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Agroecological transition in Southern Benin: What challenges for more efficient vegetable farming systems?

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Abstract

In Benin, agroecological intensification and agroecological transition of vegetable farming systems is an undeniable necessity for achieving the objectives of food and nutrition security while preserving natural resources, human and animal health. The present study analyses vegetable farming systems in southern Benin, to highlight bottlenecks and challenges in the process of an agroecological transition and intensification of these systems. Data were collected with questionnaires and interview guides through individual interviews and focus groups among a sample of 105 producers practicing one of the three types of vegetable farming systems encountered in south of Benin. These data concern mainly production factors, cropping systems, costs of cropping operations, and production constraints. They were analysed using parameters of descriptive statistics. The results revealed a diversity of cropping practices according to agroecological zones. Vegetable farming systems in flooded land value agroecological practices more than those in coastal areas. The performance of these systems is limited by constraints such as land insecurity, difficulties in accessing organic inputs, low technical capacities of farmers, and low development of agroecological markets. Therefore, facing the challenges of agroecological transition and intensification of vegetable farming systems in the south of Benin, requires the implementation of appropriate technical, organisational and political measures to overcome these obstacles. Among others, these measures will consist to facilitate producers' access to secured land, to make agroecological technologies accessible and affordable for producers, to facilitate their learning process, and to promote the development of short circuit sales.

Keywords: agroecology, garden crops, organic, intensification, sustainability, West Africa

1 Introduction

Vegetable crops are important sources of proteins, vitamins, and micronutrients for the proper functioning of the body. Its consumption contributes to the achievement of food and nutrition security objectives (Souleymane *et al.*, 2021). In Benin country (West Africa), the use of synthetic chemical fertilisers and pesticides to increase production yield compromises the quality of vegetables due to the presence of toxic residues with harmful consequences on human health and the environment (Yarou *et al.*, 2017; Adjatini *et al.*, 2019). Few farmers abide by the afterglow time of pesticides used before the harvest and the sale of vegetables. This practice exposes consumers to chronic food poisoning (Zoundji *et al.*, 2018). Indeed, it has been shown that pesticide residues are the cause of reproductive disorders, respiratory and gastrointestinal problems, pneumonitis in the immune and nervous systems, etc. (Soro *et al.*, 2018). Studies carried out on certain vegetable sites in South Benin have revealed residual toxicity of vegetable crops with heavy metals

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and organochlorine pesticides (Sæthre *et al*., 2011; Agnandji *et al*., 2018). Therefore, the need to evolve vegetable production systems towards more sustainable modes becomes indispensable. Thus, ecological intensification appears today as the agrarian transition to be promoted for increasing sustainable agricultural production (Vall *et al*., 2015). So, some initiatives are developed for conversion of producers from the conventional system to organic or ecological systems. These sustainable systems emphasize the valorisation of local resources and promote the use of organic fertilisers, integrated management of soil fertility, pest control and the minimization of the use of chemical pesticides and mineral fertilisers (CPF) (Simon *et al*., 2014; Vidogbéna *et al*., 2016). Also, the production systems in Benin are undergoing deep change by the agroecological transition. Agroecology has different meanings. It is perhaps considered as a science with a specific methodological approach (Francis *et al*., 2003; Gliessman, 2016; Gliessman, 2018), as a social movement, in response to current problems such as climate change, malnutrition, etc. (Altieri & Toledo, 2011; Rosset *et al*., 2011; Rivera-Ferre, 2018) but also as agroecological practices (Gliessman, 1990; Wezel *et al*., 2014). In the latter sense, agroecology is defined as a process that aims to improve agroecosystems through the valorisation of natural processes by promoting beneficial biological interactions and synergies between their components (Gliessman, 1990). Widespread adoption of agroecological practices requires, among others, a better understanding of the bottlenecks faced by producers. This article focuses on a diagnostic analysis of vegetable production systems in South Benin that are part of an agroecological perspective to highlight the constraints related to their implementation and to identify the challenges of the transition or the agroecological intensification of production systems.

2 Materials and methods

2.1 Study area

The study took place in South Benin where traditionally, three (3) vegetable production areas are distinguished: flood zone (valley), coastal zone, and plateau zone. This typology of vegetable production areas is based on the ecological, edaphic, climatic, and socio-economic characteristics of the environment, integrating the pressure of urbanization, water availability, and infrastructure (Assogba-Komlan *et al*., 2007; Ahouandjinou *et al*., 2019). Also, the intervention of the Project to Support the Development of Market Gardening (*Projet d'Appui au Développement du Maraîchage: PADMAR*) and the diversity of production sites for the best contextualization of the constraints related to vegetable production were considered to define three (3) sites, one in each zone for the empirical phase of this study: Dangbo in the Oueme Valley, Market Garden village of Seme-Kpodji (VIMAS) in the coast and production site in Koundokpoue (Ze) in the plateau area. The choice of these sites also considered the seniority of the producers in the implementation of agroecological practices and the rational use of synthetic chemicals in the production of vegetables and the accessibility to the site.

