9,5
Craft	8	18,2	5	8,9	6	12,8	19,0	12,9
Food service	1	3,0	5	8,9	26	55,3	32,3	22,0
Healthcare	1	3,0	2	3,6	0	0,0	3,3	2,3
Others	19	43,9	24	42,9	12	25,5	55,3	37,6
Total	44	100,0	56	100,0	47	100,0	147,0	100,0

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

In terms of age, 90% of respondents were between 18 and 55. This is true for all actors as well as for each category : farmers (86%), traders (91%) and processors (92%). This implies that the DAGL vegetable supply chain is made up of people in younger age brackets. Age is therefore an important factor in increasing the productivity and profitability of Greater Lomé's vegetable supply chain. In terms of experience, 55% of respondents have been working in the GLA vegetable supply chain for more than five (5) years; this rate is low at the vegetable processing stage (38%), but higher at the production (71%) and marketing (57%) levels. For all stakeholders, those with at least two (2) years' experience make up around 80% of the supply chain, including the 55% with more than five (5) years' experience. This means that we can simultaneously gather information on the knowledge and practices that are most deeply rooted in the daily lives of those interviewed, as well as those that are tending to emerge.

Regarding level of education, non-literate people represent 25% of the sample, i.e. a quarter. The remaining 75% were divided between 8% with higher education, 46% with secondary education and 21% with primary education. The fact that 54.4% of the sample had secondary or tertiary education may facilitate their adherence to the most recommended vegetable handling practices, in terms of the use of new technologies and innovations that can boost their productivity and profitability, as well as their ability to protect natural ecosystems and apply hygiene and health rules. This in turn is a factor that can positively influence the structuring of their knowledge, attitudes and practices in food production and post-production processes.

Of those involved in the Greater Lomé vegetable supply chain, 49% were married, while 41% were single (31%) or widowed (9%). What's more, 82% of the 147 respondents have at least one (1) dependent, and 54% of them support at least three (3) people. This rate is by no means less than 50%, even when considering the players at each level of the chain: producers (59%), traders (52%), processors (51%). In fact, married life and the number of people they have to look after can undermine the capacity-building possibilities of these players, as they may find it difficult to optimize their income and invest in updating or renewing their working equipment.

Now that the socio-demographic profiles of the respondents are known, what about the overview of their knowledge concerning the effects that their activities may have on the socio-economic, environmental, health, food and nutritional sustainability of the DAGL market garden sector?

Table 3.
Producers', processors' and traders' awareness of the socio-economic, environmental and health implications of their activities.

Actors	**Producers**		**Traders**		**Street caterers**		**All stakeholders**	
Scores	**Correct answers score**	**Total score**	**Correct answers score**	**Total score**	**Correct answers score**	**Total score**	**Overall score of correct answers**	**Overall total score**
Right answers/ Frequencies	Number of right answers	Fréquence (%)	Number of right answers	Fréquence (%)	Nombre bonnes réponses	Fréquence (%)	Score global	Fréquence globale (%)
Respondents' average level of knowledge of the sustainability factors directly influenced by their market gardening activity	105	352	139	448	82	376	326	1176
	8	29,73	8	31,03	8	21,81	8	27,69
Respondents' average level of knowledge of the sustainability elements indirectly influenced by their IGAs	35	220	49	280	22	235	106	735
	5	15,76	5	17,50	5	9,36	5	14,38
$\bar{x}_{p1}$ / $\bar{x}_{c1}$ / $\bar{x}_{t1}$ / $\bar{x}_{pct1}$	$\bar{x}p1$	22,74	$\bar{x}c1$	24,27	$\bar{x}t1$	15,59	$\bar{x}pct1$	21,03

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

3.2. Lack of Awareness of Sustainability Principles Among Vegetable Farmers, Traders and Processors in the DAGL

The average rate of awareness among DAGL vegetable producers, processors and traders regarding the direct (27.69%) or indirect (14.38) influence of their respective IGAs on socio-economic, health and ecological sustainability is low ($\bar{x}$pct1=21.03%). From most to least important, this rate is 24.27% for market garden vegetable traders, 22.74% for producers and 15.59% for processors. With regard to the modalities of the variables by which these results are obtained, the research shows that only 7% of the producers, traders and consumers surveyed are aware of the fact that their IGAs influence natural ecosystems. This rate is almost equal to the proportion at which the actors surveyed are aware of the possible influences of their activities on the variation of Gross Domestic Product (6.8%) and on the health well-being of consumers (18.6%). What these players are highly aware of is more related to their recognition of the contribution of their respective activities to the fight against hunger; they affirmed this at an overall average rate of 73.7%. Looking at this level of awareness by category, we found that it was well in excess of average among market gardeners (84.8% versus 73.7%), while among traders and processors it was 67.9 and 70.2 respectively. That said, the sanitary and ecological sustainability of the DAGL market garden supply chain may be difficult to achieve. Indeed, the low level of sanitary and ecological awareness of the actors questioned inevitably contributes to a bottleneck in the overall sustainability of the DAGL market garden supply chain.

