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Characterization of irrigation techniques and typology of vegetable gardens in the districts of Covè and Zangnanado in center of Benin

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ABSTRACT

The main objective of this study was to contribute to a better knowledge of the vegetable farm types in the centre of Benin and made inventory of the different irrigation techniques used in the area.To achieve this objective, one hundred and three market gardeners from Zangnanado and Covè were interviewed. Mean comparison tests were carried out to see whether or not there was significant difference between age, household size, and experience in vegetable gardening and the market garden farm size of the two municipalities. Also, Multiple Correspondence Analysis and Ascending Hierarchical Classification were performed to classify the gardenfarms in thestudy area. The results shown that there was a significant difference ($P < 5\%$) for the garden farm sizes betweenZangnanado (0.73±0.35 ha)and Covè (0.35±0.45 ha). As far as water management is concerned, the results revealed that for irrigation, market gardeners use watering cans, bowls, manual sprinkling and motorized sprinkling. As for the typology of market gardening farms, it revealed six types of vegetable farms, each one with some specificity.. The vegetable farms classified in the types 1, 2, 4 and 5 are those which produce only local vegetables with manual irrigation technologies. As for the type 3 and 6, they produce both local and exotic vegetables with manual irrigation and/or motorized technologies.

Keywords: vegetable farms; typology; irrigation technology; Covè; Zangnanado.

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I. INTRODUCTION

Water is source of life and one of the non-biological determinant factors in plant production(Karam et *al.*, 2002[1]). As result, the allocation and management of water resources are part of the major challenges of the 21st century for population food and environmental preservation. In 2015, world statistics have shown that the African population has increased by about 158 million inhabitants from 2009 to 2015 and is estimated to have reached 4.25 billion by 2100 (ONU, 2015 [2]). In Benin, the population has increased from about 6.8 million in 2002 to 10 million inhabitants in 2013 (RGPH4, 2013[3]). This population increases are coupled with an increase of demand for agricultural productswhich can only be supplied through agriculturalintensification. However, this requires a proper water management for agricultural purposes through irrigation. This is the case for vegetable gardening which is one of the thirteen priority agricultural sub-sectors of Benin where an expansion of private initiative for water control has been observed for decades. This sector has been the main focus of Agbossou, (2008)[4]; Assogba, (2008)[5] andAhouangninou, (2013)[6] who carried out studies in vegetable gardening areas of Sèmè-Podji, Houéyiho, and Ouidah in southern Benin. The main goals of these studies were to understand their functioning, the challenges encountered by the farmers and to make the typology of the vegetable gardens. It is important to note that although the other parts of the country are also vegetable production areas, they have not been the focus of similar studies. It is the case of the region covering the districts of Covè and Zangnanado which, thanks to its potential in shallows managed, is reputed for its high production of rice. However, the farmers are increasingly adopting a strategy for diversifying their sources of income. Thus, in addition to rice farming, they develop other activities such as vegetable farming which is the main focus of this study. This study was therefore carried to fill the gap of information about the typology of the vegetable

farms of central Benin that the choice was made on districts of Covè and Zangnanado.

This study also aimed at availing stakeholders and local council information to well apprehend the diversity of the farms located in their areas and the opportunitiesthat each of them offers, in order to implement strategies and policies that are suitable to the local conditions. Specifically, this study first sought to identify irrigation techniques used by the vegetable farmers in Covè and Zangnanado and secondly, to determine the typology of the farms. Three research questions were addressed in this study: What are the reasons behind the expansion of vegetable farming in the districts of Covè and Zangnanado? What types of vegetable farming characterize vegetable production in these districts? What will the knowledge acquired about the types of vegetable farming, benefit to the stakeholders and local council?

II. MATERIALS AND METHODS

Study area

This study was carried out in two neighboring districts Covè and Zangnanado of the departmentof Zou, located in central Benin (Figure 1). This area is characterized by a transitional subequatorial-tropical climate. It has a bimodal annual rainfall distribution characterized by two rainy and two dry seasons with an average annual rainfall of 985 mm spread over 74 rainy days. On average, the minimum and maximum temperatures of two districts are respectively, 16.4°C and 40.3°C. (Fahala, 2006 [7]).There are ferralitic; hydromorphic and ferruginous soils (Fahala, 2006[7]). The main types of vegetation are bush Savannah, some islets of sacred forest and gallery-forest which have high anthropic pressure. In terms of hydrography, the districts of Covè and Zangnanado have important water resources. In effect, in Zangnanado district, surface waters are the most important waters resources which are about 70 rivers in addition to Ouémériver and its tributary Zou. They are spread into the boroughs such as seven in Don-Tan, eight in Banamè, eight in Zangnanado, eleven in Kpedekpo, fourteen in Agonlin-Houégbo, and eighteen in Dovi (Fahala, 2006[7]). As far as Covè is concerned, there are the Zou river with important tributaries with permanent regimes like Koussin, Lélé, Towé, Laha, Loto, Kètè, Wassa, Wantè, Fionzoun, lake Nacava, etc. which are the main sources of drinking water and fishes of the population (Fahala, 2006[7]). According to the General Population and Habitat Census (RGPH4) carried out in 2013, the population is 105 149 inhabitants and is mainly engaged in agriculture, fisheries, animal husbandry and hunt (Fahala, 2006[7]).

