



Research article

Diversity of market gardening farms in western Burkina Faso. Nexus between production environment, farm size, financial performance and environmental issues

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ABSTRACT

This study characterizes market gardening in Houet province in order to determine the various categories of market gardening farms based on specific socioeconomic variables, as well as to analyze the main factors influencing their economic performance. Using principal component analysis (PCA) and hierarchical ascending classification, the main factors influencing the economic situation of the market garden farms in Houet were analyzed through the interrelationships between the variables considered. Findings revealed four clusters of vegetable farms with different socioeconomic features depending on the farming environment (urban, peri-urban and rural). In the same vein, the results showed that market gardeners in urban areas have the best economic performance. With the regard to the durability of the production, results showed that the majority of market gardeners (95%) have a conventional production method and often use in an uncontrolled way chemical pesticides, as well as mineral fertilizers that some combine with organic amendments.

1. Introduction

According to Food and agriculture organization (FAO) statistics, fruit and vegetable production in the West African region has increased by more than 50% in recent years between 2004 and 2014. This progression, mainly due to an increase in cropped areas has yielded about 43 million tons of fruits and vegetables for Francophone West African countries and 18 million for Francophone Central African countries (Jeune Afrique, 2018). In Burkina Faso in general and in the Houet province in particular, market gardening is becoming an increasingly dynamic agricultural activity regarding both assets and income. As pointed out by Bambio (2021), there is a significant growth in market gardening in Burkina Faso (Bambio, 2021). However, the development of this activity is facing a growing shortage of cultivable land and progressive degradation of cultivated area. Nowadays, in an increasingly globalized and climate-changing environment, the major challenge facing Burkina Faso is to ensure food and nutritional security for a rapidly growing population (2.8 %) while sustainably preserving its natural resources. Such a challenge requires a concrete adaptation of current

production methods to the need for sustainable development (Tapsoba et al., 2020; World Bank, 2020).

However, there is a high level of chemical input use in the market gardening sector (Sanou et al., 2020; Son et al., 2017). This use is often uncontrolled, with recurrent cases of systematic use of chemical pesticides in vegetable production that are reserved for cotton cultivation, due, to the low level of literacy among the market gardeners of the country (Congo, 2013; Sangaré, 2012; Son et al., 2017). Moreover, market garden production according to current conventional practices is highly dependent on imported chemical pesticides while the share of non-chemical treatments based on local products remains insignificant because of the lack of immediately available agroecological alternatives for effective pest management (FAO, 2013; Tarnagda et al., 2017). This raises the essential problem of the nutritional quality of market garden products and the sustainability of market gardening, which is an important activity in improving the food rations of populations and their socioeconomic conditions (Hansen et al., 2022; Kaboré et al., 2017).

Given this reality, it is necessary to determine the real characteristics of market gardening operations in order to identify the main constraints

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to the implementation of economically viable and sustainable market gardening, while also diversifying the supply chains. The main concern is to understand the structure of the various type of farms in order to guarantee the effectiveness of development actions in the sector. Accordingly, considering the diversity of farms is for development organizations and initiatives an essential step for the success of their interventions with farmers (Stringer et al., 2020). In this regards knowledge of the characteristics of farm types and their determinants provides important information in the development of agricultural development models adapted to the different realities identified (Sinha et al., 2022). However, due to the particularity of each farmer in the combination of production resources, there are as many production systems as there are farms and the diversity is such that not all farms could be considered individually. To efficiently deal with that diversity, it is therefore important to establish groups of more or less homogeneous vegetable farms based on their similar characteristics (Alvarez et al., 2014, 2018; Kuivanen et al., 2016; Tittone et al., 2010).

Previous studies on vegetable farms characterization and typology have already been carried out in Burkina Faso (Abdulkadir, 2012; Kolie, 2009; Ouattara, 2016; Sanfo et al., 2017). Kolie (2009) for instance identified five clusters of market gardeners according their socio-demographic categories and economic performance. However, his finding at the national level did not identify characteristics specific to different production environments (Kolie, 2009). Analyzing the environmental and economic dynamics of market gardening, Abdulkadir (2012) quantified nutrients (nitrogen, phosphorus, and potassium), flows, and economic performance of urban and peri-urban market gardening in three West African cities (Kano in Nigeria, Bobo Dioulasso in Burkina Faso, and Sikasso in Mali) (Abdulkadir, 2012). However, his research focused on the economic performance of farms without really considering specificities of the production environment (urban, peri-urban and rural). Ouattara (2016) conducted an exclusively agro-ecological typology of market garden farms in Houet, focusing especially on the identification of socio-economic and agro-ecological characteristics of the types of vegetable farms in the Houet province (Ouattara, 2016).

In this context, this study aimed to provide a comprehensive understanding of market garden diversity in Western Burkina Faso, by establishing the nexus between the production environment, farm size, financial performance and environmental issues. For this purpose, this paper is organized as follows: this section (1) provides the rationale and objectives of the research while Section 2 presents the theoretical framework of the study and the research hypotheses. Section 3 detailed the methodology used, and sections four and five deal with the results-discussion and conclusion respective. In order to properly analyze the market garden diversity this research build on the theoretical framework proposed by Sossou et al. (2013).

2. Theoretical framework

Farms are the basic units of agricultural production (cultivation, livestock, fishing, forestry, gathering), where decisions regarding the allocation of input in the production system are made as well as the choice of practices to be implemented (Bélières et al., 2014; Lowder et al., 2016). Each farm is characterized by its farming system, i.e., the way it combines its inputs, available technologies and activities to achieve its objectives (Innazent et al., 2022; Sossou et al., 2013). These objectives constitute the principles that guide the organization and functioning of the farm (Silva et al., 2020; Sossou et al., 2013). Farms can be considered as a complex organization with several highly interconnected dimensions including economic, patrimonial, social, territorial, etc. (Gasselin et al., 2014). In addition, it has been highlighted that the family character is one of the main components of this complexity that imbues the operation of the farm and that this character varies according to the type of farm (Aït Abdelmalek, 2000; Graeb et al., 2016; Lamarche, 1991). According to Sossou et al. (2013), in order to carry out a typology that aims to

understand the overall functioning of production systems, it is necessary to have a descriptive model of the functioning of the farm. For these authors, this model guides the methodological approach to be adopted to observe and account for the diversity of existing farms. In this regard, they build a general model of farm as follows (Figure 1).

