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Adoption of Agroecological Practices by Smallholder Farmers: Opportunities, Influencing Factors and Barriers in Urban and Peri-Urban Senegal

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Abstract

Market gardening plays a central role in food security and improving household income in Ziguinchor, Senegal. Faced with growing environmental and socio-economic challenges, agroecology emerges as a sustainable pathway for strengthening this agro-economic activity. This study evaluates the adoption of agroecological practices by urban and peri-urban market gardeners, identifying influencing factors and constraints. A survey of 300 farmers was conducted in Ziguinchor, and data were analyzed using Excel. Relative Importance Index (RII), Weighted Average Index (WAI), and Problem Confrontation Index (PCI) ranked the most used practices, influencing factors, and adoption barriers. Results show that 79.67% of respondents were women, mostly over 45 with secondary education. Most of market gardeners consider this activity main source of income, and have been doing so for more than 10 years. Common agroecological practices include: removing weeds and diseased plants, organic fertilization, watering, crop rotation, and recommended fertilizer application, with relative importance indices of 0.75, 0.75, 0.72, 0.73, and 0.62, respectively. Key constraints include the lack of labor (PCI=789), lack of information and training (PCI=597), high cost of improved seeds (PCI=549), and limited access to organic fertilizer (PCI=538). Reinforcing extension services, capacity building, and both technical and financial support is essential to promote agroecological practices.

Keywords: agroecological practices; adoption; obstacles; enabling factors; market gardeners

1. Introduction

The issue of food security is becoming increasingly complex and worrying in a world where the population is growing rapidly and consumption needs are increasing [1]. In fact, in 2023, approximately 2.33 billion people worldwide were experiencing moderate or severe food insecurity. These food crises are often the result of known factors such as conflicts, economic shocks, food price spikes, climate change, and droughts, which have had a particularly severe impact on African countries [2]. According to the March 2024 Harmonized Framework analysis published by the Permanent Inter-State Committee for Drought Control in the Sahel (CILSS), approximately 55 million people in West and Central Africa have been food insecure during the June-August 2024 lean season [3]. In Senegal, the interior and southern regions are particularly affected, with 20 departments vulnerable to chronic food insecurity. In Sedhiou, 29% of the population is affected, while in

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Kédougou, Kaffrine, and Tambacounda the rates are over 25% [4]. Faced with sustained population growth from 13,508,715 inhabitants in 2013 to 18,126,390 inhabitants in 2023 [5,6] and environmental challenges, ensuring sufficient and sustainable agricultural production is becoming a priority. Agriculture, which remains a pillar of the Senegalese economy, employs more than 60% of the working population and accounts for 15.74% of gross domestic product (GDP) in 2022 [7]. In 2021-2022, national horticultural production reached 1.6 million tons, of which 106,000 tons were exported, generating more than 75 billion CFA francs [8]. Among the various agricultural activities, market gardening plays a crucial role in the local economy, both in rural and urban areas, particularly in the Ziguinchor region. It not only improves food security but also generates income. However, the predominance of conventional agricultural practices raises many concerns today. It is being questioned because of its intensive nature, which depletes the soil and is therefore unsustainable [9]. On the one hand, the intensive use of chemical inputs (synthetic fertilizers, pesticides, herbicides) has various negative impacts on the soil, the most significant of which are the disruption of biological activity, deep soil compaction, and increased susceptibility to erosion [10,11]. According to [9], conventional agriculture is one of the main causes of deforestation and the depletion of arable land, reducing its long-term fertility. In addition, inappropriate or excessive use of pesticides can have adverse impacts on the environment, the quality of agricultural products, and human health [12–14]. At the same time, the effects of climate change, notably irregular rainfall and rising temperatures, are heightening farmers' vulnerability, making it essential to transition to more resilient farming practices. Market gardening also faces challenges such as poor technical expertise, limited access to water, difficulties in seed supply, post-harvest losses, and poor market organization [15].