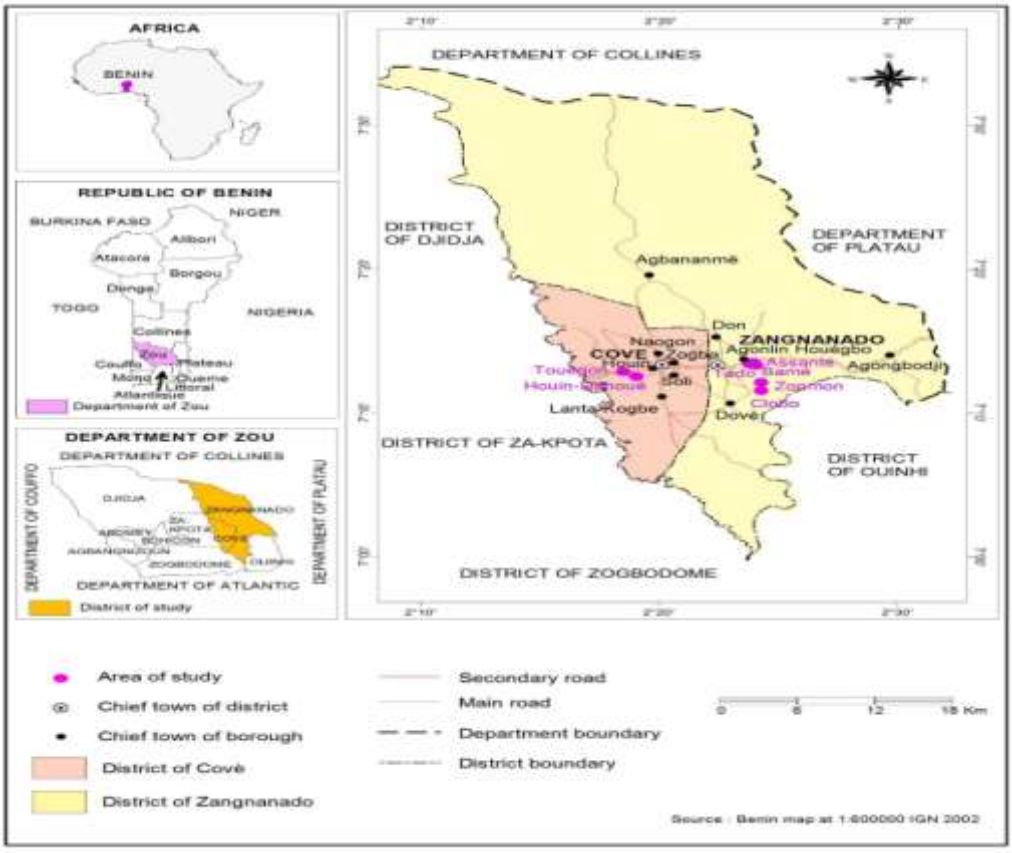

Figure 1: Geographical map of Covè and Zangnanado districts

Sampling procedure

The study units were chosen using a stratified sampling method that takes into account the diversity of the vegetable farms and gender criteria. Selection criteria were set for both the choice of production sites and vegetable gardens that served as observation units. These criteria were adopted to ensure a representative sampling. Four major criteria were therefore adopted in the choice of village and sites study after the exploratory phase: (i) importance of vegetable farming in the study units determined by a minimum of 20 vegetable gardeners per village or site, (ii) cultivated area determined by a minimum of 0.5 ha; (iii) presence of a source of water nearby the production site with a maximum distance of 50 m far from the site; (iv) accessibility of the area determined by a maximum distance of 20 km far from the urban center.

The sample size was determined using the formula developed by Dagnelie (1998)[8]

$N = \frac{4*p*(1-p)}{0,05^2}$, where N is the sample size and p is the proportion of vegetable gardening households to the total number of farming households in the village. According to the results of the General Population and Habitat Census (GPHC) of 2013 and the reports of the district offices for agricultural development, the numbers of vegetable gardening and farming households are respectively 25 and 187 in Bamè (Zangnanado) versus, 21 and 191 respectively, in Houin- Dahoué (Covè). The statistics of Bamè and Houin-Dahoué were selected because these were the two villages with the smallest numbers of households. After sampling, 30% of sample size was selected for field survey giving a total of 103 gardeners (Table 1).

Table 1 : Mode of sampling and distribution of the interviewees per village

Districts	Selected Villages	Number of vegetable gardening households	Number of farming households	Sampling rate (p in %)	Number of interviewees (N)	Distribution of interviewees per village
Zangnanado	Bamè	25	187	13.37	56	20
	Klobo	43	91			20
	Zonmon	67	159			16
Covè	Houin-Dahoué	21	191	11	47	21
	Touégon	39	172			26
Total					**103**	

Data collection

Non-stratified interview was used during the exploratory phase to collect data from the district offices for agricultural development on vegetable gardening. It was also used during the first contact made with the presidents of the sites in order to obtain information on the, area dimensions, number of gardeners farming at the site, watering techniques mostly used, source of water used, etc.