Toutefois, la conscience de ces acteurs en ce qui concerne leur responsabilité sociale est moins préoccupante même si elle est quelque peu au seuil de la proportion générale moyenne de 50% chez l'ensemble des acteurs pris individuellement et singulièrement à l'exception des producteurs.

3.3. Fair Awareness of Social Responsibility in The DAGL Market Garden Supply Chain

The average level of social responsibility is low for all the categories of market garden vegetable supply actors in Greater Lomé ($\bar{x}$pct2=42.46%). This rate varies between 33.07% (processors, $\bar{x}$t2) and 54.55% (producers, $\bar{x}$p2), passing through an intermediate value of 40.83 (traders, $\bar{x}$c2). Only the average proportion relating to actors' awareness of their contribution to the national economy is good (75.28%). Whether it's the social responsibility of the respondents with regard to their working relationships with their employees (25.02) or with regard to the latter's health well-being and improved living conditions (40.82), the average level of awareness is below 50%. These data lead to the following statement: around 60% of respondents are not aware of their responsibility for the health and living conditions of their employees. This situation can have a negative impact on the socio-economic development of the sector, due to the risk of inequality and social injustice. Indeed, employers who ignore their social responsibility towards their employees in terms of health and living conditions jeopardize the efficiency of their work performance, and even the productivity of their business.

Considering the level of social responsibility within the Greater Lomé market gardening sector, doubts may already be raised as to the average level of knowledge of the players surveyed regarding the health risks inherent in their practices.

Table 4.
Awareness levels of stakeholders about their responsibility to society in their relations with their employees.

Actors	**Producers**		**Traders**		**Street caterers**		**All stakeholders**	
Scores	**Correct answers score**	**Total score**	**Correct answers score**	**Total score**	**Scores**	**Correct answers score**	**Total score**	**Correct answers score**
Right answers/ Frequencies	**Number of right answers**	**Fréquence (%)**	**Number of right answers**	**Fréquence (%)**	**Right answers/ Frequencies**	**Number of right answers**	**Fréquence (%)**	**Nombre bonnes réponses**
average level of awareness among stakeholders of their contribution to the national economy through their IGAs	41	44	45	56	25	47	111	147
	1	92,42	1	80,36	1	53,19	1	75,28
Average level of social responsibility awareness of stakeholders in their working relationship with their employees	71	132	29	168	11	141	111	441
	3	53,54	3	17,26	3	7,57	3	25,02
Respondents' average level of awareness about their social responsibility for the health and well-being of their employees.	32	88	50	112	38	94	120	294
	2	36,36	2	44,64	2	40,43	2	40,82
Stakeholders' average level of awareness regarding the social needs that market gardening/Vegetable sales/Vegetable catering can meet	41	88	30	112	35	94	106	294
	2	46,97	2	26,79	2	37,23	2	36,17
Average proportion of stakeholders adopting best practices to improve working and living conditions	57	132	59	168	38	141	154	441
	3	43,43	3	35,12	3	26,95	3	35,00
$\bar{x}_{p2}$ / $\bar{x}_{c2}$ / $\bar{x}_{t2}$ / $\bar{x}_{pct2}$	$\bar{x}p2$	54,55	$\bar{x}c2$	40,83	$\bar{x}t2$	33,07	$\bar{x}pct2$	42,46

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

Table 5.
Trends in actors' knowledge and best practices relating to health risks in the market gardening sector.

Actors	**Producers**		**Traders**		**Street caterers**		**All stakeholders**	
Scores	**Correct answers score**	**Total score**	**Correct answers score**	**Total score**	**Scores**	**Correct answers score**	**Total score**	**Correct answers score**
Right answers/ Frequencies	**Number of right answers**	**Fréquence (%)**	**Number of right answers**	**Fréquence (%)**	**Right answers/ Frequencies**	**Number of right answers**	**Fréquence (%)**	**Nombre bonnes réponses**
Average level of interviewees' good knowledge of the diseases that poorly controlled use of fertilizers and pesticides can cause in consumers	115	396	28	504	21	423	164	1323
	9	29,04	9	5,56	9	4,96	9	12,40
Average trend in relation to the main source of water used by players for cultivation/ Processing vegetables for sale/ cooking vegetables	95	132	22	56	19	47	136	235
	3	71,97	1	39,29	1	40,43	9	57,87
Average rate of correct crop water treatment practices for each player	0	44	6	112	18	94	24	206
	1	0,00	2	5,36	2	19,15	2	11,65
Average level of knowledge of market gardeners / Traders / Processors about the possible effects of growing / Processing / Cooking water on the quality of food / dishes produced / Served	4	44	5	56	1	47	10	147
	1	9,09	1	8,93	1	2,13	1	6,80
Average rates of trends in self-protection and vegetable protection measures taken by market gardeners/Traders for spreading or applying plant protection products/Treating, storing and displaying vegetables	64	176	6	112	0	423	70	288
	4	36,36	2	5,36	9	0,00	9	24,31

