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Assessment of Market Gardening Potential and Investment Profitability at WFP Sites in the Maradi Region (Niger): Case of Rafa, Dagouagé, and Daratou

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Abstract

In the Sahel, particularly in Niger, market gardening is a key source of income and food production for local populations. As food security remains a national priority, the World Food Programme (WFP), in partnership with the NGO Karkara, supports market gardeners on the sites of Rafa, Dagouagé, and Daratou. The objective of this study is to assess the profitability of the investments carried out. A survey was conducted among 128 producers. The methods applied included arithmetic calculations, econometric analyses, and Multiple Correspondence Analysis (MCA). The main crops grown are potato, tomato, onion, lettuce, cabbage, pepper, eggplant, moringa, sorrel, maize, and cassava. Land access modalities differ across sites: outright purchase at Dagouagé and Daratou, and land lending at Rafa. The annual economic profitability is estimated at 0.297 in Rafa, 2.924 in Daratou, with a very low profitability observed in Dagouagé. Results indicate that farmers' experience ($p = 0.001$) as well as certain crops such as potato ($p = 0.001$) and eggplant ($p = 0.007$) significantly influence farm income. In addition, the major constraints identified include water scarcity (up to 53.3% of farmers in Dagouagé), pest pressure (32.5% in Daratou), and lack of agricultural equipment (13.3% in Dagouagé). These findings highlight the need for site-specific approaches that combine technical solutions with supportive measures.

Keywords

Market Gardening, Assessment, Economic Profitability, Investment, Niger,

Maradi, WFP

1. Introduction

Agriculture is one of the main pillars of socio-economic development worldwide. According to the Food and Agriculture Organization of the United Nations [1], Africa remains the region with the highest proportion of employment in agriculture, forestry, and fishing, representing nearly 47.8% of the active population. Among the various agricultural productions, vegetable farming holds a strategic place. Defined as a specialized form of agriculture, it is recognized as one of the most productive production systems on the African continent [2]. Beyond its contribution to dietary diversification, it provides a regular source of income for rural households, thus strengthening the resilience of food systems in times of crisis ([3] [4]). In West Africa, this activity has gradually established itself as a lever for food sovereignty and is now an integral part of public policies and agricultural development programs due to its contribution to nutritional security, poverty reduction, and job creation [5]. This importance is accentuated by the vulnerability of rainfed crops to climate hazards, which necessitates diversification towards irrigated crops, which are more resilient and have a higher added value. In Niger, where agriculture employs nearly 87% of the active population [6], food crop production remains insufficient to meet dietary needs. This insufficiency is attributed to various factors such as poor soil fertility, rainfall variability, demographic pressure, and accelerated degradation of natural resources [7]. To address this, public authorities, with the support of their technical and financial partners, have encouraged the development of off-season irrigated crops, particularly vegetable farming, since the 1980s. Today, it represents a major economic opportunity in rural areas and a tool for resilience against food insecurity. The Maradi region, often referred to as the "agricultural granary" of Niger, illustrates this dynamic well. Vegetable farming occupies a prominent place there, with an estimated area of 73,345 hectares, of which 18,680 ha (25%) are dedicated to recession agriculture [8]. It is a source of pride for local populations, providing a variety of quality products and generating substantial income [9]. For example, potatoes are widely grown on sites along the Goulbi Maradi and Goulbi Kaba rivers, with yields allowing producers to earn significant economic margins [10]. However, this potential remains limited by major constraints, notably poor soils often deficient in organic matter and nutrients, and exposed to risks of alkalinization and salinization [7]. To tackle these challenges, several initiatives have been implemented by development partners. The World Food Programme (WFP), along with its partners, has supported the development and protection of several vegetable farming sites in the Maradi region. These interventions aim to strengthen the resilience of populations by improving access to irrigation water, securing production perimeters, and promoting sustainable farming practices. However, despite the scale

of investments made, the question of their economic and financial profitability remains poorly documented. While vegetable farming is recognized as an income generating activity, few studies rigorously assess the performance of the sites developed by the WFP. This gap raises several questions: do the investments truly improve the profitability of vegetable farms? What are the key factors influencing the productivity and economic performance of beneficiary producers? And how can future interventions be optimized to ensure the sustainability of these developments? It is within this perspective that the present study is situated, entitled: "Diagnosis of the vegetable farming potential and investment profitability of WFP sites in the Maradi region: case of the Rafa, Dagouagé, and Daratou sites."