Stratified questionnaire-based interview was used to collect socio-economic data (sex, age, tribe, educational background, main and secondary activities etc.) and other types of data (mode of land acquisition, diversity of the vegetables products, agronomic practices, quantity of vegetable produced, source of water, mode of transport, mode of distribution, challenges, etc.) to characterize the gardens.

Participating observation was done during some field activities to gain practical skills as well as to triangulate some information collected during the interviews.

Focus group discussions were carried out to disseminate the results of this study to the gardeners.

Data analysis

Data collected were analyzed using descriptive statistics (mean, standard deviation and cross tabulation). Socio-demographic data were also process in order to carry out a descriptive comparison of the two districts. In regard to this, a sample-mean comparison was performed using Minitab software 16th edition. The data was not normally distributed so an inter-variable comparison was performed in the two districts using Kruskal-Wallis test.

Based on the diversity observed among the vegetable gardens, a typology was made to create homogeneous groups. To determine the typology, Multiple Correspondence Factorial Analysis (MCFA) and Hierarchical Cluster Analysis (HCA) were performed using R statistical software version 3.0.2. The different classes obtained were later confirmed using k-means method. The data used enabled the characterization of 103 individuals based on 20 qualitative and quantitative variables with 58 associated modalities. These were: location of production area, age, sex, seniority, group membership, water source used, irrigation techniques used, cultivated area, access to technical supervision, access to credit, pest and disease management

method, fertilization method, type of vegetables produced, access to land, type of labour used, ecological site, type of seeds used, household size, secondary activities and level of education.

III. RESULTS

Characterization of vegetable gardeners and their gardens

The mean age of the vegetable gardeners sampled was about 40 years with a standard deviation of 12 years (Table 2).

Tableau 2 :Means and standard deviations of quantitative variables characterising the vegetablegardens

Variables	Zangnanado (N=56)		Covè (N=47)		Total (N=103)		Kruskal-Wallis (Probability)
	Mean	SD	Mean	SD	Mean	SD	
Age (years)	77.54	11.98	39.55	13.12	39.50	12.39	0.778
Experience (years)	16.49	8.27	9.49	9.37	8.89	8.72	0.627
Household size	6.61	2.48	6.72	2.75	7.34	2.58	0.939
Cultivated area (ha)	0.73	0.37	0.35	0.45	0.36	0.41	0.047

SD = Standard Deviation

The youngest gardenerwas 17 years old while the oldest was 80 indicating that most of the gardeners are adults though they are relatively younger in Covè compared to Zangnanado. The gardenershad on average 9 years of experience with a standard deviation of 9 years. The gardnershad a longer experience in Zangnanado (16 years) than Covè (9 years). This suggests a high variability in the gardeners'experience probably because the number of years of experience was proportional to the age as both men and women have traditionally been initiated to vegetable gardening at young age. The production techniques used do not necessarily result from a specific training but rather from endogenous knowledge acquired from the parents. Coming to the variable household size, it varies from one to fourteen with an average of seven people and a standard deviation of three. The average household sizes observed in Zangnanado (7±2) and Covè (7±3) were more or less equal. In this study, the average of cultivated area in Zangnanado and Covè were 0.73 ha and 0.35 ha respectively with a standard of deviation of 0.35 ha and 0.45 ha. At the scale of the area of study, the average of cultivated area was 0.36 ha with a standard of deviation of 0.41 ha. This reflects a significant disparity in the access to land resources even if gardeners in Zangnanado possess more land than in Covè.

The Kruskal-Wallis test showed that there was no significant difference in the gardeners' age, experience, household size in the two districts except of cultivated area which was significantly ($p < 0.05$) different from one district to the other.

Characterization of irrigation techniques

Sources of water and pumping techniques

Water is an essential factor for every crop in general and particularly for the horticultural crops. Even when available, this resource needs to be mobilized and availed to the plants hence several pumping techniques have been developed. In this study area, two sources of water and four pumping techniques were used to collect water and irrigate the plants (Figure 2 and 3).

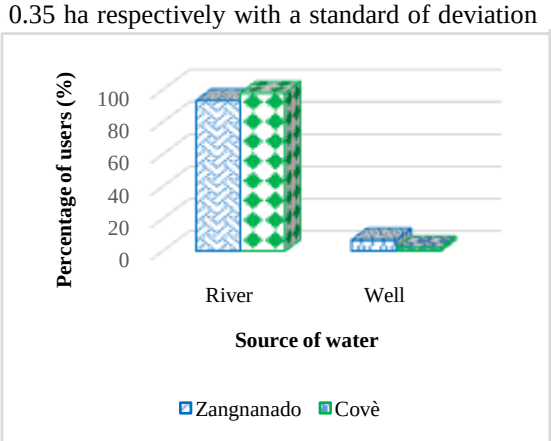

Figure 1 : Source of water used

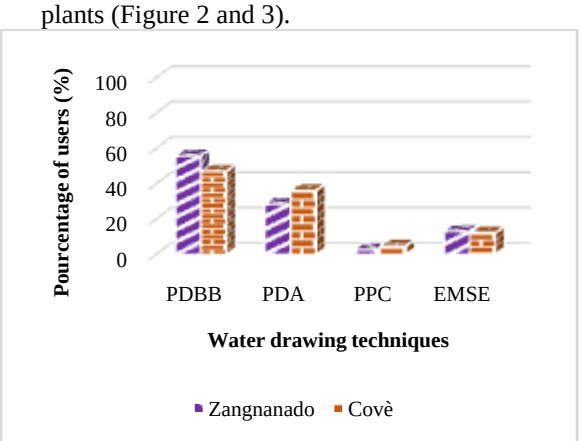

Figure 2 : Water drawing technique used

PDBB : Direct water drawing with basin or bowl with or without storing
PDA : Direct water drawing with watering can
PPC : Water drawing with a rope dipper with/without storage