2.2 Sampling and data collection

The survey took place in September 2019 with 105 vegetable producers among them 51 women and 54 men, including 34 producers (21 women and 13 men) in the flood zone of Oueme Valley (Dangbo), 35 producers (7 women and 28 men) in the Coastal Zone (Seme-Kpodji) and 36 producers (23 women and 13 men) in the Plateau zone (Ze). These producers were selected by simple random sampling. A sampling frame for market gardeners was used for this purpose. All selected market gardeners were subjected to structured individual interviews by using digitized questionnaires on the CS Entry application under the CSPro 7 software. Data collected with this tool mainly concern the socio-economic and demographic characteristics of producers, the factors of production, the cropping system, and the costs of cultivation operations. In addition, three semi-structured interviews in mixed focus groups using interview guides were conducted to collect data relative to the strengths-weaknesses-opportunities-threats of farming systems, the relationship of market gardeners with producers support structures.

2.3 Data processing and analysis

The data collected were processed using the analysis software SPSS V.16 and presented in the form of graphs, tables and pie charts. The calculated descriptive statistics relate to the parameters of position (mean, frequencies), dispersion (variance, standard deviation) and cross-tabulations and have been used for the socio-demographic and economic characteristics of market gardeners.

3 Results

3.1 Demographic and socio-economic characteristics of market gardeners

The socio-economic and demographic characteristics of the market gardeners surveyed are shown in Table 1.

The analysis of the table reveals a low predominance of male farm managers (52 %) over women (48 %). However,

Table 1: *Demographic characterisation of market gardeners by production area.*

Variables	*Modalities*	*Oueme Valley (n = 34)*	*Ze (n = 35)*	*Seme-Kpodji (n = 36)*	*Total (n = 105)*
Gender	Female	62 %	20 %	64 %	48 %
	Male	38 %	80 %	36 %	52 %
Provenance	Autochthonous	100 %	42 %	42 %	60 %
	Allochthonous	00 %	58 %	58 %	40 %
Socio-cultural Groups	Fon	00 %	29 %	58 %	30 %
	Goun	00 %	34 %	08 %	14. %
	Weme	100 %	06 %	00 %	34 %
	Xwla	00 %	13 %	03 %	06 %
	Yoruba	00 %	03 %	00 %	01 %
	Adja	00 %	09 %	08 %	06 %
	Aïzo	00 %	06 %	23 %	09 %
Marital status	Married	94 %	91 %	22 %	69 %
	Single	06 %	09 %	78 %	31 %
Education	No formal schooling	56 %	11 %	17 %	28 %
	Primary school	15 %	34 %	22 %	24 %
	Secondary school	23 %	54 %	22 %	34 %
	University	06 %	00 %	39 %	15 %
Main activities	Vegetable production	62 %	97 %	72 %	77 %
	Other crops	12 %	00 %	03 %	05 %
	Livestock	10 %	00 %	03 %	04 %
	Trade	03 %	00 %	00 %	01 %
	Food processing	13 %	00 %	07 %	07 %
	Off-farms activities	00 %	03 %	15 %	06 %

the proportion of women is higher (62 %) than for men in the Oueme Valley, unlike in other localities. The Oueme Valley, a flood zone, requires little investment, especially because of the good level of soil fertility and water availability. This advantage allows women to invest more in market gardening. Overall, nearly 40 % of market gardeners (60 %) are not native to the area where they operate. In search of arable land, they had to migrate from other production areas or neighbouring villages or municipalities to their current production area. About 58 % of the market gardeners of Seme-Kpodji (Benin) come from big cities such as Cotonou and Porto Novo (Benin) because of urbanization and land scarcity. This migration would explain the variability of the socio-cultural groups encountered in Seme-Kpodji. On the matrimonial level, 92 % of the market gardeners surveyed in the Oueme Valley and Seme-Kpodji are married while nearly 78 % of those in the commune of Ze are single. About 72 % of market gardeners have an average level of education. Indeed, 28 % of market gardeners have not received any education. In particular, 56 % of market gardeners in the Oueme Valley are not educated against 12 % and 17 % of producers respectively in the areas of Seme-Kpodji and Ze. These differences in educational level and marital status are largely explained by the fact that Ze and Seme-Kpodji are student residences of the main University of Benin. Several students develop extracurricular activities as sources of income to meet their financial needs. This can explain that 39 % of the market gardeners of Ze who have a high study level carry out gardening farm. The seniority of farm managers in the profession is 7 to 8 years for market gardeners in the Oueme Valley and Seme-Kpodji. The market gardeners of the area of Ze are young singles (78 %) and started the activity not a long ago (2 years).

3.2 Characterisation of vegetable production systems in South Benin

3.2.1 Factors of production

Edaphic complex

The importance of land access patterns in the different study areas is shown in Fig. 1.

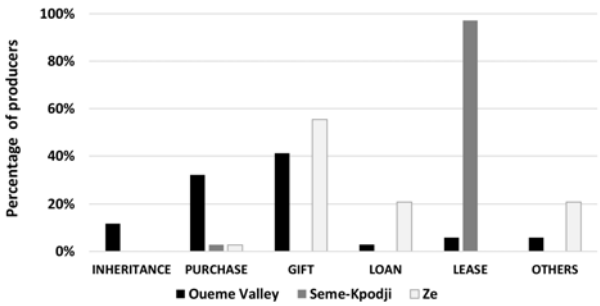

Fig. 1: *Modes of access to land by market gardeners in South Benin*

According to the Fig. 1, inheritance, purchase, gift, loan and lease are the main modes of land access. A case of the Roman Catholic Church providing land to gardeners was observed in the commune of Ze. Overall, indirect modes of access to land are predominant. This creates land insecurity which is amplified for women in a socio-cultural context where they do not inherit the land. Producers' perception of soil fertility varies from one area to another as shown in table 2.