2. Methodology

2.1. Study Area and Population

The study was conducted in three vegetable farming sites in the Maradi region, namely Rafa, Dagouagé, and Daratou. The first two are located in the Gazaoua municipality. These sites were selected due to their representativeness in the support provided by the World Food Programme (WFP) and the diversity of vegetable farming practices observed there (see Figure 1).

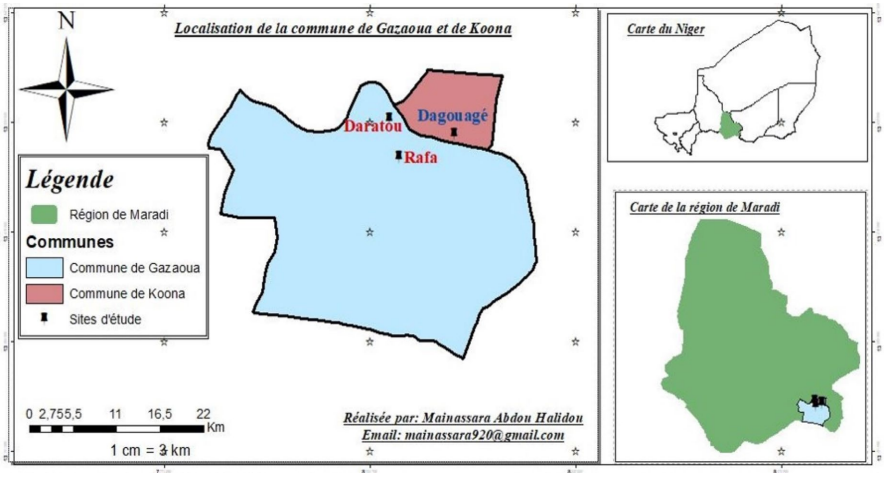

Figure 1. Location of the study sites.

2.2. Data Collection and Sampling Methods

The study combined a field survey with beneficiaries (128) and a statistical analysis of the collected data, supplemented by secondary information from institutional documents. Primary data were collected using a questionnaire administered individually to the producers. The questionnaire gathered data on: socio-economic characteristics; production factors; and information related to institutional services. The total sample size was determined using the following formulas [11]. The distribution of the 128 producers across Rafa, Dagouagé, and Daratou (Table 1) was based on WFP beneficiary density, cultivated area, and crop diversity. This

stratification ensures balanced representation of site specific conditions.

$$n = \frac{t_p^2 \times P(1-P) \times N}{t_p^2 \times P(1-P) + (N-1) \times y^2}$$

With

n : final sample size (population surveyed); N: total number of beneficiaries (target population size); P (0.5): actual proportion (true proportion in the population); t_p (1.96 for 95%): confidence interval (confidence level of sampling) and y (0.05): sampling error margin (margin of error).

Table 1. Distribution of samples by production site.

Production sites	Number of surveyed individuals	Proportion in %
Rafa	40	31.25%
Dagouagé	24	18.75%
Daratou	64	50%
Total	128	100%

2.3. Methods of Analysis

The method and approach used in this study combine the use of economic profitability calculation formulas (Table 2), descriptive and multidimensional statistical analysis [12]. For the first part, economic profitability was evaluated using standard calculation formulas, such as economic profitability ratios, allowing comparison of incomes generated between production sites ([13] [14]).

Table 2. Economic and financial indicators.