EMSE : Motorized water pumping and storage

Rivers constitute the main sources of water used for gardening both in Zangnanado (93.22%) and Covè (97.92%) (Figure 2) followed by ground water wells. This is because there are several rivers present in the two districts and most of the gardens are either crossed by or located near one or many rivers. In consonance with Agbossou et *al.*, (2010), the water drawing techniques can be classified into two groups which are, manual water drawing (using cans, buckets, or basins) and the motorized water drawing (using motor pump or immersed pump) both with water storage. Thus, it can be deduced from figure 3 that, the most water drawing technique used in these two districts was direct water drawing with basin or bowl (56% and 47% in Zangnanado and Covè respectively) followed by the use of cans (29%) and motor pump (13%). It is however important to note that direct water drawing with cans was more used in Covè than in Zangnanado.

Irrigation techniques

Irrigation is the artificial supply of water to cover the plants' needs in case of rain deficit. The irrigation frequency and quantity of water supplied depend on the seasons (dry or rainy). In general, plants are watered twice a day in the morning and in the evening. During the rainy season, gardeners do use punctual irrigation which is different from the perennial irrigation as it consists of supplying small amount of water to plants to compensate for the lack of rains in order to maintain the yield potential. It is mostly valuable when applied at critical growth stages such as flowering and maturity periods. It is important to note that no particular irrigation systems are exclusively used, the gardeners usually use a combination of them.

Two key elements were determinant for characterizing the existing irrigation systems: the water drawing and water distribution techniques. Considering these, four irrigation systems were identified in this study confirming the results of Agbossou et al., (2010)[9] who carried out an inventory of the endogenous irrigation techniques used in Benin. The various systems and proportion of using gardeners are summarized in Table 3.

Table 3 : Summary of the different systems and proportion of gardeners using them

System	Source of water	Mode of water drawing	Mode of distribution	Level of utilization in Zangnanado (%)	Level of utilization in Covè (en %)
Irrigation with watering cans	Rivers/wells	Direct drawing with bowls/ water drawing with dipper with/without stocking pond/direct drawing with watering can	Watering cans	29.17	31.31
Irrigation with bowls	Rivers/wells	Direct drawing with bowls/ water drawing with dipper with/without stocking pond/	Bowls	67.5	55.56
Manuel sprinklingirrigation	Rivers/wells	Motor-pump	Pressure on flexible pipes	2.5	13.13
Sprinklingirrigation with sprinklers	Rivers/wells	Motor-pump	Sprinklers	0.83	0

From the results obtained in Table 3, irrigation with bowls is the most technique used both in Covè (67.5%) and Zangnanado (55.56%). Insecond position, the irrigation with watering cans that was used by about 29.17% and 31.31% of the gardeners in Zangnanado and Covè respectively. These two techniques were the most used because they do not require an important investments and technical skills. The third most used technique in Zangnanado (2.5%) and Covè (13.13%) was manual sprinkling irrigation. As far as the irrigation with sprinklers was concerned, it was only used in Zangnanado by 0.83% of the gardeners. Overall the sprinkling irrigation techniques were the least used in the two districts because they require more financial investment and technical skills. This was specifically the case of sprinklingirrigation with sprinklers which was the most water use efficient but, on the other hand, the most expensive technique.

Typology of the vegetable gardens

Multiple correspondence factorial analysis (MCFA)

The procedure *"dudi.acm of ade package''* enabled to perform the multiple correspondence factorial analysis (MCFA) and obtained the results in Table 4.

Table 4: Percentage values of the MCFA of the 20 variables

Axes	Inerties	Cumul	Ratio
1	19.90	19.90	10.47
2	13.66	33.56	17.66
3	12.71	46.26	24.35
4	10.99	57.26	30.14
5	09.86	**67.11**	**35.32**
6	09.34	76.46	40.24
7	08.61	85.06	44.77
8	08.29	93.35	49.13
9	07.68	101.03	53.17
…	…	…	…
27	02.23	178.44	93.91
…	…	…	…
37	00.67	190	100

On one hand, the results showed that there were several (exactly 37) factors or axis which is normal as they are associated not with variables themselvesbut rather with the total number of their modalities. Such a high number of values makes difficult the choice of factors to be retained. On the other hand, the results also shownthat the percentage of inertia (variance) determined by each axis is low which is common with MCFA. Thus, the first axis with inertia of 19.90% account for 10.47% of the total inertia. Based on the MCFA values, the first five axes that accounted for 35.32% of the total inertia were retained. However, for simplification, the analysis only focused on the two first axes while the principles remain the same for the three remaining.

Since the objective was to determine the numerical scores of individuals with high percentage of coefficient of determination for all the variables, the focus will be on the correlation ratios of the original variables and factors. The correlation ratios of the five factors retained based on the MCFA analysis are presented in Table 5.