Table 2: *Perception of the state of soil fertility by market gardeners in South Benin*

	Levels of soil fertility			
Production zones	*Very fertile*	*Fertile*	*Low fertile*	*Not fertile*
Oueme Valley	71 %	29 %	00 %	00 %
Seme-Kpodji	09 %	00 %	86 %	06 %
Ze	00 %	61 %	39 %	00 %

While most market gardeners in the Oueme Valley recognize that their soils are very fertile or fertile, those in Seme-Kpodji attest to the low fertility of their soils. Only 8.57 % of producers agree that the land is very fertile in this area. For those of Ze, they are fertile (61.11 %) and low fertile (38.89 %). This low soil fertility is a major constraint to agroecological intensification or transition.

3.2.2 Labour

One of the main constraints to vegetable production in urban and peri-urban areas of southern Benin is access to quality labour. Casual labour is the main type of labour mobilised for vegetable production activities. It is used by 100 %, 51 %, and 84 % of vegetable farmers respectively in the Oueme Valley, Seme-Kpodji, and Ze areas. The farm workers mostly come from Lomé in Togo and the Adja Plateau in Benin. Unfortunately, the vegetable farmers complain about the high cost of the services and above all the lack of seriousness they show in the execution of their tasks: sloppy weeding, irregular watering, badly made beds, etc. This low availability of the quality of agricultural labor poses a threat to the practice of ecological and organic farming systems; it forces many farmers (28 %) to resort to the use of synthetic chemicals (herbicides) for soil preparation and weeding activities.

3.2.3 Agricultural inputs

Vegetable farmers obtain their seeds mainly by purchase (67.62 %). The existence of seed supply centres such as "Benin seed", "Accueil Paysan", "Centre Songhaï", "Garden of Eden", etc. constitute an opportunity for producers to access seeds in quantity. Nevertheless, nearly 30 % of farmers obtain their seeds by deduction from harvests, compared to 02 % who obtain them by donation. Nearly 53 % of producers use exclusively improved seeds against 20 % who choose exclusively local seeds. Some farmers use both improved and local seeds (27 %) depending on the type of seed they have access to as they mainly get their supplies from seed shops. Most farmers report difficulties in accessing tomato seeds that are often unavailable. Regarding the phytosanitary products, three (03) categories of farmers have been identified. Farmers who are part of a phytosanitary fight focused exclusively on aqueous botanical extracts, those who combine the use of synthetic pesticides and biopesticides and those who exclusively use synthetic chemical pesticides (Fig. 2).

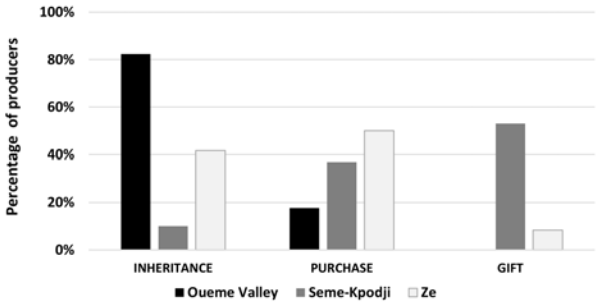

Fig. 2: *Types of phytosanitary treatments adopted by market gardeners*

The use of aqueous botanical extracts is more noticeable in the Oueme Valley (82 %) and in Ze (42 %) than in Seme-Kpodji (10 %). Farmers of Seme-Kpodji preferentially opt for chemical pesticides and mineral fertilisers (CPF) (53 %) and a combination of biopesticides and CPF (37 %). Nearly half of Ze farmers adopt a combination of biopesticides and CPF. "Pacha" is the main product used by farmers. As for the aqueous extracts, they are purchased from suppliers such as Bio-Phyto or are produced by the farmers themselves. Farmers' perceptions of the effectiveness of biopesticides vary from one area to another (Fig. 3).

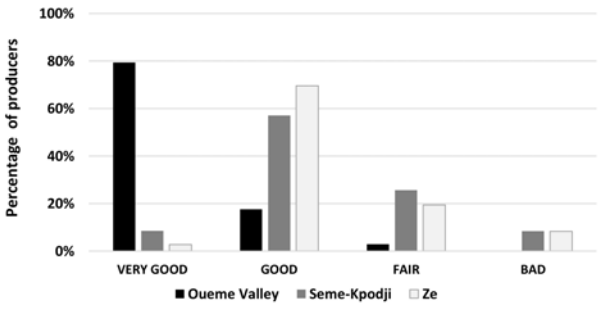

Fig. 3: *Market gardeners' perception of the effectiveness of biopesticides*

Overall, farmers in the Oueme Valley (79 %) have a very good perception of the effectiveness of biopesticides, while most farmers in Seme-Kpodji (57 %) and Ze (70 %) have a good perception of them. Approximately 26 % producers in Seme-Kpodji and 19 % in Ze rated the effectiveness of biopesticides as fair, while 8 % of producers in each of these zones rated the effectiveness of biopesticides as bad.