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Average rate of self-protection and food protection measures taken by restaurateurs to process, cook and present vegetables in dishes	0	44	0	56	20	188	20	188
	1	0,00	1	0,00	4	10,64	4	10,64
Average level of market gardeners' willingness to consider less hazardous phytosanitary products than those they usually use, for their own health and that of consumers	27	88	0	56	0	47	27	88
	2	30,30	1	0,00	1	0,00	9	30,30
Average frequency of safety checks on vegetables sold / During processing	0	44	35	56	34	47	69	103
	1	0,00	1	62,50	1	72,34	2	66,99
Average frequency of cleaning, washing and disinfecting sales/cooking, vegetable and food preservation and presentation tools	0	44	26	56	45	47	71	103
	1	0,00	1	46,43	1	95,74	2	68,93
Rate of use of good tools by retailers and processors to wash, clean and disinfect your vegetable storage and display tools	0	44	54	168	114	188	168	356
	1	0,00	3	32,14	4	60,64	2	47,19
$\bar{x}_{p3}$ / $\bar{x}_{c3}$ / $\bar{x}_{t3}$ / $\bar{x}_{pct3}$	$\bar{x}p3$	35,35	$\bar{x}c3$	25,69	$\bar{x}t3$	38,25	$\bar{x}pct3$	33,71

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

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Table 6.
Ensuring the protection and preservation of foodstuffs at the production, processing and marketing stages.

Actors	Producers		Traders		Street caterers		All stakeholders	
Scores	**Correct answers score**	**Total score**	**Correct answers score**	**Total score**	**Scores**	**Correct answers score**	**Total score**	**Correct answers score**
Right answers/ Frequencies	**Number of right answers**	**Fréquence (%)**	**Nombre bonnes réponses**	**Fréquence (%)**	**Right answers/ Frequencies**	**Number of right answers**	**Fréquence (%)**	**Nombre bonnes réponses**
Rate of use of suitable techniques for preserving vegetables for which there are no buyers	22	88	43	112	32	94	97	294
	2	24,62	2	38,39	2	34,04	2	32,88
Rate of good protection practices for vegetables on sale	0	44	94	168	0	47	94	168
	1	0,00	3	55,95	1	0,00	9	55,95
Levels of respondents' good knowledge of the effects of overuse of fertilizers, pesticides and herbicides on crop quality	25	88	0	56	0	47	25	88
	2	28,79	1	0,00	1	0,00	9	28,79
Levels of market gardeners' good knowledge of the possible effects of growing water on the quality of the food produced	31	176	18	112	0	94	49	288
	4	17,42	2	16,07	2	0,00	2	16,90
Level of best practices for protecting vegetables during transport (multiple)	0	44	70	112	0	47	70	112
	1	0,00	2	62,50	1	0,00	1	62,50
Average rate of adoption of good protection practices for chemicals or pathogenic microorganisms by stakeholders	0	44	0	56	67	141	67	141
	1	0,00	1	0,00	3	47,52	3	47,52
Average rates of practices to protect food from microbes and toxic products during presentation	0	44	0	56	68	141	68	141
	1	0,00	1	0,00	3	48,23	3	48,23
$\bar{x}_{p4}$ / $\bar{x}_{c4}$ / $\bar{x}_{t4}$ / $\bar{x}_{pct4}$	$\bar{x}p4$	23,61	$\bar{x}c4$	43,23	$\bar{x}t4$	43,26	$\bar{x}pct4$	41,82

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

Table 7.
Risks of loss and waste.

Actors	Producers		Traders		Street caterers		All stakeholders	
Scores	**Correct answers score**	**Total score**	**Correct answers score**	**Total score**	**Scores**	**Correct answers score**	**Total score**	**Correct answers score**
Right answers/ Frequencies	**Number of right answers**	**Fréquence (%)**	**Nombre bonnes réponses**	**Fréquence (%)**	**Right answers/ Frequencies**	**Number of right answers**	**Fréquence (%)**	**Nombre bonnes réponses**
Average rate of good management practices for vegetables in the start of mildew and putrefaction (Growers)	1	44	0	56	0	47	1	44
	1	3,03	1	0,00	1	0,00	1	3,03
Average rates of good handling practices for rotten, moldy or decaying vegetables (Growers)	13	44	0	56	0	47	13	44
	1	29,55	1	0,00	1	0,00	9	29,55
Average trends in respondents' desire to improve the resistance of their products to the effects of decomposition (Retailers) / Frequency of checks on dishes sold	0	88	70	112	41	94	111	206
	2	0,00	2	62,50	2	43,62	2	53,88
Average rates of good management practices for vegetables in the early stages of mildew and putrefaction (Producers)	1	44	0	56	0	47	1	44
	1	3,03	1	0,00	1	0,00	1	3,03
Average rates of good management practices for decayed vegetables (Producers)	13	44	0	56	0	47	13	44
	1	30,30	1	0,00	1	0,00	1	30,30
Average frequencies of cooked and raw food throwing	0	44	28	56	0	47	28	56
	1	0,00	1	50,00	1	0,00	1	50,00
Average rates of good management practices for leftovers of food served or prepared in excess	0	44	0	56	43	47	43	47
	1	0,00	1	0,00	1	91,49	3	91,49
Average frequency of throwing away cooked or raw food by caterers	0	44	0	56	29	47	29	47
	1	0,00	1	0,00	1	61,70	3	61,70
$\bar{X}_{p5}$ / $\bar{X}_{c5}$ / $\bar{X}_{t5}$ / $\bar{x}_{pct5}$	$\bar{x}p5$	16,48	$\bar{x}c5$	56,25	$\bar{x}t5$	65,60	$\bar{x}pct5$	40,37