Economic and Financial Indicators	Arithmetic Formulas
Gross Rice Product (GRP)	GRP = Quantity produced × Unit selling price
Variable costs (VC)	VC = Cost of inputs + variable labor cost
Fixed costs (FC)	FC = Costs related to depreciation + other fixed expenses
Production cost (PC)	PC = FC + VC
Intermediate consumption (IC)	IC = Σ (Quantity of consumables × Unit selling price)
Gross added value (GAV)	GAV = Production value − IC
Net added value (NAV)	NAV = GAV − Depreciation
Agricultural profitability index	API = Gross margin (GM)/Total production cost (TPC)

Note: Source: Mahamadou, I.S., Boubacar, S. and Ouedraogo, A. (2025).

The second method was used to summarize and characterize the collected data by employing indicators of central tendency and dispersion, as well as graphical representations to visualize the distribution of variables [15]. Finally, to understand the diversity of the vegetable farming operations studied, Multiple Correspondence Analysis (MCA) was used. This method is particularly suited for the

simultaneous analysis of a large number of qualitative variables, making it a relevant tool to explore the relationships between the socio-economic characteristics of producers, their farming practices, and the economic performance of the sites. MCA effectively reduces the dimensionality of the data while highlighting the factorial axes that structure the observed variability ([16] [17]). This facilitates the identification of the most discriminant variables and the highlighting of typical producer profiles. When combined with hierarchical ascending classification, this statistical approach is a robust and widely used method in agronomic and social sciences to build typologies of farms ([18] [19]). In this study, MCA enabled the identification of the key dimensions of vegetable farming potential and helped to better understand the factors explaining the profitability of investments at the Rafa, Dagouagé, and Daratou sites.

The multiple linear regression model was used to identify, among socio-economic and technical factors, those that could influence the profitability of the production sites. Indeed, linear regression is a widely used statistical method in agricultural economics to identify the key variables driving economic performance and to estimate their relative contribution [20]. It allows for evaluating the marginal effect of each production factor on profitability while controlling for the effects of other variables. Several previous studies in West Africa have demonstrated the relevance of this method in studying agricultural productivity and the profitability of investments ([21] [22]). The variables included in the model are presented in **Table 3**. The model equation is given by the following formula:

$$\begin{aligned} Y\left(\text{agricultural profitability}\right) = {} & \beta_0 + \beta_1\left(Mat\_ag\_uti\right) + \beta_2\left(Dispo\_sour\_rev\right) \\ & + \beta_3\left(Age\right) + \beta_4\left(Nbre\_ann\_\exp\right) + \beta_5\left(C\_\text{Prov}\_poiv\right) \\ & + \beta_6\left(C\_\text{Prov}\_poiv\right) + \beta_7\left(C\_\text{Pro}\_aub\right) + \beta_8\left(C\_\text{Prov}\_morin\right) \\ & + \beta_9\left(C\_\text{Pro}\_pom\_ter\right) + \beta_{10}\left(C\_\text{Pro}\_toma\right) + \beta_{11}\left(C\_\text{Pro}\_choux\right) \\ & + \beta_{12}\left(C\_\text{Pro}\_laitue\right) + \beta_{13}\left(C\_\text{Pro}\_oign\right) \end{aligned}$$

The dependent variable Y represents the total agricultural income per producer, expressed in FCFA. Independent variables include crop-specific production costs, cultivated area, and farmer experience. Although costs are linked to income, their inclusion allows for assessing marginal effects and identifying cost-effective crops (**Table 3**).

Table 3. Specification of the econometric model variables.

Model Variables	Measurement of Variables	Mathematical Notation
Modern agricultural equipment	1 Yes, 2 No	Mat_ag_uti
Available non-agricultural income source	1 Yes, 2 No	Dispo_sour_rev
Respondent's age	Continuous	Age
Gender	Binary (1 Male, 2 Female)	Sexe

Continued

Number of active persons	Continuous	Nbre_pers_actif
Number of years of experience	Continuous	Nbre_ann_exp
Production cost of bell pepper	Continuous	C_Pro_poiv
Production cost of eggplant	Continuous	C_Pro_aub
Production cost of moringa	Continuous	C_Pro_morin
Production cost of potato	Continuous	C_Pro_pom_ter
Production cost of tomato	Continuous	C_Pro_toma
Production cost of cabbage	Continuous	C_Pro_choux
Production cost of lettuce	Discrete	C_Pro_laitue
Production cost of onion	Continuous	C_Pro_oign