According to this model, the environment of the farm is composed of human and natural elements. The natural element includes physical (water, soil, sunshine, temperature, etc.) and biological (plant and animal physiology, pests, etc.) factors, while the human element is subdivided into exogenous (community structures, norms and beliefs, geographical location of fields, etc.) and endogenous (needs and perspectives of farm households, production factors, etc.) factors. These human and natural elements that constitute the environment of the farm represent the constraints and opportunities of the farm (Jouve, n.d.). Farmers, in order to achieve their goals in an increasingly constrained environment, intentionally or not develops strategies, which are guidelines expressed through choices of agricultural and extra-agricultural activities and through the mobilization of the necessary assets to achieve the objectives set for the farm by its owner in a changing environment (Gafsi et al., 2007; No Rushigira, 2017). Ever since a production system is considered as a way of producing and combining production factors, it implies that a given cropping system will be implemented by a set of farmers who have access to the same resources in equivalent proportions (Ferrato and Touzard, 2009; Siqueira et al., 2022). In this study, market gardening will be considered as part of family farming in western Burkina Faso, strategically intended to diversify farmers diets, and improve their cash income (Hansen et al., 2022; Kaboré et al., 2017, 2018). In that vein, several cropping systems have been identified among market gardeners in Houet province, and these cropping systems remain influenced by the production site in which the market gardener operates (Ouedraogo et al., 2019). These authors have shown, for instance, that depending on whether the market garden farm is located in a rural, semi-rural or rural environment, the doses of chemical fertilizers vary considerably. Moreover, Kaboré et al. (2017) shown that income from market gardening varies greatly depending on the locality and the production environment. For instance, these authors have shown that in Ouahigouya, urban market gardeners have the best profits compared to semi-rural and rural market gardeners, while in Bobo-Dioulasso and Ouagadougou, rural market gardeners have the best profit margins. Under these conditions it can therefore be hypothesized that:

According to their socio-technical and economic characteristics, there is a large diversity of market gardening operations in western Burkina Faso.

3. Methods

3.1. Type development

“The main problem in determining a typology is determining the criteria for type construction” (Del Bayle, 2000). In agricultural research, the choice of the typology method used depends on the defined objectives and the discriminating indicators chosen (Agossou et al., 2015; Alvarez et al., 2014, 2018). Generally, two approaches in the construction of a typology can be distinguished: structure typology and functioning typology (Kumar et al., 2019; Mbetid-Bessane, 2002). According to these authors, at the farm level, the structure typology is based on the inputs used for production. It provides a description of the situation of the farm at a given time. As for the operating typology, its construction is reasoned and requires a baseline farm that guides the modus operandi to be adopted to observe and account for the diversity of farms (Alvarez et al., 2014; Capillon, 1993). It is developed by using criteria related to the production and decision-making processes within the farms (Mbetid-Bessane, 2002). For this study, the structural typology approach has been preferred. This choice is motivated by the fact that the socioeconomic analysis concerns well-defined periods and focuses mainly on the inputs (resources, financial, material and human means) mobilized by the market gardeners and on the outputs (yield and socioeconomic benefits) of the farms considered.

3.2. Sampling and data collect

The study was carried out in the province of Houet. This province was chosen because its location in an agroclimatic zone favorable to market gardening. It includes Bobo Dioulasso, the second-largest city in Burkina Faso (Figure 2).

This research involved market gardeners with at least ten years working experience in urban areas (sites located in the urban commune of Bobo Dioulasso), peri-urban areas (sites belonging to villages located on the outskirts of the city of Bobo Dioulasso), and rural areas (sites belonging to rural communes in the Houet province). These market gardeners, mainly market-oriented, producing a various range of vegetables. Data collection has been carried out in two steps (Table 1).

The first step consisted of exploratory surveys. For this purpose, two focus groups involving 10 farmers from each production environment have been carry out. During the first focus group, qualitative data about agronomic and socio-economic realities of farmers as well as their believes on the main factors of market garden diversity have been collected. These data have been processed and highlighted the production environment, farm size, financial performance and environmental issues as the main factors of diversity in market gardening in the region (Figure 3). During the second focus group, finding from the first focus group, mainly the identified factors of market garden diversity have been presented and discussed with the farmers who confirm their accuracy. These factors have therefore been used to reinforce the individual interview questionnaire.

After this exploratory stage, individual interviews were conducted. Ever since market gardener in the study area are more congested in urban environment, than peri-urban and rural environments, 5, 3 and 2 production sites have randomly been selected respectively in these environments. Then, proportional to the number of market gardeners in each locality, 12, 20, and 30 market gardeners have been randomly selected per production site respectively in urban, peri-urban and rural Environment. In each production environment, 60 market gardeners have therefore been selected for 180 gardeners overall (Table 1). Using a partially structured questionnaire, both variables required for the clustering, and farmers' perception about their financial performances have finally been collected.

3.3. Data analysis

Data analysis included both data from the exploratory survey and individual interviews. Concerning data from the exploratory survey, a qualitative analysis has been carried out. Using the IRAMUTEQ software, a word cloud has been established to highlight the various concepts and, which are relevant for the typology according to the farmers. As for the individual survey data, analysis have been carried out using SPSS and XLSTAT and QDA Miner software.

To establish typology and characterization of clusters, both descriptive and multivariate analyses have been performed using SPSS and XLSTAT software. The descriptive analyses were used to characterize the farms, while PCA and hierarchical ascending classification (HAC) were used to determine the structure of the interrelationships between the variables considered in order to analyze the main factors influencing the economic situation of the market garden farms in Houet. As a reminder, PCA is a tool for reducing the dimensionality of a set of quantitative variables which explores the links between variables and the similarities between individuals (Busca and Toutain, 2009; Larini and Barthes, 2018). Variables considered by FAO to be the main variables that characterize farms from an economic point of view have then been used to analyze the results of economic and financial profitability of farms. According to (FAO, 2005), the use of these commodity chain analysis variables is relevant in the context of economic studies aimed at preparing sectoral (agricultural and food) or global economic policy decisions. These are essentially the variables "Intermediate Consumption (IC)", "Depreciation", "Gross Operating Product (GOP)", "Value Added (VA)" and "Net Operating Income (NOI)", "Gross Operating Income (GOI)" and "Net Operating Income NOI". Out of these variables, the GOP, GOI, NOI have been selected and completed by additional variables namely the "Total Expenses (TE)" and "Profit/Cost Ratio (PCR)" usually considered as agricultural economics indicators and adapted for the financial analysis of vegetable farms (Table 2) (Paraíso et al., 2011). While these variables are financial and seem inappropriate for a classification of family farms, the study population is mostly market-oriented and consequently these variables are adequate for their classification.