Soil fertility is generally ensured by the addition of organic fertilisers (poultry droppings, cow dung, compost, and household waste) and mineral fertilisers. In the Oueme Valley (100 %) and Ze (89 %), biofertilisers are the main form of fertiliser used, while most vegetable farmers in Seme-Kpodji (80 %) use NPK and urea fertilisers Some farmers use a mixture of neem meal and poultry droppings in the proportions of 100 kg of cake for 50 kg of droppings respectively. Most farmers report constraints related to the accessibility of quality biofertilisers.

According to vegetable farmers, the pests that cause crop damage are mainly *Helicoverpa armigera* and *Plutella xylostella*, especially in cabbage. Faced with these attacks, some farmers implement defensive strategies by using synthetic chemical pesticides (CSP). Others, on the other hand, adopt preventive strategies by abandoning crops such as cabbage. Still, others implement offensive strategies by alternating the production of *Amaranthus* and that of *Ocimum gratissimum* to break the life cycle of the pests. This practice is an asset to be promoted as part of an initiative to convert farmers to more sustainable modes. The main constraint arises in terms of the availability of these products; farmers are forced to travel long distances to obtain them, which increases the cost of production. The CSP often cited by vegetable farmers to fight pests are Emacot Fort, Pacha 25 EC, Kinikini (a mixture of cyfluthrin and malathion).

3.2.4 Agricultural machinery and equipment

The equipment used by vegetable farmers consists of small field tools, irrigation equipment and phytosanitary treatment. There is a variety of tools and equipment that can vary from farm to farm and from area to area depending on farm size and environmental conditions. Small tools are made up of hoes, cutters, hoes, rakes, watering cans, etc. and are found among all the farmers interviewed. Some production sites have somewhat advanced equipment in terms of irrigation systems. This is the case, for example, of the *Sainte Jeanne d'Arc* vegetable site in Koudokpoue (Ze), which has a water drilling system with water tanks and photovoltaic panels for lighting the site and water pumping. In Seme-Kpodji on the other hand, the vegetable market has an electric pump, accompanied by a flexible piping system or in some cases combined with basins allowing manual watering. In Oueme Valley, vegetable markets have more small manual tools.

3.2.5 Financial capital

Access to agricultural financing sources is one of the main constraints faced by the vegetable farmers surveyed, regardless of the area. Overall, vegetable farmers have very limited access to agricultural credit due to the conditions of access to microfinance institutions (MFI) that are often not within reach of producers. These include, among other things, the guarantee that is too restrictive (land purchase agreement for example), the often high interest rate (13 % to 22 ,% per year), the low credit granted, and the short loan repayment (two months to one year). Some farmers have received loans and subsidies from institutions such as PADMAR, CLCAM (*Caisse Locale de Credits Agricoles Mutuels*), PADME (*Projet d'Appui au Developpement des Moyennes Entreprises*) and PAPME (Projet d'Appui au Petites et Moyennes Entreprises) to finance their activities. Given the exorbitant rates charged by the so-called loan sharks, many producers refuse to seek loans from them and therefore prefer to set up local tontine groups to meet their financial needs even a little.

3.2.6 Cropping systems

Vegetable farmers in the Oueme Valley rely almost exclusively on local leafy vegetables (tomato, pepper, onion, African nightshade, Vernonia, etc.). On the other hand, in Ze and Seme-Kpodji, both local and exotic vegetables (lettuce, cabbage, carrot, cucumber, parsley) are produced. The vegetables are produced on beds of variable dimensions of 4m*1m and 8m*2m on average respectively in Ze and Seme-Kpodji in the South of Benin. The technical itinerary includes the following operations: clearing, ploughing, sowing, weeding, irrigation/watering, spreading, and phytosanitary treatments. For sowing, vegetable farmers often face the unavailability of tomato seeds of the Caraïbo variety and carrots, especially between September and December. The

plate represents the unit of sale of vegetables, except for tomatoes and peppers which are sold in baskets.

3.2.7 Marketing of vegetables

The different profit margins from vegetable production are positive in all the areas surveyed (Table 3).

Vegetable production in dry season conditions appears more profitable, compared to production in the rainy season, particularly for tomatoes, *crin-crin*, and in some cases peppers. The location of the Seme-Kpodji market gardening site on the sandy shoreline does not allow vegetable farmers to produce enough vegetables in the dry season. The water evaporates very quickly, which requires several waterings a day. All these elements are limiting factors to vegetable farmers' production. Vegetable production activities, therefore, decrease in the dry season. In addition, in this time of year the water stress increases, the water level in the basement decreases and the amount of water in the water basins decreases as well. Producers are forced to water their vegetable fields twice as much as during the rainy season. Therefore motor pumps consume more fuel to pump water from the basement, which leads to higher energy costs. In the dry season, the supply of vegetable products decreases while the demand does not decrease. Vegetable products such as tomatoes and peppers, which are essential vegetables, are becoming scarce on the market and becoming more expensive than in the rainy season.

Producers mainly feed the urban areas of Abomey Calavi, Cotonou, and Nigeria. According to the vegetable farmers of Seme-Kpodji, 60 % of the vegetable production is intended for the Nigerian market. However, if access to the Nigerian market can be perceived in some respects as an opportunity for vegetable farmers in southern Benin, it is important to specify that the narrowness of the market (little diversified market) constitutes a threat to market garden production in the sense that a closure of the borders between Benin and Nigeria leads to strong loss of vegetable products.