3. Results

3.1. Typology of Vegetable Producers by Cluster Classification Analysis

The analyses from Figure 2 reveal two main axes: The primary axis (Dim1) explains 23.1% of the total inertia and primarily distinguishes farms based on their access to modern resources, level of education, and social capital. The secondary axis (Dim2), explaining 11%, captures additional nuances mainly related to household size and land acquisition modalities. From the analysis of the figure, three distinct profiles of vegetable farms emerge: The first profile consists of farmers with a low level of education, a predominance of women, medium-sized family units (3 to 8 persons), and limited access to modern resources. The second profile is mainly composed of farms managed by men, often in polygamous marriages, with religious education (Quranic school). These operators have better access to productive resources as well as agricultural support services (credit, advisory services, membership in farmers' organizations). The last profile includes farmers aged 56 years and above, belonging to large households (11 persons and more).

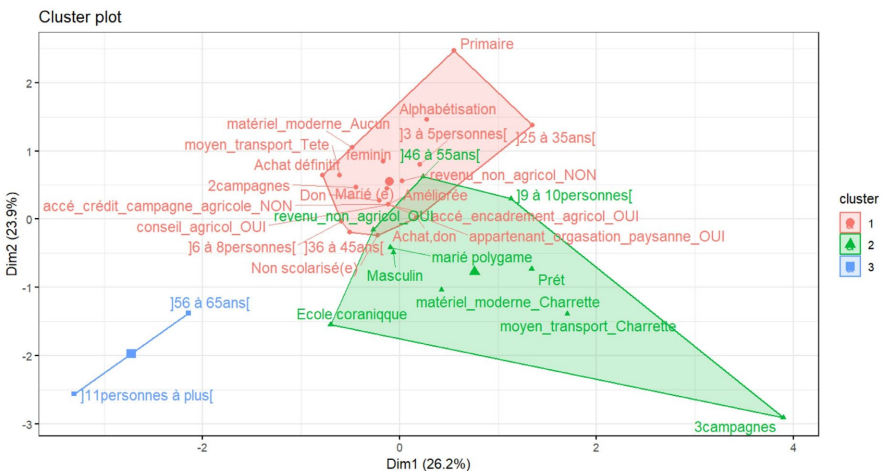

Figure 2. Socio-economic profiles of market gardening farms.

3.2. Multiple Correspondence Analysis of Socio-Economic and Agricultural Variables by the Three Vegetable Farming Sites

Figure 3 shows that the Daratou site is associated with characteristics typical of traditional farms. Producers in Daratou appear to be mostly poorly educated, poorly equipped with modern machinery, and have limited access to agricultural services. The Dagouagé site is linked to modalities reflecting some access to resources, such as agricultural advisory services and membership in farmer organizations, with heterogeneous socio-economic characteristics. This suggests that the farms in Dagouagé present a diversity of profiles, ranging from still traditional structures to farms undergoing modernization. These farms are partly positioned between Cluster 1 and Cluster 2. Finally, the Rafa site is strongly associated with modernized farms equipped with modern agricultural machinery and well integrated into financial and advisory support systems. The farms in Rafa primarily correspond to Cluster 2, representing the most dynamic and economically integrated agricultural structures.

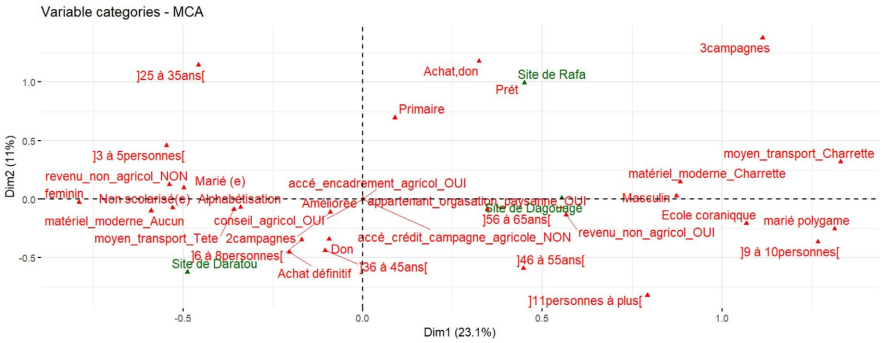

Figure 3. Correspondence analysis of socio-economic and agricultural variables by vegetable farming sites.