Indeed, comparing several vegetable farms is possible if all of the variables that determine them are considered. However, this would lead to the classification of these farms according to too many characteristics,

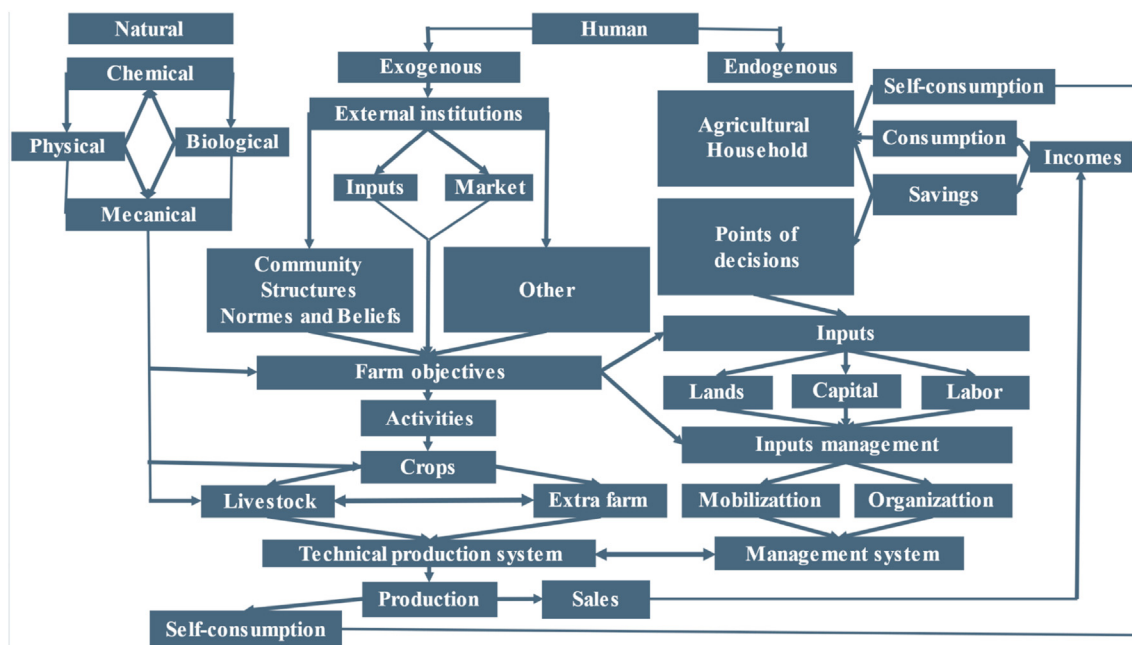


Figure 1. Operating model of smallholder Farms. Source: Adapted from Sossou et al. (2013).

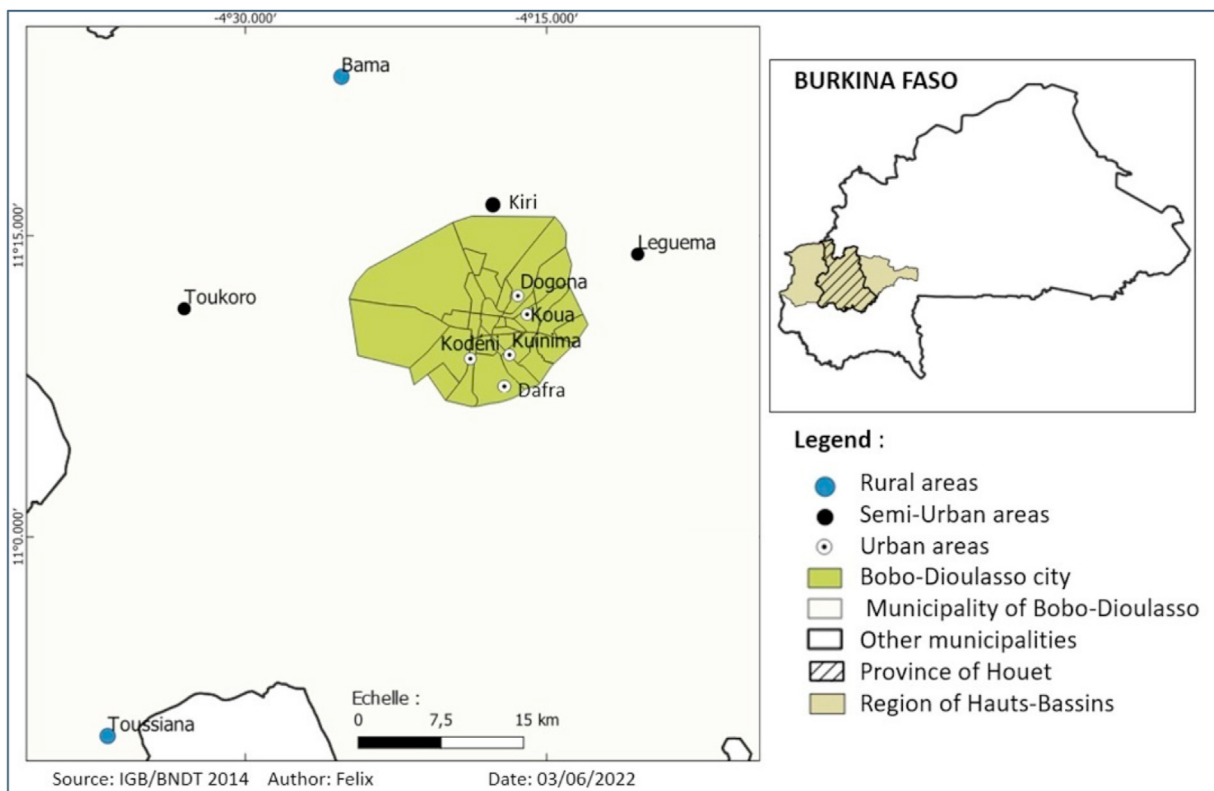


Figure 2. Study area. Source: Authors.

Table 1. Number of respondent's distribution in study area according to the data collect step, the production environment and the farms locations.

Data collection steps	Production environments	Production sites	Number of farmers	Total
First step (Focus group)	Urban	Dogona	10	30
	Peri-urban	Leguema	10	
	Rural	Toussiana	10	
Second step (individual interview)	Urban	Dafra	12	180
		Kuinima	12	
		Koua	12	
		Kodeni	12	
		Dogona	12	
	Peri-urban	Toukouro	20	
		Leguema	20	
		Kiri	20	
	Rural	Bama	30	
		Toussiana	30	

Source: Authors.

which would not allow a clear interpretation of the clusters obtained. This argues for the judicious choice of a reduced number of variables consistent with the specific objectives of the research. Two simple rules were used to reduce the number of variables. In this regards the first rule consisted in systematically eliminating variables with low variability. The level of variability was assessed using the coefficient of variation (CV) (ratio of the standard deviation to the mean). Variables with a CV of less than 0.5 are automatically eliminated, as this rate of variation is too low for these variables to be discriminating (Sossou et al., 2013). The second rule was to choose only one variable among those with implicit direct links. Based on these rules, the following economic variables have been selected: TE, GOI, NOI, and PRC. The variables “production environment” and “exploited area” were retained as additional variables in order to assess their respective influences on the economic performance of the farms.



Figure 3. World cloud of the main factors of diversity in market gardening according to farmers.