4 Discussion

The analysis of vegetable farming systems (VFS) in Southern Benin revealed a diversity of practices that vary according to the agroecological zone. The VFS implemented in Oueme Valley and in Ze are more oriented toward agroecological practices, unlike the coastal zone of Seme-Kpodji where the use of chemical pesticides and mineral fertilisers is more important, although some agroecological practices are increasingly integrated into the agricultural system in this area too. As reported by Trabelsi (2017) and Shrestha *et al.* (2021), agroecology has undeniable advantages over conventional agriculture, however, its adoption comes up against obstacles that can be technical, socio-economical and/or institutional. In the case of the systems analysed, these constraints concern mainly: the land insecurity; the difficulties of access to loans adapted to market gardening, to organic inputs and the marketing of vegetables at remunerative prices. In addition, the weak technical capacity to manage soil fertility, pests and post-harvest losses; the low level of equipment, the lack master of water; the poor seed quality and the poor organisation of market gardeners are the main constraints that limit the agroecological transition or intensification (AET/AEI). In this context, supporting intensification or agroecological transition processes of VFS requires special attention to natural resource management, farmer extension, farmer/herder conflicts, access to production factors, and the development of value chains and markets (Vall *et al.*, 2018: Naudin *et al.*, 2018). First, one of the major challenges to be met to accelerate the AEI or AET in most production systems is relative to securing land (Bayne *et al.*, 2021). In the case of VFS in southern Benin, this challenge is to facilitate producers' access to secured land to increase the motivation of producers, young and women in particular, to invest sustainably in land management. Various studies have indeed reported the aversion of producers, especially women, to invest in agroecological practices for sustainable land management in a socio-cultural context characterized by the absence of guaranteed access to land resources and the fact that women do not inherit the land (Vall *et al.*, 2015; Assogba *et al.*, 2017). The perception of this threat by market gardeners can reduce investment and extension on a large scale of the sustainable management of soil fertility and therefore in the adoption of agroecological practices. Securing land rights will have to take into account both the improvement of access rights to the land and the cultivated area protection against stray animals. In this context, the updating and effective implementation of territorial land use plans could allow the definition of spaces exclusively dedicated to agroecological practices with a system of contracting land that promotes long-term investment for sustainable land management. The definition of agroecological spaces will avoid the spatial juxtaposition of conventional and agroecological practices, will minimize the risk of compromising the biological potential of surrounding crops (Lazarev, 2009), and will also facilitate the collective adoption of agroecological practices. The advantages of the AET are better realized if the latter is generalized within the production zone (Ribier & Griffon, 2006). Furthermore, this measure will limit the anarchic extension of cultivated areas and should be reinforced by effective laws implemented on the animals straying for better protection of cultivated areas.

Table 3: *Marketing account of main vegetable products*

	*Products (FCFA/m²)**		*Variable costs (FCFA/m²)*		*Gross margins (FCFA/m²)*	
Crops	*RS*	*DS*	*RS*	*DS*	*RS*	*DS*
			Oueme Valley			
Vernonia (*Vernonia sp.*)	165	120	09	09	156	111
Basil (*Ocimum basilicum*)	150	250	10	30	140	220
Concumber (*Cucumis sativus*)	16	20	01	03	15	17
Gombo (*Abelmoschus esculentus*)	-	112	-	16	-	96
Grande (*Solanum macrocarpon*)	224	170	23	28	201	142
Crincrin (*Corchorus olitorius*)	101	184	10	16	91	168
Hot pepper (*Capsicum annuum*)	469	181	36	20	433	161
Soman (*Celosia sp.*)	364	222	25	77	339	145
Tomatoes (*Solanum lycopersicum*)	156	384	29	62	127	322
			Seme-Kpodji			
Vermonia (*Vernonia sp.*)	167	265	121	168	46	97
Crincrin (*Corchorus olitorius*)	600	-	300	-	300	-
Hot pepper (*Capsicum annuum*)	229	-	150	-	79	-
Tomatoes (*Solanum lycopersicum*)	360	-	112	-	24 8	-
			Ze			
Vermonia (*Vernonia sp.*)	1,894	302	841	134	1,053	168
Basil (*Ocimum basilicum*)	408	618	160	213	248	405
Concumber (*Cucumis sativus*)	262	6,375	90	1,922	172	4,453
Gombo (*Abelmoschus esculentus*)	23	44	09	42	14	02
Grande (*Solanum macrocarpon*)	262	422	89	148	173	274
Crin-crin (*Corchorus olitorius*)	203	418	114	181	89	237
Hot pepper (*Capsicum annuum*)	714	1,103	196	394	518	709
Soman (*Celosia sp.*)	167	292	51	82	116	210
Tomatoes (*Solanum lycopersicum*)	497	1,543	141	223	356	1,320