3.3. Agronomic and Technical Characteristics of the Studied Vegetable Farms

The analysis of Table 4 shows that at Rafa, all producers (100%) use manure, with 68% applying it twice per growing season. Moreover, 76% of producers access fertilizers by purchase, and 44% combine purchase and seed donations. The use of chemical insecticides is also dominant there (76%), with this difference being statistically significant between sites ($\chi^2 = 66.220$; $p < 0.001$). At Dagouagé, the reliance on donations remains notable (53.3% for seeds and 26.7% for fertilizers), and only 6.7% of producers apply manure twice per growing season, indicating less regularity in organic fertilization practices. The dominant crops are mainly concentrated around the tomato-onion-bell pepper association (60%). The Daratou site is characterized by total dependence on donations for seeds (100%) and fertilizers (100%), a highly significant difference between sites ($\chi^2 = 79.101$; $p < 0.001$), a low use of commercial insecticides (12.5%), but relatively frequent manure application (67.5% twice per growing season).

Table 4. Agronomic and technical characteristics of the market gardening farms studied.

Variables	Modalities	Site of Rafa (%)	Site of Dagouagé (%)	Site of Daratou (%)	Value (P-value) χ^2
Use of manure	YES	100.0	100.0	100.0	-
Manure transport method	By Head	64.0	46.7	100.0	**37.529 (0.000*)**
	Cart	36.0	53.3	0.0	
Manure application frequency	Once	68.0	80.0	67.5	**11.766 (0.067)**
	Twice	28.0	6.7	27.5	
	Thrice	4.0	13.3	5.0	
Source of seeds	Donation	56.0	53.3	100.0	**21.227 (0.000*)**
	Purchase, donation	44.0	46.7	0.0	
Insecticides used	EC with water (cypercal 50, labda2.5, karto super2.5)	76.0	26.7	12.5	**66.220 (0.000*)**
	EC, (pia pia), (leaf of neem + tobacco + soap + pepper)	24.0	46.7	47.5	
	Pacha EC25, Labda super 2.5 EC, pia pia, soap + pepper + tobacco + leaf of neem	0.0	26.7	40.0	
Type of fertilizer used	NPK (15-15-15)	52.0	26.7	30.0	**5.291 (0.259)**
	Urea	12.0	26.7	12.5	
	NPK, Urea	36.0	46.7	57.5	
Fertilizer access method	Purchase	76.0	20.0	0.0	**79.101 (0.000*)**
	Donation	8.0	26.7	100.0	
	Purchase, donation	16.0	53.3	0.0	
	Loan	100.0	0.0	0.0	**80.000 (0.000*)**
	Definitive purchase	0.0	100.0	100.0	
Main crops grown	Potato, Tomato, Onion	24.0	6.7	7.5	**20.092 (0.028)**
	Tomato, Onion, Potato, Lettuce	20.0	60.0	32.5	
	Tomato, Onion, Cabbage, Potato, Lettuce	24.0	33.3	42.5	
	Cabbage, Potato, Tomato	4.0	0.0	2.5	
	Potato, Cabbage, Tomato	8.0	0.0	12.5	

*signifiacant at 1%.