Source: Author's exploratory surveys (2016–2017 market gardening season).

Finally, in order to reinforce the clusters description QDA miner software has been used to report some farmers' statements typical of the class to which they belong.

4. Results and discussion

4.1. Results

4.1.1. Socio-demographic characteristics of market gardeners

The majority of market gardeners in Houet province is men. About 66.4% of market gardeners are under 45 years of age, with approximately

20 years of experience in market gardening. This indicates a predominantly young population. In addition, 81% of the farmers are less than primary school educated and 90.5% of the market gardeners interviewed are engaged in market gardening as their main activity. As for the transmission of knowledge, it is mainly from father to son at 89%.

4.1.2. Farm structure

The average size of market garden farms in Houet province is 4,800 m² or approximately half a hectare. In urban, peri-urban and rural areas, there is a variation in the average area with ±2350 m² in urban areas, 5750 m² in peri-urban areas and 6350 m² in rural areas. The majority (81.1%) of the market gardening areas are located less than 5 km from the farmers' homes. The predominant mode of acquisition of these market garden plots is through heritage, which is generally from father to son (66.5%). To a lesser extent, other forms of acquisition of market garden plots include rental, purchase, temporary transfer, donation and community ownership. In addition, results also show that 93% of market gardeners do not have a tenure agreement. The main irrigation sources used depend on the environment. While in urban areas wells and individual boreholes are the most widely used (95%), in peri-urban and rural areas, market gardening is highly dependent on water from dams and rivers (71% and 67%).

4.1.3. Technical and economic characteristics of the farms

4.1.3.1. Production. In order to carry out their production activities, market gardeners in Houet generally use casual labor. In this way, 47.48% of them use non-salaried family labor and 52.51% use temporary salaried labor. As for the nature of inputs, the majority of farmers use chemical fertilizers, mainly urea and mixed nitrogen-phosphorus-potassium (NPK). Roughly, 78% of market gardeners combine them

with animal manure, compost and household waste. For soil preparation, results show that 52.51% of farmers use herbicides and 96.1% of them use insecticides for phytosanitary treatment in market gardening areas. With regard to the different speculations, cabbage, tomato, bell pepper, green bean and lettuce are the most produced. The most common crop in urban areas is lettuce (produced by 76% of market gardeners), followed by peppers (produced by 65% of market gardeners) and tomatoes (produced by 55% of market gardeners). In peri-urban areas, 92.5% of market gardeners produce cabbage, while 25% of them produce lettuce. In rural areas, tomatoes are produced by 68.3% of market gardeners, followed by onions (produced by 21.7% of market gardeners). The production of these different crops is more diversified in urban areas than in other areas. In addition, farmers in urban areas generally practice crop combinations, with a preference for short-cycle crops such as lettuce, parsley, celery, etc.

4.1.3.2. Economic characteristics. Overall, the strong economic dimension of market gardening could explain its growing interest. Indeed, results showed that market gardeners face an average of 399,900 XOF (610 euros) per year in TE. They generate an average annual GOI of 1,209,300 XOF (1843 euros) and an average annual NOI of 661,900 XOF (1008 euros), while generating an average annual PCR of 214.5. However, these financial performance indicators hide some disparities according to the production environment. In urban areas, the average GOP is 1,106,200 XOF (1,686 euros) with an average RNE estimated at 690,500 XOF (1052 euros). In peri-urban areas, the average GOP is 1,331,200 XOF (2029 euros) for an average RNE of 614,100 XOF (936 euros). The average GOP is 1,188,800 XOF (1812 euros) for an NER of 681,600 XOF (1039 euros) in rural areas. With regard to the BCR, results show average values of 285.6, 156.1 and 203.2 for urban, peri-urban and rural areas respectively. Overall, the results show that urban operations are more profitable financially. These above-described Socio-demographic characteristics have been resumed as follows in Table 3.

Table 2. Definitions of the main economic variables used.

Intermediate inputs	Intermediate inputs (CI) are inputs that are completely transformed or used-up during the production or transformation process
Depreciation	Depreciation or fixed costs represent the theoretical value of the corresponding wear and tear of investments (production equipment)
Gross operating product (GOP)	GOP or gross product value represents the total sales or turnover
Added value (AV)	Value added is defined as the additional wealth generated by the operation. It measures the creation of wealth by highlighting the contribution of the production process involved to the economic growth. It represents the GOP minus the wealth that had to be destroyed to ensure production. It is the result of the difference between the GOP and the intermediate consumptions. AV = GOP – CI
Income or gross operating income (GOI)	GOI refers to the operating profit. It is defined as the GOP minus the value of all operating costs for the year: intermediate consumption, labor, financial expenses and taxes (FAO, 2005). A positive GOP means that GOP is able to cover all variable expenses. This implies that production is economically profitable. On the other hand, a negative GVA indicates that production is not profitable (FAO, 2005). GOP = AV – (labor remuneration + financial costs + taxes)
Income or net operating income (NOI)	NOI is the balance of GOI minus the value of depreciation. The NOI is also called profit. When it is positive, it illustrates the fact that the GOP covers the TE (fixed expenses and variable expenses). This implies that the relevant production is profitable (Paraíso et al., 2011). It is calculated according to the following formula (FAO, 2005): NOI = GOP - depreciation

Source: Adapted from (FAO (2005) and Paraíso et al. (2011).

4.1.4. Dimensions of farm economic performance

The PCA performed on the selected variables generated several dimensions of which the two main ones (D1 and D2) represented 93.70% of the total inertia of all the variables in the study (Figure 4).

The first axis (D1) of the PCA, representing 51.74% of the total inertia, is strongly linked to the active variables GOI and TE (Figure 3; Table 4). It associates these two active variables through a positive correlation.

In addition, it is also linked to the additional variable “Farm Size” as well as to the modalities “peri-urban environment”. This shows that farms located in peri-urban areas are characterized by higher TE and sales compared to farms located in urban areas. The second axis (D2) represents 41.97% of the total inertia. It is more strongly related to the variables PRC and NOI. It is also related to the urban environment. This shows that farms located in urban areas generate higher profits by recording higher Net Operating Income and PCR compared to farms in other areas (peri-urban and rural). The profitability of farms in the province is therefore partly linked to characteristics specific to the different production environments.

4.1.5. Farms classification

Finding of the HAC carried out based on the economic variables TE, GOI, NOI and PRC Revealed four clusters of market gardeners with different socioeconomic profiles (Figure 5).

4.1.5.1. Cluster 1: small farms with low financial performance. This cluster includes 31.73% of the farms in the sample, distributed as follows: 32% in urban areas, 35.84% in peri-urban areas and 32.75% in rural areas. It is composed of farms with an average area of 3800 m², generally acquired by inheritance. Market gardeners in this cluster have an average age of 39 years. Some 81% of these market gardeners have a level of education

Table 3. Socio-demographic and economic characteristics of sample farmlands.