* 1 euro = 655.957 FCFA. RS = rainy season; DS = dry season

At the farm level, the diversity of agroecological practices highlighted by the study suggests that the measures to be implemented take into account the specificities of the agroecological zone to enhance existing initiatives. For example, with regard to soil fertility management, the study seems to reveal the existence of a correlation between the state of soil fertility and the choice of fertilisation method. Indeed, the areas where the soils are fertile (Oueme Valley and Ze) are those in which the producers limit the use of mineral fertilisers, unlike Seme-Kpodji where the soils are little or not fertile. We could deduce that the more the soil becomes less fertile, the more vegetable farmers turn to mineral fertilisers. Wezel *et al*. (2014), based on the mechanisms mobilized by agroecological measures and the depth of the changes necessary for their implementation, considered that the practices to be promoted, in the sense of the AEI or the AET, are strategies for substitution, increasing efficiency and overhauling the production apparatus. As a result, in areas of depression such as the Oueme Valley where the use of synthetic chemical inputs is limited, an AET can be envisaged from a strong ecological perspective (Duru *et al*., 2014), through a strategy of overhauling the production system (Wezel *et al*., 2014). Farms can thus be supported towards a complete conversion to organic farming. On the other hand, in coastal areas such as Seme-Kpodji where various practices like the combination of the CSP with natural products, the cultivation of vegetables weakly attacked by pests, it would be more relevant to consider the evolution of VFS from a low agroecological perspective. This will involve developing strategies to increase the effectiveness of these practices and promoting alternative practices (Wezel *et al*., 2014). However, if the propensity of producers to use organic fertilisation constitutes an asset for the agroecological transition or intensification, it is important to specify that the sources of biofertilisers, in particular animal waste (types of livestock), remain unavailable and need to be documented to better lead farmers in the conversion process. In addition, as reported by Griffon (2014), this approach, which is part of

a perspective of ecological intensification, presents the risk of involving more work and technicality, with consequences on the organisation of the time invested. It appears that, as shown by Silva *et al*. (2021), public investments conducive for innovation and profitable farming are required to make technologies accessible and affordable for producers and to ensure that sustainability objectives served at the farm level.

The adoption of agroecological practices involves learning processes for producers (Utter *et al*., 2021) to observe, monitor, and analyse situations for decision-making and appropriate actions at the appropriate time (Trabelsi, 2017) through different cycles of experimentation based on trial-error-adaptation (Streith *et al*., 2017). Thus, achieving better productivity in agroecology rhymes with knowledge of the agroecosystem and natural processes to better manage pest practices and soil fertility. Therefore, special attention must be paid to knowledge management and the learning processes of producers. This learning, which consumes time in the process of adaptability of agroecological practices to contexts (Dufimier, 2010; Trabelsi, 2017), leads Ribier & Griffon (2006) to argue that the adoption of agroecology is more labour-intensive compared to conventional agriculture often associated with monoculture and the massive use of synthetic chemicals. Thus, the success of the AEI or the AET, in particular with poor farmers, cannot be achieved without facilitating access to production factors such as bio-inputs, and through support for the development of production units. It appears from the study that initiatives exist in this direction, but challenges remain to be addressed in particular in terms of the quantity and quality of biofertilisers which are for the most part produced without taking into account the quality of the basic materials (case of compost) nor the state of soil fertility, which does not make it possible to ensure the nutrition of crops with a view to sustainable use of the edaphic complex.

As far as market access is concerned, the development of short circuit sales may be a relevant alternative to explore. Indeed, studies have shown that the agroecology market has great potential for personal contact and direct communication between producers and consumers. Social media, personnel, and visits to farms, are the main means of promoting agroecological products. Agroecological markets are dynamic and contribute to creating social links that not only allow greater availability and better access to agroecological products but also and above all last over time (Scheromm *et al*. 2020). Although it is often reported that organically produced vegetables are more expensive than conventional, which is a major constraint for the adoption of agroecological practices, Carmona *et al*. (2021) have shown that consumers can avoid higher prices and, at the same time, provide producers with a greater share of the income by favouring marketing channels that put the consumer in direct contact with producers or direct sellers. To do this, it is necessary to make available to consumers the necessary information on these different channels, as the scarcity of information has appeared as a factor limiting the ability of consumers to access ecological products (Carmona *et al*. 2021). In Benin, short circuit marketing initiatives already exist, in particular with the Association for the Maintenance of farmer Agriculture (AMAP), and deserve to be promoted.

5 Conclusion

This study analysed vegetable production systems in southern Benin and highlighted a diversity of agroecological practices according to production areas. Vegetable farming systems implemented in valleys promote agroecological practices more than those in a coastal zone, characterised by low levels of soil fertility and a slower adoption of agroecological practices. In terms of implications, to facilitate an evolution of vegetable farming systems towards more sustainable systems in southern Benin, strategies to be implemented could be part of a transition perspective of agroecological transition or intensification, depending on the production areas. These objectives could be achieved by facilitating farmers' access to secured land and other natural inputs; by developing value chains and agroecological markets; by promoting public and private investments to make technologies accessible and affordable to producers; by facilitating the management of knowledge and producers' learning processes; by promoting the development of organic inputs production units to facilitate farmers' access to these products.

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Conflict of interest

The authors declare that they have no conflict of interest.

References

Adjatini, A., Bonou-Gbo, Z., Boco, A., Yedomonhan, H., & Dansi, A. (2019). Diversité biologique et caractérisation de l'activité de maraîchage sur le site de Grand-Popo au Sud Bénin. *International Journal of Biological and Chemical Sciences*, 13(6), 2750–2764.