Face with these challenges, agroecology is emerging as a viable and sustainable alternative, promoting environmentally-friendly practices such as the use of organic fertilizers, biopesticides, as well as sustainable management of water and land resources. It helps improve the resilience of agricultural systems and reduce vulnerability to the effects of climate change [16]. Agroecology, conceived as a science, a practice and a movement, integrates ecological principles into the management of agricultural systems. . It is based on a set of techniques that are both innovative and traditional, such as agroforestry, crop rotation, and biological control [17].

In Senegal, several studies have been devoted to the use of agroecological practices in market gardening, notably in localities such as: Ndiongolor (Fatick Department) by [18], in the Niayes zone, the groundnut basin, and the Tambacounda Department by [19]. However, these studies did not specifically analyze the factors facilitating or limiting the adoption of agroecological practices by market gardeners. Yet understanding these determinants is essential to promote their wider dissemination. To our knowledge, in the Ziguinchor region, existing studies on market gardening have not yet addressed the issue in any depth [20,21]. This is why we conducted a study in Ziguinchor to help fill this knowledge gap. Our study specifically aims at (1) identifying and classifying the agroecological practices most widely adopted by market gardeners; (2) identifying the factors that influence and hinder market gardeners' decisions to adopt agroecological practices.

2. Material and Methods

2.1. Study Area

This study was carried out in the commune of Ziguinchor, located in southwestern Senegal, between 12°33′ north latitude and 16°16′ west longitude. It covers an area of 7,339 km2, representing around 3.7% of the national territory [6]. The area is subject to a coastal submarine climate [22] characterized by an average annual temperature of 27°C, with extremes reaching 37°C in April and a minimum of 15.50°C in January [23]. Average annual rainfall is estimated at 1,200 mm [6]. Agriculture is practiced by around 71% of households in rural areas and 29% in urban areas [24], with market gardening, arboriculture, pig breeding and poultry farming predominating [25,26]. It seems that Market gardening, an essential source of income and food security for farming households [27], is generally carried out on small areas ranging from 200 to 1200 m^2 [28], and is characterized by a wide diversity of crops [29].

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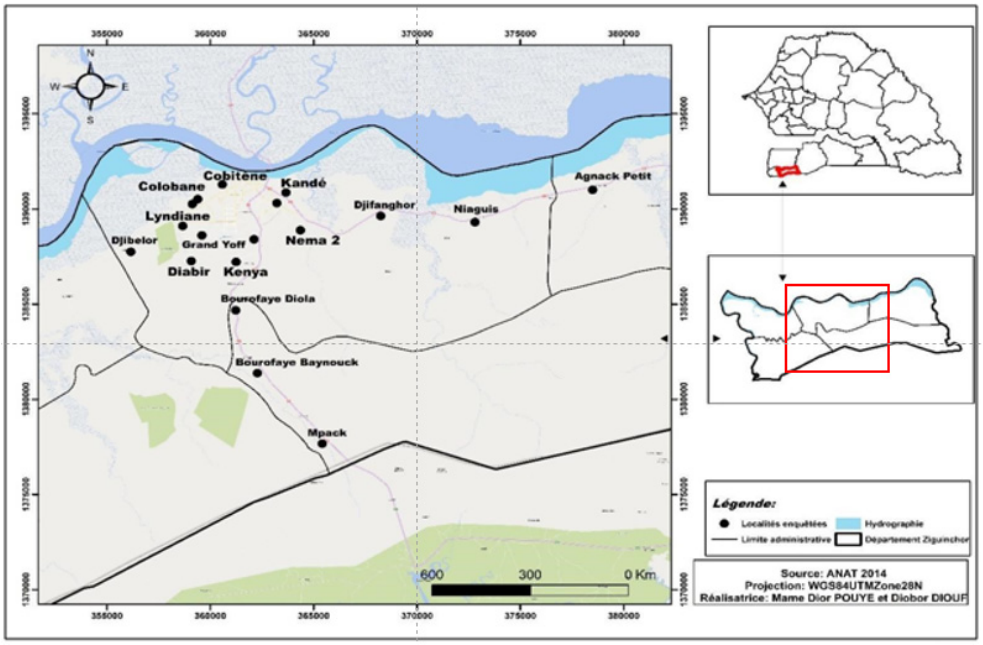

Figure 1. Location map of the study area.