Socio-demographic characteristics	Farm structure	Technical and economic characteristics of the farms	
		Production	Economic characteristics
About 66.4% of market gardeners are under 45 years	average size of market garden farms in the region is 4,8 m ²	47.48% of market gardeners use non-salaried family labor and 52.51% use temporary salaried labor	An average annual TE of 399,900 XOF (610 euros) per farmer
approximately 20 years of experience in market gardening	81.1% of the market gardening areas are located less than 5 km from the farmers' homes	78% of farmers use, combine animal manure with urea and mixed nitrogen-phosphorus-potassium (NPK)	An average annual GOI of 1,209,300 XOF (1843 euros) per farmer
About 81% of the farmers are less than primary school educated	The predominant mode of acquisition of these market garden plots is through heritage (66,5%)	52.51% of farmers use herbicides and 96.1% of them use insecticides for phytosanitary treatment in market gardening areas	An average annual NOI of 661,900 XOF (1008 euros) per farmer
Market gardeners is the main activity of 90.5% of the sample	93% of market gardeners do not have a tenure agreement	The most common crop in urban areas is lettuce (produced by 76% of market gardeners), followed by peppers (produced by 65% of market gardeners) and tomatoes (produced by 55% of market gardeners)	An average annual PCR of 214.5 per farmer
Transmission of knowledge, it is mainly from father to son at 89%.	in urban areas wells and individual boreholes are the most widely irrigation source used (95%), while in peri-urban and rural areas, market gardening is highly dependent on water from dams and rivers (71% and 67%)	In peri-urban areas, 92.5% of market gardeners produce cabbage, while 25% of them produce lettuce. In rural areas, tomatoes are produced by 68.3% of market gardeners, followed by onions (produced by 21.7% of market gardeners)	In urban areas, the average GOP is 1,106,200 XOF (1686 euros) with an average RNE estimated at 690,500 XOF (1052 euros). In peri-urban areas, the average GOP is 1,331,200 XOF (2029 euros) for an average RNE of 614,100 XOF (936 euros). The average GOP is 1,188,800 XOF (1812 euros) for an NER of 681,600 XOF (1039 euros) in rural areas
–	–	–	As for the BCR, results show values of 285.6, 156.1 and 203.2 for urban, peri-urban and rural areas respectively

Source: Author's survey (2016–2017 market gardening season).

below primary school. They have an estimated average of 18 years of experience in market garden production. The market gardeners in this category operate in a conventional mode of production. They spend an average of 278,900 XOF (425 euros) in TE for their activities. However, these farmers are also more likely to use family labor for specific stages of production (plowing, semi-repotting and harvesting), while 14% use external salaried labor. On average, two women work on these farms. Their investments result in an average GOI estimated at 685,500 XOF (1044 Euros) and an average Net NOI of 175,000 XOF (267 Euros). They have an average PCR estimated at 77. By relating their average NOI to their average area, the ratio index obtained is 46. In addition, 85% of these market gardeners have no household economy and only 9% of them claim that their living condition has improved due to the market gardening activity. Finally, for 81% of them, there are heirs who are motivated to be involved in market gardening activities.

4.1.5.2. Cluster 2: medium-sized farms with low financial performance. The market gardeners in this cluster have an average age of 41 years and 20 years of experience in market gardening. This cluster includes 27.54% of the farms in the sample, of which 19.56% are located in urban areas, 50% in peri-urban areas and 30.43% in rural areas. These farms have an average area of about 5200 m². Inheritance is the main way in which land is acquired. In addition, 37.2% of market gardeners have less than a primary school education. These farms are characterized by conventional production methods, with TE estimated to be 691,800 XOF (1,054 euros) on average. 85% of market gardeners in this cluster use family labor and 27.6% use external paid labor. Furthermore, an average of three women are involved in the labor force. With regard to the economic performance of farms in this class, results show an average annual GOP of 1,577,800 XOF (2405 euros), an annual NOI of 633,500 XOF (965 euros) and an average annual PCR of 106. 24% of market gardeners in this cluster have savings in a local financial institution, and nearly 21% of them believe that market gardening improves their everyday living conditions. Similarly, 82% of market gardeners consider that their heirs are motivated to continue developing their production activities. The ratio of the net operating income of cluster 2 to the average area farmed is 121.

4.1.5.3. Cluster 3: large farms with high financial performance. Of this third cluster of farms, representing 11.37% of the sample, 26.21% are in urban areas, 36.84% in peri-urban areas and 36.84% in rural areas. The average size of these farms is about 11,600 m². Inheritance was the major way of acquisition for 58% of them. Farmers in this cluster have an average of 25 years of experience in market gardening and an average age of 46 years. Their educational level is low. In other words, 61% of these market gardeners have a primary level of education. As with the majority of market gardeners in Houet province, most of these market gardeners produce conventionally, with average total annual expenses of 586,700 XOF (895 euros). Most of them (73%) use family labor and 28.6% use salaried labor. The involvement of women in market garden production activities is preponderant in this class. There are six women on average employed as laborers. This cluster generates an average annual GOP of 2,711,500 XOF (4133 euros), an average annual NOI of 2,124,700 XOF (3239 euros) and an average annual PCR of 405. Approximately 32% of market gardeners have savings in a local micro-finance institution and nearly 68.4% of them claim that the market gardening activity improves their standard of living on a daily basis. Similarly, 88.15% of market gardeners in cluster (3) are motivated to continue developing their activities. The ratio of the average net operating income to the average area farmed is 183.16.

4.1.5.4. Cluster 4: small farms with high financial performance. This last cluster represents 29.34% of the farms in the sample, 50% of which are located in urban areas, 32% in peri-urban areas and 18% in rural areas. The average area of these farms is 2350 m². The majority of the farmers (68.73%) obtained their land through inheritance. On average, market gardeners are 42 years old, with an average experience of 20 years in this activity. The education level of 46.2% of market gardeners is lower than primary school. The majority of these market gardeners practiced conventional production, with average TE of approximately 184,300 XOF (291 euros). In addition, 89.36% of them use family labor and 46.84% of them use external salaried labor. On average, two women are employed as laborers. In terms of economic benefits, Cluster 4 market gardeners have an average annual GOI of approximately 847,600 XOF (1292