Table4 : Values of correlation ratios of factors and original variables

Variables	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
com	0.226	0.055	0.120	0.259	0.048
age	0.047	**0.309**	0.018	0.023	0.087
sex	0.006	0.078	0.113	0.005	0.186
anc	0.050	**0.281**	0.079	0.023	0.007
group	0.230	0.043	0.025	0.259	0.001
s.eau	0.083	0.229	0.279	0.045	0.104
irrig	0.152	0.262	**0.643**	0.092	**0.295**
sup	0.144	0.064	0.062	0.072	0.190
enca	0.059	0	0.005	**0.350**	0.003
créd	0.031	0.125	0.064	0.042	0.006
mal	0	0.145	0.024	0.048	0.175
fert	**0.736**	0.013	0.002	0	0.001
lég	**0.597**	0.157	**0.320**	0.028	0.010
terre	0.235	0.049	0.034	0.064	0.249
m.o	0.006	**0.414**	0.059	0.264	0.008
écolo	**0.554**	0.047	0.020	0.110	0.136
sem	**0.671**	0.016	**0.325**	0.031	0.082
t.mén	0.035	0.181	0.101	0.009	0.149
act.s	0.068	0.128	0.141	**0.332**	0.056
n,ins	0.049	0.138	0.106	0.142	0.180

Considering the most structuring variables identified based on the correlation ratios, the first axis was the one of different kinds of agricultural inputs used. It helped to establish the relationship between four different variables including, type of seed used, mode of soil fertilization, ecological site and type of vegetable cultivatedand helped therefore in characterizing the individuals using these variables. The second axis was related to the socio-demographic characteristics of the gardeners and it highlights the

age, experience and type of labour used. The third axis is determined by irrigation techniques, the type of vegetable produced and the type of seed used. It underlines the relationship between the irrigation techniques used and types of vegetables cultivated. Consideringthe fourth axis, it is characterized by the technicality and alternative sources of income of the producers and brings out the link between access to technical monitoring and secondary activities. Finally, the fifth axis was characterized by only the irrigation techniques.

Hierarchical cluster analysis

The main goal here was to complement the MCFA analysis by determining a typology of individuals based on their factorial coordinates. The ascending hierarchical classification (HCA) was performed using the procedure "hclust" of stats package. First, the Euclidean distances among individuals were determined based on the factorial coordinates obtained from the MCFA then the classification was done using Ward algorithm. The dendrogramobtained suggests the presence of six clusters (Figure 4). The clusters are represented by corresponding numbers in color and a rectangle of the same color. The absolute and relative frequencies of individuals are presented in table 6.

Table 6: Absolute and relative frequencies of individuals

Classes	**1**	**2**	**3**	**4**	**5**	**6**
Absolute frequency	31	21	2	12	9	28
Pourcentage relative frequency	30.10	20.39	1.94	11.65	8.74	27.18

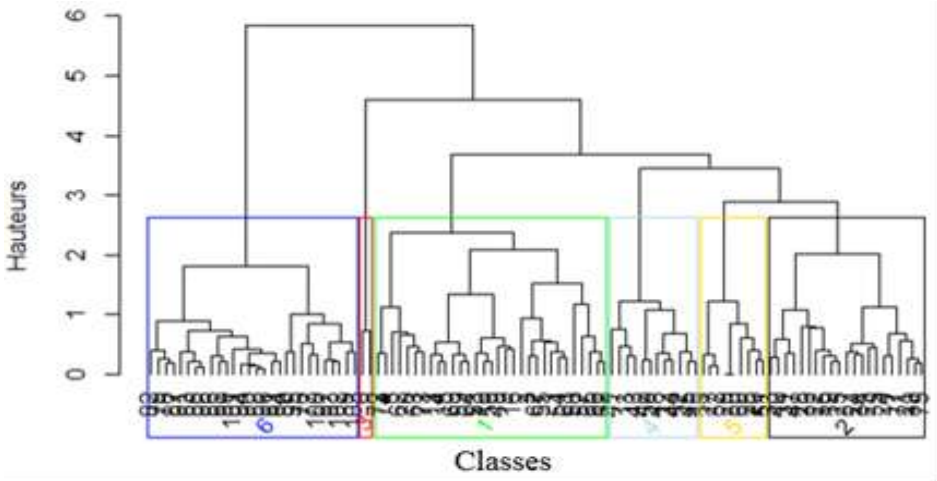

Figure 3 : Dendrogram of the ascending hierarchical classification of the 20 variables

The results of the classification were validated using the k-means method. The exact number of clusters was determined by estimating the number of classes that maximize the average width of silhouette, an indicator of grouping quality. Similar to the ascending hierarchical classification, the k-means method also confirmed that clustering into six groups maximizes the best the average width with about 67.4% variability (Figure 5).