2.2. Data Collection

2.2.1. Survey

Data collection was based on a questionnaire drawn up on the basis of an in-depth review of the scientific literature. To ensure the relevance of the questions and the methodological appropriateness to the local context, a pilot survey was carried out in the study area. The questionnaire, comprising 74 questions, is structured under six main headings: (1) socio-demographic characteristics of respondents, (2) information on crop plots, (3) use of agroecological practices, (4) opportunities linked to the practice of agroecology, (5) factors influencing the adoption of agroecological practices and (6) obstacles to the adoption of agroecological practices. The KoboToolbox platform (version 2.024.05) was used to develop the questionnaire, which was then deployed on the KoboCollect application (version 2023.2.4) to ensure effective data collection from October 28 to November 19, 2024.

In urban areas, the survey was carried out in Ziguinchor neighborhoods where market gardening is most developed: Lydiane, Diabir, Djibock, Diefaye, Colobane, Co-bitene, Kande, Kantene, Kenia, Nema 2, Grand Yoff, Castor, and Boucotte. In rural areas, it was carried out in villages on the outskirts of Ziguinchor, notably in the commune of Niaguis (Agnack Petit, Djifanghor and Niaguis) and in the commune of Boutoupa Camaracounda (Bourofaye Diola, Bourofaye Bainounck and Mpack).

Data collection was carried out using the snowball method, where selected initial participants helped to identify other potential participants. In the interests of a higher response rate and contextual observation, this method was combined with the door-to-door method, which involves going directly to individuals' homes to collect data.

2.2.1. Sampling

Since, at the time of the study, there was no database on the size of the city's market gardening population, the sample size was determined using the formula of [30], described by [31] :

$$no = \frac{z^2 pq}{e^2} \quad (1)$$

With :

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no: sample size required if the population is unknown; z: the standard value of 1.96 at a confidence interval of 95% and a precision of ±5%; p: the estimated share of the population = 0.5; q: 1-p; e: the desired level of precision.

The resulting sample size is as follows:

$$no = \frac{(1{,}96)^2(0{,}5)(0{,}5)}{(0{,}05)^2} = 384 \ (2)$$

It should be noted, however, that due to the unavailability of some market gardeners during the data collection phase, the survey covered only 300 market gardeners instead of 384.

2.3. Data Analysis

Basic descriptive statistics, such as mean, frequency, percentage, and count, were used to present the results. To assess the agroecological practices adopted, the associated opportunities, and the factors promoting or hindering their adoption, scoring criteria were defined, scores calculated, and a ranking made.

2.3.1. Relative Importance Index (RII)

The agroecological practices used were identified and ranked using the Relative Importance Index (RII). In addition to assessing the level of use of agroecological practices, the RII also helps prioritize agroecological knowledge and practices in order of frequency of adoption, so that adaptation actions or support can be targeted on the right practice(s). This method has been used in previous research by [32] and [33] to examine the most popular agroecological practices among small-scale farmers in northern and eastern Ghana, respectively. Formula 2 was used to calculate the RII:

$$\text{RII} = \sum \frac{W}{A \times N} \ (3)$$

Here, W is the weighting of a particular response on a Likert scale with 4 response modalities: never used = 1, rarely used = 2, often used = 3, and used every year = 4. A is the highest response (4), and N is the number of respondents taken into account (300).

2.3.2. Weighted average index (WAI)

WAI is a statistical analysis method that determines the mean of an outcome by multiplying the weight given to a particular event by the associated quantitative result, then adding up all the results. This is very useful for determining a theoretically expected outcome where each event has different probabilities of occurring. WAI is therefore crucial in determining the perceived opportunities for adopting agroecological practices, and the factors that may influence their adoption.