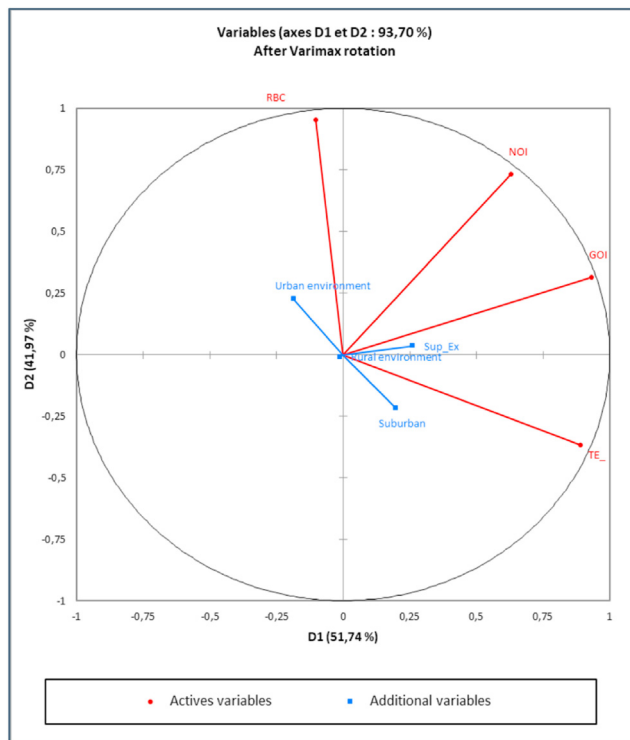


Figure 4. Different Dimensions of Farm Economic Performance. Source: Author's survey (2016–2017 market gardening season).

Table 4. Correlations between variables and factors.

Actives variables	D1	D2
Total Expenses (TE)	0,890	−0,368
Gross Operating Income (GOI)	0,932	0,315
Net Operating Income (NOI)	0,631	0,733
Profit/Cost Ratio (PCR)	−0,102	0,952
Additional variables		
Operating area (Sup_Ex)	0,259	0,036
Urban environment	−0,186	0,226
Sub-urban	0,198	−0,217
Rural environment	−0,012	−0,009

Source: Author's survey (2016–2017 market gardening season).

Euros), an average NOI of 648,000 XOF (988 Euros) and an average annual PCR of 390. Approximately 35% of them have savings in a local financial institution and nearly 42% consider that the market gardening activity improves their standard of living on a daily basis. For 72.66% of them, there are heirs within their family who are motivated to continue developing their market gardening activities. These farms record the best financial performance with an average net operating income/average area ratio of 275.74. The main characteristics of the various identified clusters can be summarize as followed (Table 5).

4.2. Discussion

4.2.1. Socio-demographic characteristics of market gardeners

Finding revealed that a greater number of men than women are involved in the production of vegetables in the Houet province. As for women, their full participation in the production of vegetables is restricted by socially entrenched norms, rules and traditional values. However, despite these socio-cultural obstacles, they are renting market gardening plots, exploiting them, and becoming increasingly involved in vegetable

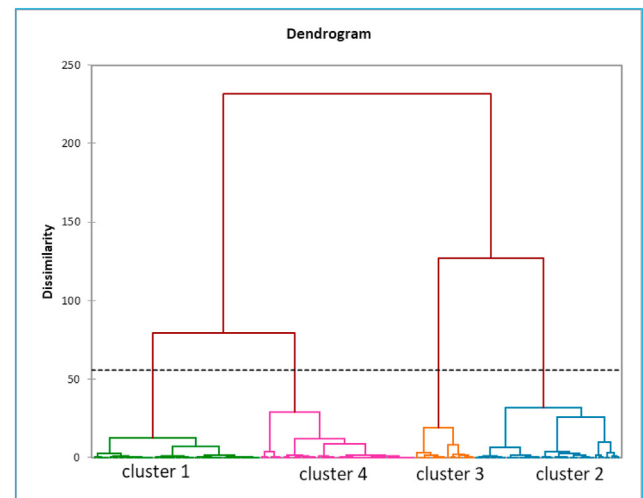


Figure 5. Graphical representation of the main market gardeners' clusters. Source: Author's survey (2016–2017 market gardening season).

harvesting and marketing, as well as in many other ordinary consumer products (MAHRH, 2007; Miassi et al., 2019; Moussa, 2016). The high economic dimension of the market gardening activity, which is increasingly attracting young people, can explain the relative youthfulness of market gardeners in Houet. Research conducted in other West African (Benin) and Central African (Cameroon) regions explains the youthfulness of the market gardening population by the reality of the high unemployment rate in these countries. As a result, more and more young people are learning market gardening and are engaging in market gardening as a profession (Ahouangninou, 2013; Ahouangninou et al., 2013; Kaffo, 2005). Overall, market gardeners in Houet have a low level of education. 83.31% of the farmers interviewed had no more than a “primary” level of education. This confirms the general level of education of the sector's actors, which is also low in almost all regions of Burkina Faso. In the same vein, Ouédraogo et al. (2019) showed that Nearly 60% of market gardeners are not educated and only 8–10% have completed high school.

These results provide levers to improve the sector's contribution to the region's socio-economic development. Indeed, the youthfulness of the region's vegetable farmers is an advantage for the extension of sustainable agricultural practices. It has been established that young farmers are more likely to adopt innovations (Balasha and Fyama, 2020; Issoufou et al., 2017). Moreover, they are nowadays more accustomed to the use of new communication technologies (Radhakrishnan et al., 2020; Yang et al., 2021). Public policy aimed at promoting sustainable agricultural practices for young market gardeners, based on new communication technologies, is therefore likely to be effective under these conditions. In this regard, the BioSPG label, which is one of the first national organic labels in West Africa, could be particularly appreciated by market gardeners in the Houet province, most of whom are young and open to innovation. Indeed, it is an alternative organic certification system, adapted to the local context and inexpensive, based on rigorous organic agriculture tools and standards that integrate all actors in the cycle: producers, processors, transporters, distributors, support associations and NGOs, and consumers (CNABIO, 2021). It thus contributes to the achievement of the Sustainable Development Goals (SDGs) promoted by the UN and to the success of the agroecological transition advocated by the FAO, ECOWAS and donors. It also meets the criteria of the National Economic and Social Development Plan (PNDES) of Burkina Faso (CNABIO, 2021). According to statistics from the National Council for Organic Agriculture in Burkina Faso, between 2015 and 2021, BioSPG certification activities have, for example: (i) certify 52 BioSPG sites in several regions of the Country, for a total of (ii) 1323 producers spread over (iii) an area of 177.8 hectares, creating in the process (iv) 800 fixed jobs at the production level of private and associative farms, (v) about

thirty jobs in processing and marketing, and finally (vii) seasonal and/or temporary jobs (CNABIO, 2021). In view of its proven socio-economic impact, promoting this label in the horticultural sector in the Houet region could be a concrete alternative for guaranteeing employment for young market gardeners and ensuring healthy food for the entire local population.