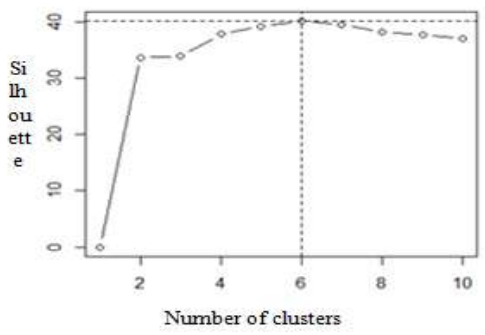

Figure 4 : Number of clusters obtained from the silhouette quality indicator

A comparison among the clusters generated by the HCA and k-means revealed a correspondence between two classes (Table 7). A perfect correspondence was observed between the cluster 3 of HCA and the cluster 5 of k-means (two individuals out of two). Similar correspondence was also observed between the clusters 6 and 2 of HCA and K-means respectively. This correspondence between the two methods confirms the clustering results into six groups.

Table 5 : Contingency table of clusters obtained from HCA (rows) and k-means (columns)

Clusters		**k-means**					
		1	**2**	**3**	**4**	**5**	**6**
HCA	**1**	22	1	2	4	0	2
	2	0	0	0	17	0	4
	3	0	0	0	0	2	0
	4	0	0	11	1	0	0
	5	0	0	0	0	0	9
	6	0	27	1	0	0	0

Interpretation of Clusters or types

The description of the clusters generated is based on the means comparison of the factors used during the MCFA (Table 8) without considering the relations among these factors. In table 8, the percentage of inertia explained showed that the development of the clusters was mainly controlled by the mode of soil fertilization, type of seed used, type of vegetable cultivated, the nature of the ecological site and by watering technique (factors 1 and 3). This variability helps to estimate the distance between the clusters.

Table 8: Means of factors and percentage of inertia explained

Clusters	Fact1	Fact2	Fact3	Fact4	Fact5
C1	-0.2713	0.1042	-0.0514	-0.2740	-0.1324
C2	-0.2919	-0.1610	0.0951	0.1462	0.3532
C3	0.1767	1.1218	1.9540	0.2216	-0.0392
C4	-0.0009	-0.4694	0.2628	0.2438	-0.3432
C5	-0.4206	0.2087	-0.3771	0.4254	-0.1038
C6	0.6422	0.0594	-0.1455	-0.0634	0.0650
% explained	**84.2747**	46.4256	**81.0688**	47.0645	47.2367

Producers of local vegetables in shallow using only manual irrigation techniques

Cluster 1 was composed of 30.1% of the gardeners with an inclusion of gardens from both districts especially the villages Bamè, Klobo and HouinDahoué (Table 9). These gardens were managed by young and adults, with a wide range of experience in gardening, who cultivate in shallows without any technical training. Thus, the producers of this class only used farmer saved seeds and mineral fertilizers to produce local vegetables. Daily activities are performed with the family and salaried labour. Fields are irrigated only during dry season for the off-season production. They use various irrigation techniques such as watering cans, bowls and manual water sprinkling.

Producers of local vegetables in shallow and upland using only manual irrigation techniques

Cluster 2 was made of 20.39% of the producers sampled. It included producers from the villages Bamè, Klobo, Zonmon, HouinDahoué. These gardens are managed by young and adults with an experience relatively proportional to their age. This category produces on upland and shallow during the rainy and dry seasons, respectively (Table 9). Although these gardeners had access to the technical monitoring but they only produced local vegetables because of their financial limits and lack of skills for production of exotic vegetables. They used farmer saved seeds and only mineral fertilizers. They use various irrigation techniques with some producers combining watering cans, bowls and manual water sprinkling.

Producers of local and exotic vegetables in shallow using only motorized irrigation techniques

This cluster counts for 1.94% of the producers sampled and is composed of only two producers from the village Bamè, Zangnanado (Table 9). These gardeners are adult, with a long experience in the field and have access to technical monitoring.

This group produced in the shallows, local and exotic vegetables and used both farmer saved and improved seeds and both mineral and organic fertilizers. It is an improved production system that uses more modern equipment and more inputs. In this case, watering is with a modern irrigation system namely with sprinklers and sometimes with cans were used.

Producers of local vegetables in shallow and upland using only manual irrigation techniques and low rate of organic fertilizers

The fourth cluster contained about 11.65% of the gardeners sampled; they are from both districts namely Bamè, Klobo, Zonmon and HouinDahoué. Both young and adult gardeners belonged to this group, they all had little experience, produced in both shallows and upland, and used mineral fertilizers combined with a low rate of organic fertilizers to enhance the fertility of the soil. Having access to technical advice, they used some few improved seed in addition to the farmer saved seeds but they only produced local vegetables. Coming to the labour typeused, it was more salaried than familial and the irrigation technique was manual combining bowls, cans and manual sprinkling.

Producers of local vegetables in shallows and upland using solely manual irrigation techniques and low rate of organic fertilizers

Cluster 5 counted about 8.74% of the gardeners sampled who were all from Zangnanado district namely the villages Bamè, Klobo and Zonmon. There were adults and young with a big experience in vegetable gardening and had access to technical advice. In this category, the gardeners used mineral fertilizers and farmer-saved seeds, produced local vegetables in upland or shallows using both salaried and familial labour. The irrigation technique consisted of cans and manual sprinkling.