To assess the factors motivating producers to adopt agroecological practices, the WAI was estimated on the basis of a 4-point Likert scale: 1 = “disagree”; 2 = “more or less agree”; 3 = “agree”; 4 = “strongly agree”.

For the assessment of factors influencing farmers’ adoption of agroecological practices, the WAI was estimated based on a Likert scale with the following 4 modalities: 1 = very low level of influence, 2 = low level of influence, 3 = medium level of influence, 4 = very high level of influence.

Several studies have used the WAI to evaluate climate change adaptation measures [34–36]. The WAI is mathematically given by formula 3 :

$$WAI = \frac{\sum F_i W_i}{\sum F_i} \ (4)$$

Where F denotes frequency, W represents weight or importance, and i shows the score of each factor and opportunity related to agroecological practices, or the score of each factor that can influence the adoption of agroecological practices.

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2.3.3. Problem Confrontation Index (PCI)

To classify the barriers to the adoption of agroecological practices, the Problem Confrontation Index (PCI) was used. This index has been used in previous studies to identify factors that prevent smallholder farmers from adopting climate-smart farming practices [34,37,38]. For the estimation of PCI, a list of 9 questions was asked with a 4-point Likert scale to classify the obstacles that hinder the adoption of agroecological practices: 0 = "this is not a constraint"; 1 = "low-level constraint"; 2 = "moderate-level constraint"; 3 = "high-level constraint".

$$PCI = Pn \times 0 + Pl \times 1 + Pm \times 2 + Ph \times 3 \quad (5)$$

Where *Pn* is the number of small-scale farmers who rated the obstacle as no problem; *Pl* is the number of small-scale farmers who rated the obstacle as low-level; *Pm* is the number of small-scale farmers who rated the obstacle as moderate-level; and *Ph* is the number of small-scale farmers who rated the obstacle as high-level.

3. Results

3.1. Sociodemographic Characteristics of Market Gardeners

Table 1 presents the sociodemographic characteristics of the market gardeners surveyed. Women make up the majority, representing 79.67% of the sample, compared to 20.33% men.

In terms of age distribution, more than half of the market gardeners surveyed (50.66%) are over 45 years old, while young people aged between 20 and 30 remain poorly represented in the sector (11%). Those under 20 account for only a marginal share (1.3%). The majority of respondents (66.33%) are married, compared with 18% widowed, 13% single, and 2.67% divorced. In terms of household size, a large proportion (74%) has between 5 and 15 members. The study also shows that the Diolas (49%) and Socés (26.33%) are the ethnic groups that practice market gardening the most in the study area. Approximately 30% of market gardeners have no schooling, unlike the others who have varying levels of education, dominated by secondary level (22.67%) and primary level (21.33%). In addition, 57.67% of respondents are heads of households. Furthermore, a large proportion of market gardeners (84.33%) have not received training in market gardening techniques and are not members of a production association (84%). Furthermore, the majority (83.66%) do not have access to credit. The study also reveals that agriculture is the main activity of market gardeners (99.6%), followed by trade (92.6%) and livestock farming (35%). Their main sources of income are vegetable production (96%), followed by trade (87.33%), cashew nut production (47.33%) and mango production (33.33%). It was also noted that more than half of the vegetable farmers surveyed (50.33%) have more than 10 years of experience.

Table 1. Socio-demographic characteristics of respondents.

Parameter	Modality	Number	Percentage (%)
Gender	Female	239	79.67
	Male	61	20.33
Age	>45 years	152	50.66
	30-45 years	111	37
	20-30 years	33	11
	<20 years	4	1.3
Marital status	Married	199	66.33
	Widowed	54	18.00
	Single	39	13.00
	Divorced	8	2.67
Household size	5-15 people	222	74
	>15 people	50	16.66
	<5 people	28	9.33
Ethnic group	Diola	147	49.00