4.2.2. Farms structures and vegetables production

Regardless of the production environment, market gardeners in Houet work on an average area of about 4,800 m² (less than half a hectare). However, the cultivated area differs somewhat depending on

the environment (urban, 2350 m², peri-urban, 5750 m², and rural, 6350 m²). In fact, the average production area is larger in peri-urban and rural areas where arable land is more available. In urban areas, where expansion is increasingly limited and controlled by the public authorities, production areas are smaller. In this regard (Ahouangninou, 2013; Ahouangninou et al., 2013; Blein et al., 2008), have stated that due to constraints related to the increasing urbanization of African cities, land availability is becoming more limited. This reality hinders the expansion of fields. Apart from the irrigated areas developed by the State for farmers in peri-urban areas, most of the land used by market gardeners is family property. As a result, inheritance appeared in the study as the

Table 5. Main characteristics of the identified farms clusters.

Main variables	Clusters' values																				
Average farm size (m ²)	<table border="1"> <tr><th>Cluster</th><th>Average farm size (m²)</th></tr> <tr><td>Cluster 1</td><td>3800</td></tr> <tr><td>Cluster 2</td><td>5200</td></tr> <tr><td>Cluster 3</td><td>11600</td></tr> <tr><td>Cluster 4</td><td>2350</td></tr> </table>	Cluster	Average farm size (m ²)	Cluster 1	3800	Cluster 2	5200	Cluster 3	11600	Cluster 4	2350										
Cluster	Average farm size (m ²)																				
Cluster 1	3800																				
Cluster 2	5200																				
Cluster 3	11600																				
Cluster 4	2350																				
Proportion of the sampled farms	<table border="1"> <tr><th>Cluster</th><th>Proportion (%)</th></tr> <tr><td>Cluster 1</td><td>33</td></tr> <tr><td>Cluster 2</td><td>30</td></tr> <tr><td>Cluster 3</td><td>37</td></tr> <tr><td>Cluster 4</td><td>18</td></tr> </table>	Cluster	Proportion (%)	Cluster 1	33	Cluster 2	30	Cluster 3	37	Cluster 4	18										
Cluster	Proportion (%)																				
Cluster 1	33																				
Cluster 2	30																				
Cluster 3	37																				
Cluster 4	18																				
Various clusters' farms locations (%)	<table border="1"> <tr><th>Location</th><th>Cluster 1 (%)</th><th>Cluster 2 (%)</th><th>Cluster 3 (%)</th><th>Cluster 4 (%)</th></tr> <tr><td>Rural area</td><td>33</td><td>30</td><td>37</td><td>18</td></tr> <tr><td>Peri-urban areas</td><td>36</td><td>50</td><td>37</td><td>32</td></tr> <tr><td>Urban areas</td><td>32</td><td>20</td><td>26</td><td>50</td></tr> </table>	Location	Cluster 1 (%)	Cluster 2 (%)	Cluster 3 (%)	Cluster 4 (%)	Rural area	33	30	37	18	Peri-urban areas	36	50	37	32	Urban areas	32	20	26	50
Location	Cluster 1 (%)	Cluster 2 (%)	Cluster 3 (%)	Cluster 4 (%)																	
Rural area	33	30	37	18																	
Peri-urban areas	36	50	37	32																	
Urban areas	32	20	26	50																	
Average age of market gardeners in the cluster (years)	<table border="1"> <tr><th>Cluster</th><th>Average age (years)</th></tr> <tr><td>Cluster 1</td><td>39</td></tr> <tr><td>Cluster 2</td><td>41</td></tr> <tr><td>Cluster 3</td><td>46</td></tr> <tr><td>Cluster 4</td><td>42</td></tr> </table>	Cluster	Average age (years)	Cluster 1	39	Cluster 2	41	Cluster 3	46	Cluster 4	42										
Cluster	Average age (years)																				
Cluster 1	39																				
Cluster 2	41																				
Cluster 3	46																				
Cluster 4	42																				
Experience in market gardening (years)	<table border="1"> <tr><th>Cluster</th><th>Experience (years)</th></tr> <tr><td>Cluster 1</td><td>18</td></tr> <tr><td>Cluster 2</td><td>20</td></tr> <tr><td>Cluster 3</td><td>25</td></tr> <tr><td>Cluster 4</td><td>20</td></tr> </table>	Cluster	Experience (years)	Cluster 1	18	Cluster 2	20	Cluster 3	25	Cluster 4	20										
Cluster	Experience (years)																				
Cluster 1	18																				
Cluster 2	20																				
Cluster 3	25																				
Cluster 4	20																				
Annual NOI (Euros)	<table border="1"> <tr><th>Cluster</th><th>Annual NOI (Euros)</th></tr> <tr><td>Cluster 1</td><td>267</td></tr> <tr><td>Cluster 2</td><td>965</td></tr> <tr><td>Cluster 3</td><td>3239</td></tr> <tr><td>Cluster 4</td><td>988</td></tr> </table>	Cluster	Annual NOI (Euros)	Cluster 1	267	Cluster 2	965	Cluster 3	3239	Cluster 4	988										
Cluster	Annual NOI (Euros)																				
Cluster 1	267																				
Cluster 2	965																				
Cluster 3	3239																				
Cluster 4	988																				

Source: Author's survey (2016–2017 market gardening season).

main method of acquiring market garden production areas, with an average rate of 66.5%. This is above the national rate estimated to be 43% according to the Ministry of Agriculture and Hydraulics of Burkina Faso (MAH, 2011). Regardless of a few market gardeners (5%) who claim to practice the agroecological production method, the majority of market gardeners (95%) have a conventional production method characterized by frequent and often uncontrolled use of chemical pesticides, as well as mineral fertilizers that some combine with organic amendments. Farmers explain the low level of agro-ecological adoption by pointing out that most consumers do not distinguish conventional vegetables from organic ones. This leads van Caloen and de Richecour (2015) to assume that the existence of a specific demand for agroecological products in the market garden chain is a basic condition to motivate farmers to move towards agroecological market garden production (van Caloen and de Richecour, 2015).

4.2.3. Profitability factors and economic performances of vegetable farms

An analysis of the economic performance of market garden farms in the Houet province using variables related to inputs and outputs shows that the average NOI in urban, peri-urban and rural areas is 690,500 XOF (1052 euros), 614,100 XOF (936 euros) and 681,600 XOF (1039 euros) respectively, for an average area of 2350 m², 5750 m² and 6350 m². As for the PCR, they are respectively 285.6, 156.1 and 203.2 for the urban, peri-urban and rural areas. Similarly, the ratio of NOI to cultivated area for the three environments is 293.8 in urban areas, 106.8 in peri-urban areas and 107.5 in rural areas. These results show that market gardeners in urban areas have the best economic performance. These findings reinforce the belief that market gardening is one of the most profitable agricultural businesses in Burkina Faso (Bambio, 2021). Moreover, the correlation circle of the PCA revealed a positive correlation in dimension 2 between the variables PCR, NOI and the urban environment. The difference in average net operating income in these three areas can be explained by several reasons. First, urban farmers tend to produce a larger variety of crops in the same season through crop combinations. In addition, because of their proximity to the main distribution centers for market garden products, urban farmers generate better profits because of low transportation costs. In fact, many urban farmers involve their wives in the direct marketing of their produce (without intermediaries) in order to benefit from the advantages of their geographic access to the market. The possibility of direct sales allows these farmers to set very advantageous selling prices (Rocchi et al., 2020; Virto, 2022). In the same way, market gardeners in urban areas do not have as many problems with the conservation of their crops because of their immediate contact with buyers. Their situation contributes to improving their PCR.