3.4. Economic and Financial Analysis of Vegetable Farming Sites

The results show significant differences in cost structures, production, and profitability among the three studied sites. The average cultivated area is respectively 0.6 ha, 0.06 ha, and 0.07 ha at Rafa, Dagouagé, and Daratou. Variable costs amount

to 78,128 FCFA, while fixed costs reach 750,000 FCFA at Rafa. The profitability ratio is 0.297. At Dagouagé, although variable costs are relatively low (62,761 FCFA), fixed costs are the highest among the three sites at 1,041,666 FCFA. This combination results in a production cost of 1,144,900 FCFA against a gross product of only 1,036,275 FCFA, leading to a negative net margin (−108,625 FCFA) and an unfavorable net added value to production cost ratio (VAN/CP) of −0.094. At Daratou, the performance is notably better. The cultivated area (0.07 ha) is close to that of Dagouagé, but variable costs (107,000 FCFA) and fixed costs (546,875 FCFA) are better controlled. The net margin is therefore 1,951,675 FCFA, with profitability reaching 2.924, indicating very high economic profitability (Table 5).

Table 5. Economic and financial results.

Indicator	Rafa Site	Dagouagé Site	Daratou Site
Average cultivated area (ha)	0.6	0.06	**0.07**
Variable costs (VC)			
Small equipment (in FCFA)	10,360	11,544	**53,581**
Fertilizers, biopesticides (FCFA)	39,215	20,259	**30,149**
Seeds (in FCFA)	28,553	30,958	**23,270**
Total variable costs	78,128	62,761	**107,000**
Fixed costs (FC)	750,000	1,041,666	**546,875**
Family labor (in FCFA)	4,765	40,473	**13,500**
Total fixed costs (TFC)	754,765	1,082,139	**560,375**
Gross product = P*Price (in FCFA)	1,087,000	1,036,275	**2,619,050**
Production cost = VC+FC (in FCFA)	832,893	1,144,900	**667,375**
Gross margin (VAB) = GP-VC (in FCFA)	1,002,572	973,514	**2,512,050**
Net margin (VAN) = GM-FC (in FCFA)	247,807	−108,625	**1,951,675**
VAB/CP (ratio)	1.203	0.850	**3.764**
VAN/CP (ratio)	**0.297**	**−0.094**	**2.924**

3.5. Analysis of the Determinants of Socio-Economic Profitability

The analysis of Table 6 reveals that, from a social perspective, the number of years of experience in vegetable farming is a significant factor contributing to household income generation across the study sites, with a p-value of 0.001. Economically, potato and eggplant cultivation contribute most significantly to the profitability of the surveyed farmers, with respective p-values of 0.001 and 0.007.

Table 6. Determinants of socio-economic profitability.

Independent Variable	Unstandardized Coefficient (B)	Standard Error	Standardized Coefficient (Beta)	t-value	Significance (p-value)
Constant	115,261.176	98,742.384	—	1.168	**0.245**
Modern agricultural equipment	2,262.419	4,191.411	0.021	0.540	**0.591**
Number of fields cultivated by household head	3,592.450	1,128.111	0.153	3.183	**0.002**
Availability of non-agricultural income (FCFA	2,592.455	3,529.450	0.051	0.735	**0.463**
Potato cost in FCFA	0.702	0.725	−0.011	-0.968	**0.335**
Cabbage cost in FCFA	0.752	0.703	0.012	1.070	**0.286**
Lettuce cost in FCFA	0.763	0.741	0.012	1.030	**0.305**
Onion cost in FCFA	0.764	0.743	0.012	1.028	**0.306**
Bell pepper cost in FCFA	0.763	0.741	0.012	1.030	**0.305**
Corn cost in FCFA	0.764	0.743	0.012	1.028	**0.306**
Carrot cost in FCFA	0.763	0.741	0.012	1.030	**0.305**
Plant income in FCFA	0.764	0.743	0.012	1.028	**0.306**
Number of people in the farming operation	44,512.090	12,188.036	0.151	3.652	**0.001**
Gender	−44,512.090	12,188.036	−0.151	-3.652	**0.001**
Model Summary	**R = 0.736 R^2 = 0.541 Adjusted R^2 = 0.377 Standard Error of the Estimate = 11118.39. The dependent variable is agricultural income.**				