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	Soce	79	26.33
	Peul	15	5.00
	Ballante	10	3.33
	Mancagne	8	2.67
	Mandjack	7	2.33
	Serere	5	1.67
	Wolof	3	1.00
	Other	26	8.67
Educational attainment	No formal education	89	29.67
	High School	68	22.67
	Basic school	64	21.33
	Qur'anic	56	18.67
	Tertiary education	20	6.67
	Literacy	3	1.00
Head of household	Yes	173	57.67
	No	127	42.33
Principal activity	Agriculture	299	99.6
	Breeding	105	35
	Beekeeping	2	0.66
	Fishing	8	2.66
	Forestry	9	3
	Trade	278	92.6
	Crafts	4	1.33
	Salaried employment	27	9
	Other	5	1.66
Farming experience	>10 years	203	67.66
	5-10 years	59	19.66
	<5 years	38	12.66
Technical training	No	253	84.33
	Yes	47	15.66
Member of an association	No	252	84
	Yes	48	16
Access to credit	No	251	83.66
	Yes	49	16.33

3.2. Characteristics of the Market Gardening System in the Study Area

Table 2 provides information on the characteristics of the market gardening system in the study area. It shows that the total area of cultivated plots is most often between 1,000 and 5,000 m². With regard to land tenure, the majority of market gardeners obtain their plots through loans (62.67%) or inheritance (29.33%), revealing a problem of insecure land tenure. Production is mainly carried out on low-lying land (45%) and plateau areas (35.33%). In terms of soil fertility, most respondents (70.67%) consider their soil to be fertile, compared to 27.33% who consider it to be of average fertility. In addition, most of the crops grown are intended for food and sale (89.67%). In terms of the active workforce in the household, the study reveals that the number of people in the household involved in production work rarely exceeds five (14.6%).

Table 2. Characteristics of the market gardening system in the study area.

Parameter	Modality	Number	Percentage (%)
Product destination	Sales and consumption	269	70.67
	Consumption	30	10
	Sales	1	0.33
	Lowland soil (Gleysol)	135	45

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Soil type	Plateau soil (Acrisols)	106	35.33
	Both	59	19.67
Evaluation of soil fertility	Good	212	70.67
	Average	82	27.33
	Poor	6	2
Land tenure system	Borrowed	188	62.67
	Inherited	88	29.33
	Offered	17	5.67
	Purchased	11	3.67
	Other	11	3.67
Total area of cultivation plots	<200m²	23	7.66
	200 à 500m²	48	16
	500 à 1000m²	61	20.33
	1000 à 5000m²	90	30
	>5000m²	78	26
Number of participants in the household	<5 people	256	85.33
	5-10 people	39	13
	>10 people	5	1.6

3.3. Agroecological Practices Used by Smallholder Farmers

Table 3 shows the relative importance of agroecological practices used by smallholder farmers.

The analysis reveals that market gardeners employ a range of agroecological practices. Maintaining proper spacing between plants during sowing or transplanting and quickly identifying and removing weeds and diseased plants are among the agroecological practices most commonly adopted by market gardeners with an RII value of 0.75. These agroecological practices include using manure to fertilize plots (RII = 0.73); watering crops in case of water shortages (RII = 0.72); crop rotation (RII = 0.62); applying recommended doses of chemical fertilizers, and not burning dry grass and crop residues (RII = 0.60 for each). The least adopted agroecological practices are the use of weather information (RII=0.31), no-till farming (RII=0.30), and the use of resistant seeds (RII=0.29).

Table 3. Agroecological practices used by the smallholder farmers.