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

3.4. Insufficient Knowledge on the Part of DAGL Producers, Traders and Processors of the Health Risks Associated with Their Practices

As much as awareness of social responsibility, the overall average rate of the degree of knowledge of DAGL market garden vegetable producers, traders and processors about the health risks carried by non-recommended practices in their processes is low ($\bar{x}pct3$= 33.71%). At the level of vegetable production and processing links, this degree of knowledge is respectively assessed at average rates of 35.35 ($\bar{x}p3$) and, 38.25% ($\bar{x}t3$) while it is 25.69% ($\bar{x}c3$) for traders. Without a shadow of a doubt, these results show that only 12.40% of players are aware of the fact that fertilizer and pesticide residues contained in vegetables can cause gastrointestinal pathologies, cancer, nervous disorders, even reproductive abnormalities, and so on. The same applies to the average rate of self-protection among market gardeners and traders; this concerns practices relating to the use of phytosanitary products on the one hand, and on the other, those linked to the storage, conservation and commercial display of vegetables (10.64%): wearing of gloves (14.03%); wearing of protective aprons or overalls (5.0%), wearing of boots (6.1%), mufflers (18.6%). Good water treatment practices used by all categories of operator are also rated at a low overall average (11.65%). Those who sell vegetables do so at 5.36%, while those who transform them into food do so at 19.15%. However, market gardeners don't treat the water used for cultivation, and don't think too much about using phytosanitary products that are less hazardous to their own health and that of consumers (30.30%). Meanwhile, the average rate of washing, cleaning and disinfecting vegetable storage and display equipment was 68.93%. The results presented in Table 7 show that the average levels of scores associated with good practices and knowledge of DAGL market garden supply chain actors on protecting their own health and that of consumers are below 50%. This highlights the existence or potential emergence of public health problems, either on a small or large scale. With regard to food protection and preservation, good practice rates are not at their best.

3.5. Insecure Food Protection in the DAGL Market Garden Supply Chain

The data in Table 8 highlight the low average proportion of vegetable garden protection in the DAGL food supply chain with regard to good practices, knowledge and perceptions of all stakeholders ($\bar{x}pct4$= 41.82%). At the production stage of the chain, this proportion is 23.61% ($\bar{x}p4$); it stands at 43.23% ($\bar{x}c4$) at the sales stage and 43.26% ($\bar{x}t4$) at the restaurant level. At the same time, the average rate of adoption of good preservation practices for hard-to-sell raw or cooked vegetables is also below 50%, at 32.88% : placing under humidity (26.3%), refrigeration or freezing (18.4%), drying (6.3%), ... In particular, growers have little significant knowledge of the harmful effects of the abusive use of pesticides on crops (28.79%): trace of fertilizers in vegetables (10.4%); excess minerals (2.3%); pollution of ground and surface water (4.1%) .... No less true is their level of knowledge about the sources of water they use and the sanitary quality of the produce (16.90%) : pollution (2.7%), contamination (3.4%). The following deduction can be made from the data in Table 8 : market garden vegetables are exposed to unavoidable risks of pollution and contamination due to the lack of knowledge stakeholders have regarding the adoption of practices necessary for their sustainable protection. This brings to mind the challenges of food loss and waste that may arise, which is not likely to support efforts to transform food systems in Togo, particularly in the DAGL.

3.6. Differences Between Levels of Protection Practices and Food Losses in the DAGL Vegetable Supply Chain

Following the example of the tables verifying the previous indicators, the general average rate of adoption of practices that could help avoid loss and waste is insufficient ($\bar{x}pct5$ = 40.37%). Nevertheless, this average rate is acceptable at the trade ($\bar{x}c5$=56.25%) and vegetable processing ($\bar{x}t5$ = 65.60%) stages, whereas it is very low at the production link of the chain ($\bar{x}p5$=16.48%). These figures are based on the following trends: 62.5% of retailers would like to improve the resistance of the products they sell to putrefaction; good food disposal practices are adopted by 50% of retailers and 61.70% of processors, while those relating to the efficient management of leftovers are at an average rate of 91.49% among restaurateurs. Despite these results, it should be noted that vegetables in the early stages of putrefaction and moulding (3.03%) or mouldy and putrefied vegetables (29.55%) are subject to less than recommended practices. In fact, at the production stage, good management practices for vegetables in the early stages of putrefaction are 3.03%, but 29.55% for putrefied or mouldy vegetables. The risks of loss and waste are therefore not negligible in the DAGL vegetable supply chain. These risks of loss can be assimilated to loss of earnings in terms of the income that the players would have earned in the absence of these risks.