Agnandji, P., Cachon, B. F., Atindehou, M., Mawussi, I. S. Adjovi, A. S., & Ayi-Fanou, L. (2018). Analyse des pratiques phytosanitaires en maraîchage dans les zones intraurbaines (Cotonou) et péri-urbaines (Semekpodji) au Sud-Bénin. *Revue Africaine d'Environnement et d'Agriculture*, 1(1), 2–11.

Ahouangninou, C., Boko, S. Y. W., Logbo, J., Komlan, F. A,. Martin, T., & Fayomi, B. (2019). Analyse des déterminants des pratiques phytosanitaires des producteurs maraîchers au sud du Bénin. *Afrique Science*, 15(5), 252–265.

Altieri, M. A., & Toledo, V. M. (2011). The agroecological revolution in Latin America: rescuing nature, ensuring food sovereignty and empowering peasants. *Journal of Peasant Studies*, 38(3), 587–612.

Assogba, S. C. G., Akpinfa, É., Gouwakinnou, G., & Stiem, L. (eds.) (2017). *La Gestion Durable des Terres: Analyse d'expériences de projets de développement agricole au Bénin*, IASS Working Paper. Institute for Advanced Sustainability Studies (IASS), Potsdam, Germany. p. 31

Assogba-Komlan, F., Anihouvi, P., Achigan, E., Sikirou, R., Boko, A., Adje, C., Ahle, V., Vodouhe, R., & Assa, A. (2007). Pratiques Culturales et Teneur en Eléments Antinutritionnels (Nitrates et pesticides) du Solanum macrocarpon au Sud du Bénin. *Africain Journal of Food, Agriculture, Nutrition and Development*, 7(4), 1–21.

Bayne K., & Renwick A. (2021). Beyond Sustainable Intensification: Transitioning Primary Sectors through Reconfiguring Land-Use *Sustainability*, 13(6), 3225. https: //doi.org/10.3390/su13063225.

Carmona, I., Griffith, D.M., & Aguirre, I. (2021). Understanding the factors limiting organic consumption: the effect of marketing channel on produce price, availability, and price fairness. *Organic Agriculture*. 11, 89–103. https://doi.org/10.1007/s13165-020-00331-1.

Dufumier, M. (2010). Agroecology and sustainable development. In: CIRAD (ed.). *Proceedings of a symposium on Innovation and Sustainable Development in Agriculture and Food*. Montpellier, France, 28 June to 1st July 2010.

Duru, M., Fares, M., & Therond, O. (2014). Un cadre conceptuel pour penser maintenant (et organiser demain) la transition agroécologique de l'agriculture dans les territoires. *Cahiers Agriculture*, 23(2), 84–95.

Francis, C., Lieblein, G., Gliessman, S., Breland, T. A., Creamer, N., Harwood, R., Salomonsson, L., Helenius, J., Rickerl, D., Salvador, R., Wiedenhoeft, M., Simmons, S., Allen, P., Altieri, M., Flora, C., & Poincelot, R. (2003). Agroecology: the ecology of food systems. *Journal of Sustainable Agriculture and Environment*, 22(3), 99–118.

Gliessman, S. R. (1990). *Agroecology: researching the basis for sustainable agriculture*. New York, USA, Springer.

Gliessman, S. R. (2016). Transforming food systems with agroecology, *Agroecology and Sustainable Food Systems*, 40(3), 187–189.

Gliessman, S. R. (2018). Defining agroecology. *Agroecology and Sustainable Food Systems*, 42(6), 599–600.

Griffon, M. (2014). *Qu'est-ce que l'agriculture écologiquement intensive* ?. Available at : url-http://journals.openedition.org/economierurale/4357. Last accessed 02. 02. 22.

Lazarev, G. (2009). Promouvoir le développement des territoires ruraux. In: CIHEAM (ed.), *Repenser le développement rural en Méditerranée*, MediTERRA, Paris: Presses de Sciences Po., pp. 183–210.

Naudin, K., Autfray, P., Dusserre, J., Penot, É., Raboin, L. M., Raharison, T., Rakotoarisoa, J., Ra-manantsoanirina, A., Randrianjafizanaka, M. T., Rasolofo, L. I., Raveloson, H., Razaf-imahatratra, M., Salgado, P., Sester, M., Brocke, K. V., & Scopel E. (2018). L'agro-écologie à Madagascar : de la plante au paysage. In: Côte, F.-X., Poirier-Magona, E., Perret, S., Rapidel, B., Roudier, P., & Thirion, M.-C. (Eds.). *La Transition agro-écologique des agricultures du Sud, Agricultures et défis du monde*. AFD, Cirad, éditions Quæ, Versailles, pp. 43–80.

Ribier, V., & Griffon, M. (2006). Quelles politiques agricoles pour accompagner la transition vers l'agro-écologie? In: Club Déméter (ed.), *Le Déméter 2006: économie et stratégies agricoles*, Paris: Club Déméter. pp. 145–163.

Rivera-Ferre, G, M. (2018). The resignification process of Agroecology: Competing narratives from governments, civil society and intergovernmental organizations, *Agroecology and Sustainable Food Systems*, 42(6), 666–685.

Rosset, P. M., Sosa, B. M., Jaime, A. M. R., & Lozano, D. R. A. (2011). The Campesino-to-Campesino agroecology movement of ANAP in Cuba: social process methodology in the construction of sustainable peasant agriculture and food sovereignty. *Journal of Peasant Studies*, 38(1), 161–191.