In peri-urban areas, farmers explain the limited economic profitability of their activities through the fact that a large part of their production is sold locally for local consumption with less competitive prices than in urban areas. Notwithstanding this explanation, interviews reveal that an abundant production of a specific crop in the three areas (urban, peri-urban and rural) would negatively influence the selling prices of this crop in the peri-urban and rural areas, because distributors would tend to buy their supplies first in the city. Given that market garden products are perishable, in such a situation, peri-urban and rural farmers would tend to sell off their production to avoid the risk of losing all of it. B.O.¹'s comments are illustrative of this reality: "With the same quantity, I can sell all my cabbages production for XOF 500,000 (762 euros) this year and next year for less than XOF 300,000 (457 euros), all depending on the period and market". Almost all of the market garden production in the rural areas is sold to wholesalers or trade intermediaries from Bobo Dioulasso, Ouagadougou and neighboring countries. The value of the average net income obtained in rural areas can be explained through a larger area of land being farmed than in urban and peri-urban areas. This results in higher production and income. Nevertheless, average incomes in urban

areas are higher than average incomes in peri-urban and rural areas. The lower average PCR in peri-urban and rural areas than in urban areas can also be explained through the volatility of prices per kilo of the different crops sold. This lack of price control is profitable for wholesale purchasers, who tend to set the cheapest price they can. As M.T.² points out "there is no collaboration between all of us, farmers, in setting the prices of our products. Each farmer negotiates according to his own interests. For the resellers, the purchase prices they offer us are set according to the risks related to transport and the availability of the product requested in the city (urban center)".

When the average annual NOI of farmers is reported monthly, it is found that urban farmers generate an average of 57,600 XOF (88 euros), peri-urban farmers generate an average of 51,200 XOF (78 euros), and rural farmers generate 56,800 XOF (87 euros). These low monthly incomes are nonetheless significant for market gardeners. This shows that market gardening is a considerable source of income for the population (Angwafo and Eric Bime, 2020; Kaboré et al., 2018; Thiombiano, 2008). This reality is especially noticeable in peri-urban and rural areas, where most of the population lives below the poverty line of 40.1% (INSD, 2009). Consequently, it is important to stimulate this sector in these areas. The importance of market gardening for rural populations has been confirmed by the research of (Bognini, 2010), who showed that in the province of Sanguié (Center-West region), market gardening was the main source of income among the various activities carried out by rural households. This money is commonly used to buy food, send children to school, finance agricultural activities, provide medical care, and participate in festive events (weddings and baptisms) or unhappy ones (death, illness). This is how market gardening activity emerges as a real opportunity to improve the daily living conditions of farmers (Bognini, 2010; Kaboré et al., 2017, 2018). However, income from market gardening does not allow market gardening households to live above the poverty line set at \$1.9/day/person by the World Bank. This is why some market gardeners diversify their sources of income by engaging in additional activities such as animal husbandry, handicrafts, etc.

It is important to note that market garden incomes are irregular over time and also vary widely from one farmer to another. Analysis of the socio-economic typology of market garden farms in Houet confirms these different economic realities. First, it should be noted that the HAC revealed four categories of farms: small farms with low financial profitability, medium farms with low financial profitability, large farms with high financial profitability and small farms with high financial profitability. This confirms the hypothesis that, according to their socio-technical and economic characteristics, there is a diversity of market gardening operations in western Burkina Faso. The first two categories (clusters 1 and 2) had the lowest economic results. Apart from the influence of the production environment, the economic performance of market gardeners in these two clusters could be explained by the low financial returns and the high variability of expenses related to market garden production. This is due to the fact that, in general, the prices of agricultural inputs are not only high, but also volatile. The last two categories (clusters 3 and 4) had the best results in terms of financial profitability. Their better financial results could be explained by the advantages of direct sales for market gardeners operating in urban areas, and by the dynamics of the local market in this area. Despite the varying successes of market gardeners in Houet province, analysis shows that market gardeners' families were motivated to continue the activity. This reveals the definite contribution of market gardening to the improvement of household living conditions. Moreover, in light of these results, and in order to improve the financial performance of cluster 1 and 2 market gardeners, public decision-makers and non-governmental organizations working to develop the sector could undertake training in crop storage and processing techniques for these market gardeners.

¹ Market gardeners' leader of the Toussiana site.

² Market gardener: interview conducted in Toukoro on November 03, 2018.

5. Conclusion and policy implications

Moving current production systems towards greater sustainability requires knowledge of the different categories of farms with regard to social, economic and environmental sustainability. This study aimed to provide a comprehensive understanding of the western Burkina Faso market garden by establishing the nexus between the social, technical and financial dimension of these farms. For this purpose, it built on Sossou et al. (2013) theoretical framework. Overall, finding revealed that market gardeners are young and mainly produced using conventional farming practices. It also highlighted the influence of the production environment and the market risk on the market garden farms financial performances. From the hierarchical ascendant classification, it emerged that the market garden farms were divided into four clusters: (i) *small farms with low financial performance* (cluster 1); (ii) *medium-sized farms with low financial performance* (cluster 2); (iii) *large farms with high financial performance* (cluster 3) and finally (iv) *small farms with high financial performance* (cluster 4). While the majority of vegetable farms in clusters 1 and 2 are characterized by their moderate or low profitability, those in clusters 3 and 4 have a relatively high level of dynamism, which is indicative of the economic importance of vegetable production in Burkina Faso. As point out by some authors, moving towards agroecology in market gardening could be a viable alternative, especially since in the long term its externalities are positive at economic, social, and especially environmental levels. In this regard, these finding provide lever for action aimed at promoting the sector sustainability: for instance, (i) *public policy based on new communication technologies, can be carry out to promote sustainable agricultural practices among market gardeners ever since they are mainly young*. Moreover, (ii) *training about crop storage and processing techniques could improve cluster 1 and 2 farmer's financial performances*.

Declarations

Author contribution statement

Felix Ouédraogo and Kiswendsida Parfait TAPSOBA conceived and designed the experiments.

Felix Ouédraogo performed the experiments.

Felix Ouédraogo and Kiswendsida Parfait TAPSOBA analyzed and interpreted the data.

Kiswendsida Parfait TAPSOBA wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no competing interests.

Additional information

No additional information is available for this paper.

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