3.7. Ecological Insensitivity, Technico-Innovative Obliviousness and Participative Dysfunction in the DAGL Market Gardening Sector

Table 10 shows insignificant levels of knowledge when it concerns the adoption of good practices on the part of producers, traders and restaurateurs in the DAGL market garden supply chain ($\bar{x}c5$=26.13%). This rate, well below 50%, is far from helpful in preserving the balance of natural ecosystems. At production system level, this average rate is evaluated at 24.12% ($\bar{x}p6$) and does not deviate too much from those of the marketing (21.88%) and vegetable processing (29.06%) stages. As an example, reading the table shows that only 25.25% of growers know that intensive weeding and ploughing can be inopportune to the preservation of mineral elements making up and balancing the soil. Though this rate is higher (41.41%) as regards growers' awareness of the deleterious effects of pesticide misuse on soils, the state of insufficiency remains a challenge. The same applies to the percentage of growers who are aware of the harmful effects of over-use of fertilizers and pesticides on water, air and climate quality (21.97%). We also note that only 25.76% of growers have already had the idea of producing vegetables using less polluting inputs, while at the same time boosting their profitability. Even the rates of good practice associated with rebus management are low among all actors in the DAGL vegetable supply chain, ranging from 9.75% (organic waste) to 32.65% (inorganic waste).

This is reflected in the response rates chosen by respondents: with regard to the management of organic waste, for example, very few respondents (12.9%) think that it can be resold to breeders; the same applies to its transformation into compost (10%). At the same time, 59.61% of respondents throw organic waste in the garbage can without taking any initiative to recycle it. In view of these results, the risks of pollution or degradation of natural ecosystems within this sector are significant, and can be a source of the spread of diseases resulting from unhealthy conditions. The same is true for the high contribution of these activities to increasing greenhouse gas emissions, without significantly improving productivity or the socio-economic living conditions of those involved.

Table 8.
Pollution environnementale et gestion des déchets.

Actors	**Producers**		**Traders**		**Street caterers**		**All stakeholders**	
Scores	**Correct answers score**	**Total score**	**Correct answers score**	**Total score**	**Scores**	**Correct answers score**	**Total score**	**Correct answers score**
Right answers/ Frequencies	**Number of right answers**	**Fréquence (%)**	**Nombre bonnes réponses**	**Fréquence (%)**	**Right answers/ Frequencies**	**Number of right answers**	**Fréquenc e (%)**	**Nombre bonnes réponses**
Average levels of market gardeners' good knowledge of the effect that high doses of fertilizers, herbicides, pesticides and fungicides can have on the soil.	55	132	0	168	0	141	55	132
	3	41,41	3	0,00	3	0,00	1	41,41
Average level of respondents' knowledge of the effects of intensive ploughing and weeding on soil quality	33	132	0	168	0	141	33	132
	3	25,25	3	0,00	3	0,00	1	25,25
Average levels of knowledge among market gardeners about the effects that overuse of fertilizers, pesticides and herbicides can have on water, the atmosphere and the climate.	39	176	0	224	0	188	39	176
	4	21,97	4	0,00	4	0,00	1	21,97
Average trends in the use of plant protection products, which are less polluting but more productive than chemical fertilizers (Producers)	34	132	0	168	0	141	34	132
	3	25,76	3	0,00	3	0,00	1	25,76
Average rates of good organic waste management practices in the Greater Lomé market garden supply chain	13	88	10	112	6	94	29	294
	2	14,39	2	8,93	2	6,38	2	9,75
Average levels of proper treatment of inorganic waste (Paper, plastics,	14	88	39	112	43	94	96	294

metals, textiles, etc.) from the market garden vegetable supply chain in Lomé	2	15,91	2	34,82	2	45,74	2	32,65
$\bar{x}_{p6}$ / $\bar{x}_{c6}$ / $\bar{x}_{t6}$ / $\bar{x}_{pct6}$	$\bar{x}p6$	24,12	$\bar{x}c6$	21,88	$\bar{x}t6$	26,06	$\bar{x}pct6$	26,13

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

Table 9.
Degrees of technological sustainability, innovation and participatory management of the market gardening sector.

Actors	**Producers**		**Traders**		**Street caterers**		**All stakeholders**	
Scores	**Correct answers score**	**Total score**	**Correct answers score**	**Total score**	**Scores**	**Correct answers score**	**Total score**	**Correct answers score**
Right answers/ Frequencies	**Number of right answers**	**Fréquence (%)**	**Nombre bonnes réponses**	**Fréquence (%)**	**Right answers/ Frequencies**	**Number of right answers**	**Fréquence (%)**	**Nombre bonnes réponses**
Average levels of good mechanization practices in the production system	49	308	0	392	0	329	49	308
	7	16,02	7	0,00	7	0,00	7	16,02
Average levels of good digitization practices in the production system	70	176	0	221	0	188	70	176
	4	39,58	4	0,00	4	0,00	1	39,58
Average levels of good digitization practices in the market garden vegetable sales system	0	132	15	168	0	141	15	168
	3	0,00	3	8,93	3	0,00	3	8,93
Average levels of digitization practices in vegetable processing and food sales activities	0	176	0	224	13	188	13	188
	4	0,00	4	0,00	4	6,91	4	6,91
Average use of social networks in production/Marketing or restoration processes in the Greater Lomé market garden supply chain	7	44	12	56	18	47	37	147
	1	16,67	1	21,43	1	37,59	1	25,17
Average levels of application use in vegetable production/Sales/Processing processes	0	44	0	56	0	47	0	147
	1	0,00	1	0,00	1	0,00	1	0,00
Average number of good reasons for	19	88	19	112	0	94	38	200