Sæthre, M. G., Svendsen, N. O, Holen, B., Assogba-Komlan, F., & Godonou, I. (2011). Pesticide residues analysis for three vegetable crops for urban consumers in Benin. *Bioforsk Report*, 6, 1–29.

Scheromm, P., Rixen, A., Laurens, L., & Soulard, C.-T. (2020). Les acteurs publics locaux et l'écologisation de l'agriculture. *Développement durable et territoires*, 11(1). Available at : urlhttp://journals.openedition.org/developpementdurable/17367.

Shrestha, J., Subedi, S., Timsina, K. P., Subedi, S., Pandey, M., Shrestha, A., Shrestha, S., & Hossain, M. A. (2021). Sustainable Intensification in Agriculture: An Approach for Making Agriculture Greener and Productive. *Journal of Nepal Agricultural Research Council*, 7(1), 133–150. urlhttps://doi.org/10.3126/jnarc.v7i1.36937.

Silva, J. V., Reidsma, P., Baudron, F., Laborte, A. G., Giller, K. E., & van Ittersum, M. K. (2021). How sustainable is sustainable intensification? Assessing yield gaps at field and farm level across the globe. *Global Food Security*, 30. urlhttps://doi.org/10.1016/j.cosust.2019.04.011.

Simon, S., Assogba Komlan, F., Adjaïto, L., Mensah, A., Coffi, H., Ngouajio, M., & Martin, T. (2014). Efficacy of insect nets for cabbage production and pest management depending on the net removal frequency and microclimate. *International Journal of Pest Management*, 60(3), 208–216.

Soro, G., Kone, B., Kouakou,Y. E., M'Bra, K. R., Soro, P. D., & Soro, N. (2018). Utilisation de produits phytosanitaires dans le maraîchage autour du barrage d'alimentation en eau potable de la ville de Korhogo (nord de la Côte d'Ivoire): risques pour la santé publique. *Environnement, Risques & Santé*, 17(2), 155–163.

Souleymane, L. Y., Sarr, I., Martinez, R. T., & Ndiaye, S. (2021). Caractérisation des Pratiques de Traitements Phytosanitaires dans la Zone de Culture Maraichère des Niayes du Sénégal. *International Journal of Progressive Sciences and Technologies*, 30(1), 301–313.

Streith, M., Lagneaux, S., Van Dam, D., & Nizet, J. (2017). Un marché de producteurs biologiques en Auvergne (France): Approches réflexives d'un territoire agricole. *Anthropologie et sociétés*, 41(3), 311–327.

Trabelsi, M. (2017). *Comment mesurer la performance agroécologique d'une exploitation agricole pour l'accompagner dans son processus de transition*? Thèse de Doctorat en Géographie. Université Paul Valéry - Montpellier III.

Utter A., White A., Méndez V. E., & Morris K. (2021). Co-creation of knowledge in agroecology. *Elementa: Science of the Anthropocene*, 9(1), urlhttps://doi.org/10.1525/elementa.2021.00026.

Vall, E, Diallo, M. A., & Ouattara, B. F. (2015). De nouvelles règles foncières pour un usage plus agroécologique des territoires en Afrique de l'Ouest. Sciences Eaux Territoires, 16(1), 52–57.

Vall, E., Blanchard, M., Coulibaly, K., Ouédraogo, S., Dabiré, D., Douzet, J-M, Kouakou, P. K., Andrieu, N., Havard, M., Chia, E., Bougouma, V., Koutou, M., Karambiri, M. S., Delma, J-B., & Sib, O., (2018). Co-concevoir des systèmes de polyculture-élevage innovants en zone cotonnière au Burkina Faso. In: Côte, F.-X., Poirier-Magona, E., Perret, S., Rapidel, B., Roudier, P., & Thirion, M.-C. (Eds.). *La Transition agro-écologique des agricultures du Sud, Agricultures et défis du monde*. AFD, Cirad, éditions Quæ, Versailles, pp. 15–42.

Vidogbéna, F., Adégbidi, A. B. E. A., Tossou, R., Assogba-Komlan, F., Martin, T., Ngouajio, M., Simon, S., Parrot, L., Garnett, K., & Zander, K. (2016). Exploring factors that shape small-scale farmers' opinions on the adoption of eco-friendly nets for vegetable production", *Environment, development and sustainability*, 18(6), 1749–1770.

Wezel, A., Casagrande, M., Celette, F., Via, J.-F., Ferrer, A., & Peigné, J. (2014). Agroecological practices for sustainable agriculture: A review. *Agronomy for Sustainable Development*, 34(1), 1–20.

Yarou, B., Silvie, B., Assogba Komlan, P. F., Mensah, A., Alabi, T., Verheggen, F., & Francis, P. (2017). Plantes pesticides et protection des cultures maraichères en Afrique de l'Ouest (synthèse bibliographique). *Biotechnologie, Agronomie, Société et Environnement*, 21(4), 288–304.

Zoundji, C. G., Okry, F., Vodouhê, D. S., & Bentley, J. W. (2018). Towards sustainable vegetable growing with farmer learning videos in Benin. *International Journal of Agricultural Sustainability*, 16(1), 54–63. urlhttps://doi.org/10.1080/14735903.2018.1428393.