3.6. Main Constraints Faced in Three Agricultural Sites According to Farmers

Table 7 shows that across all sites, water scarcity emerges as the most significant constraint, affecting 53.3% of respondents in Dagouagé, 40% in Rafa, and 32.5% in Daratou. Crop pests also represent a major challenge in Daratou (32.5%) and Rafa (24%), while they are less problematic in Dagouagé (6.7%). Difficulties related to irrigation and pest presence affect 20% of cases in Daratou, 13.3% in Dagouagé, and 16% in Rafa. The lack of phytosanitary products and fertilizers is relatively low but consistent across the three sites, ranging from 5% to 8%. Finally, issues linked to water scarcity combined with fertilizer shortages, distance from the village, and insufficient agricultural equipment vary more widely, with equipment shortages being more pronounced in Dagouagé (13.3%) compared to the other sites.

Table 7. Main constraints encountered across the sites.

Constraints	Rafa Site	Dagouagé Site	Daratou Site
Crop pests	37.0%	43.5%	**19.6%**
Insufficient equipment	26.7%	13.3%	**60.0%**
Irrigation difficulties and pest infestation	37.0%	12.5%	**20.0%**
Lack of water and fertilizers	25.0%	37.5%	**33.3%**
Harsh terrain and lack of equipment	41.7%	25.0%	**33.3%**
Difficult plowing and lack of materials	8.3%	25.0%	**66.7%**

4. Discussion

The classification analysis identified three distinct profiles of vegetable farmers in the intervention sites of the World Food Programme, highlighting significant heterogeneity in production conditions and investment capacities. Cluster 1, the most heterogeneous, illustrates the complexity of agricultural trajectories in semi-arid areas, where survival strategies coexist with attempts at intensification. In contrast, Cluster 2 groups households with low educational attainment, limited income diversification, and restricted access to agricultural inputs. This profile is typical of vulnerable farms, often excluded from technical or financial support programs [23]. Cluster 3, characterized by access to agricultural transport means and participation in multiple cropping campaigns, appears to include households best positioned for sustainable profitability. This observation aligns with [24], who emphasize that access to productive assets (transport, tools, credit) is a key determinant of agricultural performance in sub-Saharan Africa. The MCA biplot highlights significant associations between socio-economic variables and farming practices. Land access modalities ownership at Dagouagé and Daratou, versus community allocation at Rafa appear to influence investment behavior. Secure land tenure encourages longterm investments in irrigation and soil fertility, potentially explaining profitability differences. Variables such as access to credit, agricultural advisory services, and transport means cluster within the same factorial zone, suggesting a profile favorable for investment in vegetable farming. This configuration is consistent with [25], who showed that access to credit and technical information significantly improves the adoption of agricultural innovations. Conversely, categories such as no formal education, absence of off-farm income, and lack of modern equipment are positioned oppositely, reflecting structural constraints. These findings confirm the observations of [26] on the role of education and income diversification in household resilience. The positioning of sites (Rafa, Dagouagé, Daratou) in the factorial space also allows identification of differentiated territorial dynamics, useful for targeting public policies. Analysis of agricultural constraints reveals that water scarcity is the most frequently reported issue