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using social networks or applications in the vegetable production and sales process	2	21,97	2	16,96	2	0,00	2	19,17
Average number of good reasons for using social networks or applications in the processing and sale of market garden vegetables	9	176	0	224	75	188	75	188
	4	5,11	4	0,00	4	39,72	3	39,72
Average trends in the use of equipment in the vegetable processing and presentation process	0	44	0	56	17	47	17	47
	1	0,00	1	0,00	1	35,46	3	35,46
Average trends in perceptions of possible harmful effects of food processing machinery on the environment	4	44	4	56	18	47	18	47
	1	9,09	1	7,14	1	38,30	3	38,30
$\bar{x}_{p7}$ / $\bar{x}_{c7}$ / $\bar{x}_{t7}$ / $\bar{x}_{pct7}$	$\bar{x}p7$	15,71	$\bar{x}c7$	11,83	$\bar{x}t7$	26,33	$\bar{x}pct7$	22,93
Actors	Producers		Traders		Street caterers		All stakeholders	
Scores	Correct answers score	Total score	Correct answers score	Total score	Scores	Correct answers score	Total score	Correct answers score
Right answers/ Frequencies	Number of right answers	Fréquence (%)	Nombre bonnes réponses	Fréquence (%)	Right answers/ Frequencies	Number of right answers	Fréquence (%)	Nombre bonnes réponses
Number of players involved in a public project to support their operations, technical/Financial/Logistical organization, etc.	14	88	10	112	3	94	27	294
	2	15,53	2	8,93	2	3,19	2	9,07
Number of associations with a local project run by a civil society organization(s) in support of market gardeners	6	88	3	112	47	94	56	294
	2	6,82	2	2,68	2	50,00	2	19,05
$\bar{x}_{p8}$ / $\bar{x}_{c8}$ / $\bar{x}_{t8}$ / $\bar{x}_{pct8}$	$\bar{x}p8$	11,17	$\bar{x}c8$	5,80	$\bar{x}t8$	26,60	$\bar{x}pct8$	14,06

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

Table n°11 shows the existence of a strong technological and innovative deficiency in the DAGL market garden supply chain. The overall average rate of correct answers obtained is below 23%, i.e. 22.93% ($\bar{x}pct7$) for the three categories of actors.This rate is limited to 26.33% among processors ($\bar{x}t7$), but falls further among growers 15.71% ($\bar{x}p7$) and market garden vegetable traders ($\bar{x}c7=11.83\%$). The average percentage of mechanization is very low in the productive system of this supply chain (16.02%) even though this rate is higher (39.58%) in terms of digitization. The average proportion of digitization is below 10% at the marketing (8.93%) and processing (6.91%) stages. Furthermore, for all three players, the use of social networks is limited to an overall average percentage of 25.17%. This rate is lower at the production (16.67%) and vegetable sales (21.43%) stages than at the processing stage (37.59%). As for the use of computer or mobile applications in this supply chain, the average rate is zero among producers, traders and processors alike, i.e. 0% at all levels. The average scores for good reasons given by players for their use of social networks in the DAGL vegetable sector were 21.97% for producers, 16.96% for traders and 39.72% for processors. The use of equipment in vegetable processing is estimated at an average of 35.46%. Even food processing has not been modernized to any great extent, as restaurateurs who stated that they use equipment to boost their production capacity and gain in production quality or time only came in at an overall average of 35.46%.

The low rates of mechanization and digitization of vegetable production in the DAGL show that 83.98% of farmers are still using outdated or obsolete tools, techniques and knowledge for vegetable production. These data most probably reflect the slowness associated with the production process, the low qualification of the workforce and the amateurish exploitation of the space and inputs they have at their disposal. This can have a major impact on their productivity, reducing their income and their ability to meet even their most basic needs. The low level of digitization of market gardening and post-harvest activities also represents a major loss of earnings for all these stakeholders, since the digitization of their activities could, to a certain extent, enable them to raise their profile, increase their customer base, optimize the quality of production at market-gardener level, while making marketing and catering services more in conformity with buyers' needs. This is confirmed by the high average rate of market garden supply chain actors (74.83%) who do not use social networks as a tool for getting in touch with their collaborators, like suppliers and potential customers. This interpretation of the results is confirmed by the fact that over 99% of respondents do not use digital broadcasting applications or platforms. Yet these tools could enable them to work in communities of professionals, increasing their opportunities in terms of experience sharing, access to training and retraining, and access to inputs or financing.