Agroecological practices	Score				Total weight	Total	A x N	RII	Rank
	Never used (1)	Seldom used (2)	Often used (3)	Used in every agricultural season (4)					
Removing weeds and diseased plants	0	2	885	16	903	300	1200	0.75	1
Plant spacing	1	2	885	12	900	300	1200	0.75	1
Use of manure	7	16	837	24	884	300	1200	0.73	3
Watering in case of water shortage	15	10	837	4	866	300	1200	0.72	4
Crop rotation	72	32	615	28	747	300	1200	0.62	5
Compliance with recommended fertilizer doses	78	156	246	248	728	300	1200	0.60	6
Dry grass and residue conservation	83	24	597	24	728	300	1200	0.60	6
Water conservation	100	20	564	8	692	300	1200	0.57	8
Crop association	143	38	402	16	599	300	1200	0.49	9
Mulching	169	12	372	4	553	300	1200	0.46	10
Agroforestry practices	177	4	360	4	545	300	1200	0.45	11

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Using short-cycle varieties	171	32	336	4	543	300	1200	0.45	11
Using biopesticides	131	258	111	12	512	300	1200	0.42	13
Use weather information	260	14	93	8	375	300	1200	0.31	14
Reduce or zero tillage	267	14	45	44	370	300	1200	0.30	15
Use of disease- and pest-resistant varieties	268	34	39	8	349	300	1200	0.29	16

Notes: RII. relative importance index; A. the highest response (4); N. the number of respondents being considered (300).

3.4. Opportunities and Motivating Factors for the Adoption of Agroecological Practices

The results in Table 4 show that improved soil fertility, healthy and nutritious food consumption, higher quality production, increased yields and vegetable production, and improved revenues are the factors that most motivate producers to adopt agroecological practices, with respective WAI values of 3.76, 3.75, 3.73, 3.7, and 3.62. Better environmental protection, better adaptation to climate change, biodiversity conservation, and effective disease and pest control are the factors that motivate producers the least to adopt agroecological practices.

Table 4. Factors motivating the adoption of agroecological practices.

Motivating factors	Score				WAI	Rank
	Disagree (1)	More or less agree (2)	Agree (3)	Strongly Agree (4)		
Improved fertility	5	32	72	1020	3.76	1
Healthy and nutritious food	2	44	75	1004	3.75	2
Higher-quality production	6	42	57	1016	3.73	3
Increased yields	3	52	87	968	3.7	4
Improved revenues	2	68	120	896	3.62	5
Environmental protection	3	32	255	784	3.58	6
Adapting to climate change	3	54	402	544	3.34	7
Biodiversity conservation	1	98	405	460	3.21	8
Effective pest and disease control	34	336	72	296	2.46	9

Notes: WAI. Weighted Average Index.

3.5. Factors that Influence the Use of Agroecological Practices by Smallholder Farmers

The results in Table 5 show that having technical guidance and training on agroecological practices, access to information on good agroecological practices, and being a member of a network of producers practicing agroecology, are ranked 1st, 2nd, and 3rd, respectively, among the factors influencing producers' decision to adopt agroecological practices, with respective WAI values of 3.75, 3.74, and 3.70. The factors that have less influence on the adoption of agroecological practices are access to improved seed varieties, access to organic fertilizer and biopesticides, the availability of crop plots with property title, and the receipt of information on rainfall and temperature.

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Table 5. Factors influencing the adoption of agroecological practices .

	Score				WAI	Rank
	Very low level of influence (1)	Low level of influence (2)	Medium level of influence (3)	Very high level of influence (4)		
Management and training	10	12	99	1004	3.75	1
Access to information	6	12	138	968	3.74	2
Producer networks or groups	12	12	126	960	3.7	3
Access to financing	16	20	108	952	3.65	4
Access to seeds of improved varieties	10	26	159	896	3.64	5
Having a titled plot of land	25	44	147	816	3.44	6
Rain and temperature information	168	36	141	228	1.91	7

Notes: WAI. Weighted Average Index.

3.6. Barriers Affecting the Adoption of Agroecological Practices

The results in Table 6 show that lack of manpower (PCI = 789), low level of access to information and training on good agricultural practices (PCI = 597), high cost of improved seeds (PCI = 549), difficulties in accessing organic manure (PCI = 538), difficulties in accessing financing for agriculture (PCI = 477) are ranked in this order as the most important obstacles that can block the adoption of agroecological practices by market gardeners. Factors such as difficulty of access to land (PCI = 422), crop pests and diseases (PCI=397), poor government support for access to seeds, organic fertilizers and pesticides (PCI=325), and difficulty of access to climatic information (rainfall, temperature) (PCI=153) also appear as limitations blocking the adoption of agroecological practices, but to a lesser extent, compared with the first obstacles cited.