Producers of local and exotic vegetables in upland irrigation with cans and use of mineral and organic fertilizers

This is the sixth and last cluster where 27.18% of the interviewees belonged to. It is a special group because its gardeners produced on government land (upland) in the district of Covè and they receive support from Plan Bénin through ADLDIPE NGO. Both young and adults belonged to the group with an experience proportional to their age. All the gardeners of this cluster, benefit from the technical support of the district office for agricultural developmentand ALDIPE NGO. Through this project they are given inputs especially, mineral and organic fertilizers and improved seeds. They produced local and exotic vegetables using salaried and familial labour. The production site is operational throughout the year because of the hydro-agricultural infrastructures available. The irrigation is done with watering cans, bowls and manual sprinkling.

Table 6 : Characteristics of the different types of vegetable farms identified

Criteria of classification	**Type 1**	**Type2**	**Type 3**	**Type 4**	**Type 5**	**Type 6**
Age	Young and adult	Young and adult	Adultes	Young and adult	Adults and old	Young and adult
Experience	Little	Little	Little or big	Little	Big or very-big	Little and big
Irrigation technique	Bowls, watering cans and manual sprinkling	Bowls, watering cans and manual sprinkling	Watering cans and motorized sprinkling	Bowls, watering cans andmanual sprinkling	Bowls, watering cans and manual sprinkling	Wateringcans
Access to technical support	No	Yes	Yes	Yes	Yes	Yes
Mode of soilfertilization	Mineral and organic	Mineral	Mineral and organic	Mineral and littleorganic	Mineral	Mineral and organic
Type of vegetableproduced	Local	Local	Local and exotic	Local	Local	Local and exotic
Type of labour	Familial and salaried	Familial and salaried	Familial and salaried	salaried and little familial	Familial and salaried	Very little familial and more salaried
Production site	Shallows	Upland and shallows	Upland	Upland and shallows	Upland and shallows	Upland
Type of seeds	Farmer-saved	Farmer-saved	Improved and few farmer-saved	Farmer-saved and few improved	Farmer-saved	Improved
Location of the gardens	Zangnanado and Covè	Zangnanado and Covè	Zangnanado	Zangnanado and Covè	Zangnanado	Covè

IV. DISCUSSION

The data collected showed that in these two districts, vegetable gardeningis an activity mainly undertaken by women as compared to men with 59.22% and 40.78 % of the interviewees, respectively. The findings of this study differ from those of Assogba (2008)[5], Agbossou (2008)[4], Ahouangninou (2013)[6]in the vegetable gardens of Sèmè-Podji (ViMaS), Houéyiho (Cotonou), Grand-Popo, Porto-Novo, Ouidah and Adjohoun in southern Benin and Simeni et*al.*, (2009)[10] in northern Benin who reported that men are predominant in vegetable gardening. This difference could be explained by the feeble participation of women to vegetable gardening in the areas of these previous studies. It could also be due to women's disadvantage of low access to land especially in an urban area where lack of farm land is experienced. In this study, the majority of the gardeners were adult, married with an average household size of seven persons, had a relatively low level of education and possessed a big experience in gardening. The low level of education can limit their access and comprehension capacity of the technical instructions (Simeni et*al.*, (2009)[10], Feder and Slade, 1984[11])and this could be a key determinant for the adoption of the innovations (Coulibaly and Nkamleu, 2000[12]). Gardeners with a higher level of education would have a higher rate of adoption (Strauss and *al.*, 1991[13] and Feder et*al.*, 1985[14]). This was the case of the producers in Bamè, Zangnanado who belong to cluster 3 with a high-school level. Albeit these farmers were in the same village with the majority of producers (clusters 1,2,4 and 5) who mainly produced local vegetables in shallows, with poor quality fertilizers and manual irrigation techniques, but they adopted a production system that is much more improved. Gardeners of cluster 3 cultivated both local and exotic vegetables with high quality inputs (seeds, fertilizers, pesticides etc.) and used a modern irrigation system made of motorized sprinklers in association with watering cans. They also used both mineral and organic fertilizers like the gardeners of the clusters 1, 4 and 6. Similar results were reported by Ahouangninou (2013)[10], Assogba (2008)[5], Agbossou, (2008)[4]who have shown that vegetable gardeners from southern Benin use both mineral and organic fertilizers.

As far as the age is concerned, the analysis of the six clusters indicates that these gardens were managed by a combination of young and adults except the clusters 3 and 5 which had only young gardeners. The gardeners had on average 9 years of experience because most of the young producers acquired experience while growing up by learning from their parents and remained in the same activity because of job scarcity and failure at school (Assogba et*al.*, 2008[15]). The mean comparison test performed for the variables age, household size and experience revealed non-significant differences for these variables between the two districts. These results are different from the ones reported by Ahouangninou, (2013) [10]and Agbossou, (2008)[4] and could be explained by the fact these studies were conducted in different environments with different socio-cultural factors. Nevertheless, the study revealed significant differences for the cultivated area between the two districts suggesting that the average cultivated area in Zanganado is greater than in Covè.