In the second part of the table, sustainability linked to the participative operation and organization of the market garden supply chain is also very low. Among producers, the average proportion who claimed to have benefited from an initiative or project carried out by the public authority, aimed at improving their technical, financial, etc. capacities is only 11.17% ($\bar{x}p8$) versus 5.80% ($\bar{x}c8$) for traders and 26.6% ($\bar{x}t8$) for processors, corresponding to an average rate of 14.06% ($\bar{x}pct8$). In fact, the people involved stated that public projects dedicated to strengthening their capacities are low :15.53% for producers; 8.93% for traders and 3.19% for processors, giving an average rate of 9.02%. With regard to the implementation of projects launched by civil society initiatives to improve the technical, human and financial capacities of stakeholders, the rates are also low for the production (2.68%) and sales (2.68%) links, while it is 50% for processors. However, the overall rate for all links in the chain is limited to 19.05%.

At this stage, the results show that 85.94% of the surveyed stakeholders affirmed that they had not benefited from any projects or initiatives from the sector's public services or from civil society actors. This means that the majority of players in the Greater Lomé vegetable supply chain have no opportunity for training, retraining or access to opportunities that could enable them to improve the productivity and profitability of their Income-Generating Activities (IGAs).

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4. Results Discussion

The research results reveal that the overall average rate of correct answers relating to the analysis of the socio-economic, health (food and nutritional) and environmental sustainability of the Autonomous District of Greater Lomé (DAGL) market garden supply chain is 30.31% ($\bar{x}$pct). This rate, being well below 50%, is low. This research-derived product falls far short of satisfactorily meeting the sustainability criteria and principles associated with Standard 13 of the Global Reporting Initiative 2023 relating to the agriculture, aquaculture and fisheries sector. The same applies to the Sustainable Development Goals (SDGs) of the United Nations Agenda 2030, to the international food standards of the Codex Alimentarius (FAO/WHO, 2017, 2022, 2023a, 2023b) and to the basic principles of the theory of nutrition ecology defined above (GSSB, 2023; C. Leitzmann, 2003; K. Schneider and I. Hoffmann, 2011; UN, 2017) (FAO/WHO, 2017, 2022, 2023a, 2023b; GSSB, 2023; C. Leitzmann, 2003; K. Schneider and I. Hoffmann, 2011; UN, 2017).

The discussion revolves around findings related to key dimensions of sustainability. The first result relates to the key aspects of sustainability considered for the research, but the correct answers were only selected at an average proportion of 21.03% of scores ($\bar{x}$pct1: table no. 5). The majority of respondents are therefore unaware (72.31%) of the direct influence of practices relating to their activities on natural ecosystems, biodiversity, their income, food and nutritional security, Gross Domestic Product (GDP), their own health as well as that of consumers. As a result, there is a high risk that the chain's vegetable production, marketing and processing practices are neither compliant with GRI 13 nor conducive to achieving the 17 sustainable development goals.

Similarly, stakeholders' level of consciousness with regard to their socio-economic responsibility is also dissatisfactory being below 50% ($\bar{x}$pct2 = 42.46%). While 75.28% of respondents know that their IGAs contribute to the national economy, 40.82% of them do not feel concerned about improving the health, living and working conditions of their employees. What's more, only 35% are thinking of developing strategies to improve their own working and living conditions. These results do not respond favorably to the elimination of social inequalities as advocated by SDG10; nor are they encouraging in terms of achieving SDG8, which generally aims to "Promote sustained, shared and sustainable economic growth, full and productive employment and decent work for all". These results are also in contradiction with the recommendations of themes 13.12, 13.21 and 13.22 of the GRI standard, as well as those stemming from the work of R. Vos and A. Cattaneo (2021) on the contribution of poverty reduction to the sustainability of the food supply. They are far from the socioeconomic inclusion promoted by public policies to improve food systems in West Africa.

A reading of Table 7 confirms this trend in results by the low level of the average rate of players' knowledge of the health risks relating to their activities ($\bar{x}$pct3=33.71%). However, only 12.40% know that the consumption of food containing traces of pesticides exposes the end consumer to cancerous, nervous, cardiovascular pathologies; several existing research results have reported this (D.P. Abrol and U. Shankar, 2014; A. Aggrawal, 2006; A. Ahamad and J. Kumar, 2023; U. Bajwa and K.S. Sandhu, 2014; I. 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, some 65.69% of the players surveyed do not wear clothing to protect themselves or their food from contamination, even though good practices for washing, cleaning and disinfecting tools for storing, displaying, cooking or presenting vegetables are only chosen at a rate of 68.93%. Vegetable protection at the production, marketing and processing stages is also poor, as Table 8 illustrates ($\bar{x}$pct4=41.82%). So, the choice of correct answers regarding vegetable preservation practices that don't quickly find buyers stands at 32.88% for all actors. With regard to recommended practices for storing and protecting the vegetables sold against dust, rodents, toxic products, etc., the correct answers were chosen by 62.50%. Players in this sector therefore risk endangering the health of consumers of their products due to the risks of contamination by parasites, viruses or pathogenic bacteria they face in this situation situation (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, 2014). But this is not likely to contribute to achieving SDG 3: "enabling all people to live in good health and promoting well-being for all at all ages". 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) have already discussed this in their research on health hazards related to vegetable and fruit consumption.