Table 6. Obstacles to the adoption of agroecological practices.

Obstacles	Score				PCI	Rank
	It's not a Constraint (0)	Low-level constraint (1)	Moderate level constraint (2)	High-level constraint (3)		
Lack of manpower	0	9	60	720	789	1
Poor access to information and training	0	35	190	372	597	2
High cost of improved seeds	0	16	140	393	549	3
Difficult access to financing	0	54	126	297	477	5
Difficult access to land	0	29	90	303	422	6
Crop diseases and pests	0	27	142	228	397	7
Weak government support	0	62	86	177	325	8
Weak information on climate	0	17	88	48	153	9

Notes: PCI. Problem Confronting Index.

4. Discussion

4.1. Sociodemographic Characteristics of Market Gardeners

The results of this study show that women are more involved in market gardening than men. This female predominance could be explained by the fact that men are more involved in food and cash crops, such as rice, cowpeas or cashew nuts. These observations concur with those of [27], [39],

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and [40], who report that women represent 86%, 90.8%, and 95% of the sector, respectively. More than half of market gardeners are over 45 years of age. This can be explained by the fact that this age group has significant responsibilities as heads of households, with needs to be met. But this is also linked to the strong rural exodus of young people, who no longer seem to be attracted by agriculture. With regard to education, the most represented category is that of those without formal education, but the second is that of those who have reached high school. This could be because people with no education find it difficult to find work in other sectors, thus falling back on market gardening. These findings are consistent with those of [40], who noted that the majority of market gardeners in the city (86%) have no formal schooling. With regard to technical expertise, the study also reveals that almost all respondents have not received technical training in market gardening and are not members of a producers' association. This is at odds with the work of [41], who showed that half of producers have received at least some training in market gardening, and 40% of producers are grouped in market gardening associations. As for access to credit, only a minority of respondents have access to it. This could be explained by the lack of financial guarantees and the risks perceived by lenders, given that they do not belong to producer groups.

4.2. Characteristics of the Market Gardening System in the Study Area

The results show that most of the production is intended for household consumption and sale. This demonstrates the importance of vegetable production in providing subsistence for the population and generating income. These results are consistent with those of [42] and [43] in the city of Ouagadougou, Burkina Faso. The results also show that market gardeners cultivate the types of soil studied according to their location in the region. Most of the market gardeners surveyed reported that soil quality is good in terms of fertility, hence the acceptable yields obtained according to the producers' assessment. Land insecurity was also noted, characterized by the absence of property rights, with most plots being obtained through loans. This situation is due to the difficulty of accessing property and high land acquisition costs. The areas cultivated are generally between 1,000 m^2 and 5,000 m^2. These results contrast with those of [27], who noted areas ranging from 200 m^2 to 1200 m^2. Among vegetable crops, it was found that sorrel (*Hibiscus sabdariffa*), okra (*Abelmoschus esculentus*), tomato (*Solanum lycopersicum*), and bitter eggplant (*Solanum aethiopicum*) are the most widely grown. Strong local demand, relative ease of cultivation, and the economic and cultural importance of these products explain their prevalence in market gardening in Ziguinchor [27].

4.3. Agroecological Practices Used by Smallholder Farmers

The identification and elimination of weeds and diseased plants, and spacing between plants during sowing and transplanting operations are the agroecological practices most frequently adopted by market gardeners. This stems from the observation made by producers that weeds, which compete with crops for water and nutrients, limit their growth. This finding is consistent with those of [44], who highlight the agronomic concerns associated with the presence of weeds. There is also the fact that the majority of market gardeners use manure to fertilize their fields, as it promotes crop development. These results corroborate the study by [45] conducted in the city of Abidjan, which reveals that poultry manure and cow dung are the main sources of organic matter and fertilizers used by market gardeners. However, alongside these practices, others are less commonly used, such as: using the recommended doses of chemical fertilizers, not burning dry grass and residues, water conservation techniques, and crop rotation. This situation is thought to be the result of low awareness and a lack of technical training among vegetable farmers on good agroecological practices. According to [46], the continued and excessive use of chemical fertilizers in agriculture increases the risk of soil and water pollution and soil structure degradation.