Type of vegetable produced, was a very important variable for carrying out the typology. Thus, the clusters 3 and 6 produced both local and exotic vegetables unlike the clusters 1, 2, 4 and 5 which produced only local vegetables indicating the high diversity of vegetables produced in the study area. This diversity is associated with the increasing demand as well as the cultural mixing of the urban communities. Similar results were reported by Adegbola and Singbo, (2001)[16] who stated that out of the three main vegetable production areas in Benin, the urban and peri-urban areas supplied diverse produces to the urban consumers. These areas produce local and exotic legumes (lettuce, french beans, carrot, cabbage, cucumber, hot pepper, etc.) throughout the year using a permanent irrigation of the plots.Kanda et*al.* (2014) [17]reported that similar relation was found in Togo by Tallaki in 2005, in Senegal by Diao in 2004 and in Cameroon by Dongmo and *al.*, in 2005). Temple and Moustier (2004)[18]also underlined that the new lifestyle and cultural mixing lead the urban populations to diversify their food consumption. According to the latter, the urban lifestyle often goes along with an increase in vegetable consumption. This also implies that depending on the type of vegetable produced, the gardeners are required to buy improved seeds but when they are educated, monitored and have access to technical support, they understand the importance of using improved seeds not only to have higher germination rate but also to improve the yield. Within the context of this study, only the gardeners of the clusters 3 and 6 used certified improved seeds unlike those of the clusters 1, 2, 4 and 5 who used farmer saved seeds. However, it is important to note that the gardenersof cluster 4 used very improved seeds and those cluster 3 also used very few farmers saved seeds. Producers of all the clusters except cluster 1 have access to technical monitoring and advice. The agents of the District offices for Agricultural Development (SCDA) are in contact with the producers whom they support and advise, help them to find solutions to address their challenges and help monitor their fields. Apart from the SCDA of the two districts which are public institutions, some gardenerswere identified by ALDIPE NGO which supports them through a project funded by Plan

Bénin. This support is in terms of inputs (improved seeds, pesticides, mineral and organic fertilizers), production equipment (hoes, machete, etc.) and irrigation equipment (mobile sprinklers, tank, watering cans, water tower, etc.).

The area of study does have some natural assets which, if well exploited, would really contribute to its development. There are several shallows which are used for producing vegetable as well as for growing rice. This shows that vegetables are cultivated in both shallows and upland though the production in shallows is more frequent. Despite the extension of vegetable production and the increasing annual production of vegetables, the activity still faces several challenges varying from one garden to another. Among these constraints which hinder vegetable production in Benin, some were identified by the studies carried out on vegetable gardening in sub-Saharan Africa (Kanda and *al.*, 2014[17]). Pest attacks, difficult access to land and to appropriate inputs and poor water control were the major ones reported by the interviewees. Kanda and *al.*, (2014)[17]underscored that pest and diseases pressure were the major constraints of vegetable production in Togo. According to Tchuinte (2005)[19], water scarcity during dry season and high pest pressure seriously hinder vegetable production in Benin. Pest attack is probably associated with the cropping system (previous crops, lack of rotation, intercropping that fragment the soil, use of farmers saved seeds etc.), the climatic conditions etc. The diseases are more prevalent during the rainy season while plant pests' attacks become critical in dry season. The extent of damages caused mainly depends on the ability of producer to master and implement the pest management techniques. Generally, they have limited skills in diagnosing these pests and disease and identifying the appropriate management method. In addition, the difficult access to inputs also hinders the effective pest and diseases management (Tchuinte (2005)[19], (Moustier et al., 2004[20]and Kanda and *al.*, 2014[17]). According to Singbo and *al.* (2004)[21], the prevalence of these constraints in Benin is a result of lack of financial means, shortage and high cost of the inputs.

The availability and accessibility of water are key determinants for the choice of a vegetable production site. This justifies the priority given to the question of water control hence irrigation techniques in this study. This study showed that all the clusters at different levels face serious challenges in water control. In addition to soil preparation and sowing, watering is a major that reflects the tedious aspect of vegetable production. It does require high amounts of water since the producers have to water twice or thrice a day. It also leads to higher demand of labouras the production area increases. Based the technical advice, some producers adopt the motorized irrigation systems to reduce the tediousness, demand of labourand the production cost. These findings are in accordance with those reported by Ahouangninou, (2013)[6] after carrying out a study in southern Benin. Only cluster 3 used this type of irrigation which is sprinkling with motorized sprinklers. Cluster 6 was also particular by having a positive mean for the factors associated with the variable irrigation technique except that here, the major irrigation technique used was watering can.

Albeit, the priority given to the vegetable production sector in Benin, it is noted that due to the lack of support and the disinterest of the policy makers of central Benin, the gardeners face several challenges which once addressed will revitalize the sector and improve the producers' livelihoods (Atidégla, 2006[22]). For any good development initiative, special attention should be given to the clusters 1, 2, 4 and 5 which were the most vulnerable. Nevertheless, clusters 3 and 6 also need to be attended to in order to improve the production conditions. All the production sites need support to acquire motorized irrigation systems not only to minimize the tediousness, but also to increase their productivity and income.

V. CONCLUSION

This study allowed us to have more information about the different types of vegetables gardens and irrigation systems that exist in the districts of Zangnanado and Covè. Theseresults shown six types of vegetables farms in which gardeners have use to combine four irrigation systems to produce both local and exotic vegetables. To be complete this study should be deepen to obtain further information for a better characterization of irrigation techniques and to include the economic and financial aspects for a more complete typology. Finally, development-driven models of each type of gardening should be proposed to enable the main rural stakeholders to gain more benefits from the results of this study for a proper development of vegetable gardening in their respective district.

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