Furthermore, this result is contrary to the principle of preserving food safety (GRI theme 13.9 and Codex Alimentarius Code of Hygienic Practice for Fresh Fruit and Vegetables). Nor does it guarantee the observance of health regulations to protect the consumer against contamination, disease, poisoning and pollution (GRI theme 13.10 and CXC 1-1969 of the Codex Alimentarius). Even the preservation of health and safety at work (theme 13.19) are not principles to which the research results respond, as recommended by GRI standard 13 and Codex Alimentarius codes CXC 53-2003, CXC 1-1969, CXC 56-2004 and CXC 44-1995. G.I. Balali and al. (2020) and J. Waage and al. (2022) have produced similar analyses of microbial contamination and the growth of health threats associated with fruit and vegetable consumption.

Given the low rate of good practice in the treatment of vegetables at the first signs of spoilage (3.03% among growers and 29.55% among traders) or in the valorization of rotten vegetables (31.75% among traders and 32% among growers) through processing, the risks of loss and waste are also high. These results, presented in Table 9, lead to the reasoning that losses and wastage in the DAGL vegetable supply chain represent a loss of earnings for growers, traders and processors, since the proper preservation of produce saves it from rotting. Even if deterioration does occur, and forces the players to sell their produce at a lower price or to process it for resale in a useful form, this would help to preserve their environment from pollution and reduce greenhouse gas emissions from organic waste. It would therefore serve to protect their income by minimizing losses ("SDG8") and reinforcing sustainable consumption ("SDG12"). 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) have also conducted research into the sustainability drawbacks and benefits of loss and waste in food supply chains.

The ecological sustainability of the supply of market garden vegetables has an overall non-significant average rate ($\bar{x}pct6$=26.13%) in the DAGL. This result is confirmed by the fact that few market gardeners are aware that excessive dosing of pesticides and fertilizers (41.41%) or intense ploughing (25.25%) can degrade the soil's mineral constitution and reduce its fertility rate. Organic and inorganic waste management practices can also bring added value, but only in tiny proportions (9.77% for organic waste and 32.65% for inorganic waste). This causes pollution of air and water resources, soil degradation and reduces biodiversity in the DAGL vegetable supply chain. This is a significant barrier to the achievement of SDG 6, which calls for the responsible use of water resources and the sustainable management of sanitation. Achieving SDGs 14 and 15 may also be difficult under these conditions. This is due to the risks of pollution and degradation to which aquatic and terrestrial ecosystems are exposed through the inefficient management of chemical and organic waste from fertilizers and pesticides used, or rotting vegetables (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 also fall far short of the sustainability requirements of GRI 2023 Standard 13, which rejects harmful greenhouse gas emissions (Theme 13.1), the destruction of biodiversity (Theme 13.3) and the degradation of natural ecosystems (Theme 13.4). The principles relating to soil health (Theme 13.5), the abusive or uncontrolled use of pesticides (Theme 13.6), water pollution (Theme 13.7) and inappropriate waste management (Theme 13.8) are also concerned. The same is true of Codex Alimentarius codes CXC 1-1969, CXC 53-2003 and CXC 56-2004 (FAO/WHO, 2017, p. 7-9,11; FAO/WHO, 2023b, p. 4-5).

The total average rate of correct answers from the producers, traders and processors questioned concerning the development of innovative ideas, digitization, mechanization of tasks or the use of social networks doesn't tend towards the desired sustainability either when compared to those above. It stands at 22.93% ($\bar{x}$pct7). At a time when new information and communication technologies are dominating and determining the performance of many IGAs around the world, it is irrefutably obvious that the DAGL market gardening sector needs a great deal of catching up in terms of productivity, profitability and improving the working and living conditions of the stakeholders. Producers, traders and processors, undoubtedly isolated from the rest of the world as shown in table n°11, prefer to keep to their traditional IGA processes, which is not conducive to achieving SDGs 9 and 8. Finally, the melting pot between market garden supply chain actors in Greater Lomé and the rest of the world cuts them off from opportunities for socio-economic inclusion. The second part of table n° 11 shows this, since they participate at low rates in public projects or those initiated by NGOs for their attention in order to strengthen their socio-technical capacities and access to financial assets ($\bar{x}$pct8=14.06%).

From the above, contrary to the provisions of themes 13.12, 13.21 and 13.22 of the GRI 2023 standard, the preservation of socio-economic well-being, along with decent incomes and economic inclusion cannot be guaranteed for vegetable producers, traders or processors.

5. Conclusion

The eco-nutritional knowledge, attitudes and practices of vegetable supply chain producers, traders and processors in the Autonomous District of Greater Lomé (DAGL) are assessed at an average overall rate of 30.31% ($\bar{x}$pct) with regard to the socio-economic, health, ecological, technological and innovative aspects of their activities. In Togo's leading urban agglomeration, the sustainability gap to be bridged is 69.69% in knowledge and good practices if we hope to achieve sustainable development objectives in this sector by 2030. This underscores the crucial need for integrated, ongoing eco-nutritional education for all stakeholders in the DAGL vegetable supply chain, in order to make efforts to make Togo's food systems more viable.

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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
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