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4.4. Opportunities and Motivating Factors for the Adoption of Agroecological Practices

The results of this study reveal that, according to producers' perceptions, the application of agroecological practices improves soil fertility, increases yields, and improves soil health. This motivates vegetable farmers in the study area to use agroecological practices. These results are consistent with those of [47] in Benin and [48], who noted that the use of organic fertilizer improves soil fertility, and increases yields. On the other hand, most respondents more or less agree that the application of agroecological practices enables effective control of diseases and pests and conservation of biodiversity, thus highlighting uncertainty about the effectiveness of the practices. This could be because most respondents are uneducated and uninformed about good agroecological practices, but also due to a lack of training and guidance on applying agroecology.

4.5. Factors that Influence the Use of Agroecological Practices by Smallholder Farmers

Having guidance and training in the application of agroecological practices, access to information and financing for good agroecological practices, and membership in a network or group of producers practicing agroecology, are the three factors that strongly influence market gardeners' decisions to adopt agroecological practices. These results corroborate those of [49], who state that, under the impetus of international institutions and non-governmental organizations (NGOs) that finance agroecology, producer groups are moving toward agroecological initiatives. There are also other influencing factors, such as access to improved seeds, organic fertilizers, and biopesticides, as well as the availability of crop plots with property title. The level of influence of these factors could be explained by the fact that the elements mentioned above are very expensive and sometimes inaccessible to market gardeners. These results are consistent with those of [50], which reveal that the market gardening sector is linked to biophysical conditions, producer organization, access to production factors and equipment, producers' capacity building, and the marketing, storage, and processing of products.

4.6. Barriers Affecting the Adoption of Agroecological Practices

The lack of labor, poor access to information and training on good agricultural practices, the high cost of improved seeds, and difficulty accessing organic fertilizer are perceived by producers in the study area as the main factors that could significantly constrain the adoption of agroecological practices. These results corroborate those of [48]. This can be explained by the fact that agroecology requires a good knowledge base and more labor than conventional agriculture. As for fertilizer, most producers in the study area do not raise livestock, which means they have to purchase it at high prices due to high demand. The lack of information and capacity building could be because information for producers is conveyed in inappropriate way, and there isn't much capacity building for producers.

5. Conclusions

This study analyzes the adoption of agroecological practices by market gardeners in urban and peri-urban areas in the Ziguinchor region. It highlights a growing awareness of the benefits of these techniques while also highlighting the persistence of several major obstacles. Among the main obstacles identified are a lack of technical knowledge, insufficient financial resources, and limited access to capacity building. In rural areas, market gardeners often operate in a precarious economic context, which limits their capacity for innovation. In urban areas, on the other hand, the availability of infrastructure and market opportunities can encourage faster and more effective adoption of agroecological approaches. Integrating these practices into market gardening is an important lever for boosting food security, improving farm incomes, and promoting the sustainability of local ecosystems. To accelerate adoption, it is essential to strengthen training and technical support systems, develop incentive-based public policies, and facilitate access to financing. In addition, building strong partnerships between institutions, non-governmental organizations, and local communities is a key factor in creating an environment conducive to agroecological transition.

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It is therefore imperative to continue efforts in this direction in order to build a more environmentally friendly and community-beneficial agricultural future.

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Abbreviations

The following abbreviations are used in this manuscript:

AFDB	African Development Bank
ANSD	National Agency for Statistics and Demography
DHORT	Horticulture Department
FAO	Food and Agriculture Organizations
UN	United Nations
WB	The World Bank
WFP	World Food Program

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