across the three sites, particularly in Dagouagé (53.3%). This constraint is well documented in Sahelian areas, where climate variability and limited hydraulic infrastructure severely restrict vegetable productivity [27]. In Daratou, crop pests are also highly prevalent (32.5%), highlighting the need to strengthen phytosanitary support systems. Although less frequent, the lack of fertilizers and plant protection products remains concerning, especially in Rafa. These technical constraints are often exacerbated by distance from villages and challenging terrain, as highlighted in the literature on input access costs in rural areas [28]. The Daratou site stands out for its exceptional profitability, with a net margin of 677,105 FCFA and an NPV/CP ratio of 2.924, indicating that each invested franc generates nearly three francs of net value. This performance can be attributed to better campaign organization, access to inputs, and efficient product valorization. According to [29], the ability to transform inputs into added value is a key indicator of farm economic viability. Despite a reasonable gross margin, the Dagouaé site exhibits a low net margin (50,626 FCFA) and a negative ratio, suggesting that fixed costs absorb a large portion of profits. This may reflect reliance on family labor or low resource-use efficiency. [30] emphasize that low capital farms can survive but struggle to grow without structured support. The Daratou site shows a negative net margin (−59,150 FCFA), despite higher gross output than Dagouaé. High production costs and lack of profitability indicate economic inefficiency, possibly linked to previously identified constraints (pests, water scarcity, limited advisory services). According to [31], unprofitable farms are most vulnerable to agricultural abandonment due to insufficient investment returns. Socially, experience in vegetable farming is a significant factor ($p = 0.001$), reflecting the importance of accumulated knowledge over the years. This result corroborates studies by [32] and [33], which emphasize that technical mastery and practical experience enable farmers to optimize cultivation practices, manage inputs efficiently, and minimize post-harvest losses. Thus, tenure in vegetable farming constitutes an intangible capital positively influencing productivity and profitability. Regarding economic performance, two crops stand out : potato ($p = 0.001$) and eggplant ($p = 0.007$), identified as the most profitable across sites. These findings confirm the strategic importance of these crops in the Maradi region, as reported by [10] and [34], who note that potatoes, due to high yields and commercial demand, constitute a major cash crop for farmers. Eggplants benefit from strong local and regional consumption, facilitating rapid marketing and high profitability. The study shows that water scarcity remains the primary constraint for vegetable production across all sites, with prevalence reaching 53.3% in Dagouagé, 40% in Rafa, and 32.5% in Daratou. This illustrates the vulnerability of Sahelian vegetable systems to climate variability and limited water resources, as highlighted by [35] and [36] in their work on agricultural resilience in the Sahel. Dependence on surface water resources and weak irrigation infrastructure exacerbate the precariousness of these farms and limit their productivity potential. The second major constraint concerns crop pests, particularly affecting Daratou (32.5%) and Rafa (24%). This

aligns with findings by [34], which highlight high pest pressure on vegetable crops in the Maradi region, worsened by limited access to phytosanitary inputs and weak integrated pest management practices. Watering difficulties, reported by 20% of Daratou producers, 16% in Rafa, and 13.3% in Dagouagé, likely result from a combination of insufficient equipment and low mechanization, prolonging labor time and increasing work intensity. The lack of fertilizers and plant protection products, although cited less frequently (5 to 8%), reflects structural constraints linked to agricultural input supply, often marked by heavy import dependency and unaffordable prices for smallholders. Insufficient agricultural equipment, more pronounced in Dagouagé (13.3%), further complicates production and reflects inequalities in investment and technical support across sites. These results corroborate observations by [4] and [33], indicating that inadequate inputs and equipment are major barriers to economic profitability in West African vegetable farming.

5. Conclusions and Recommendations

This study, carried out on the vegetable farming sites of Rafa, Dagouagé, and Daratou, underscores the important role that vegetable cultivation plays in boosting household incomes and supporting local food security. The findings show that economic profitability is shaped not only by social factors, such as the experience and know-how of the farmers, but also by economic factors, particularly the cultivation of high value crops like potatoes and eggplants. The analysis also revealed the diversity of farmer profiles and the different challenges they face at each site. However, the long term sustainability and profitability of these farming activities remain constrained by significant structural and environmental challenges, including water scarcity, pest pressures, irrigation difficulties, limited access to inputs, and a shortage of agricultural equipment. Based on site specific constraints, we recommend:

1) For Dagouagé: investment in water infrastructure and access to motorized pumps.

2) For Daratou: implementation of integrated pest management programs.

3) For Rafa: support for crop diversification and market linkage strategies.

While interventions by the WFP and its partners have clearly helped improve productivity, these efforts need to be strengthened to build more resilient and sustainable vegetable farming systems in the region.

Limitations

This study is based on a cross-sectional survey covering a single production cycle. As such, it does not capture seasonal variability or longterm investment dynamics. Market fluctuations and climate factors were also not fully integrated into the analysis.

Conflicts of Interest

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

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