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CLIMATE CHANGES AND FARMERS' ENDOGENOUS ADAPTATION STRATEGIES: SOCIO ECONOMIC ANALYSIS OF THE DYNAMIC USE OF AGRICULTURAL LANDS IN CENTRAL REGION OF BENIN

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ABSTRACT

There is an increasing consensus that in the next decades climate changes will generate yield decrease in low income countries. So will it be in Benin. It has been claimed that climate changes impact studies often assume certain adaptations and little explicit examination of how, when, why, and under what conditions they occur. This research aims at analysing the endogenous strategies developed by farmers in agricultural land and crop management. With random stratified sampling, 70 farmers of two villages were selected according to their level of vulnerability. Actors based mapping and R-coefficients of Ruthenberg were used to analyse the evolution of existing farming systems. This paper shows that poor farmers of the central region of Benin are developing many endogenous coping strategies: adopting new crops and cultivating more waterlogged ecologies. Though, adaptation options are determined by vulnerability level of farmers. Management and valorisation skills of farmers in low land are to be enhanced for a sustainable agriculture in the future.

Key Words: Adaptation strategies, climate changes, low land, vulnerability

RÉSUMÉ

Il y a un consensus croissant dans la littérature scientifique sur le fait que dans les prochaines décennies, les changements climatiques vont faire chuter les récoltes dans les pays à faibles revenus. Le Bénin ne fera pas exception. Les études sur les impacts des changements climatiques répertorient certaines mesures d'adaptation, mais peu examinent comment, quand, pourquoi et sous quelles conditions elles sont intervenues. Cette étude a eu pour objectif d'analyser les stratégies d'adaptation développées par les producteurs dans la gestion des terres et des cultures. A partir d'un échantillonnage aléatoire stratifié, 70 producteurs ont été sélectionnés dans deux villages. Les cartes à dires d'acteurs et le coefficient R de Ruthenberg ont été utilisés pour analyser l'évolution des systèmes de culture. Cette étude révèle que les producteurs du centre Bénin développent de nombreuses stratégies endogènes d'adaptation comme : l'adoption de nouvelles cultures et l'exploitation des bas fonds. Mais les options d'adaptation sont déterminées par le niveau de vulnérabilités. Le renforcement des capacités des producteurs, pour aménager ces bas fonds, doit être envisagé pour une agriculture plus durable.

Mots Clés: Stratégies d'adaptation, changements climatiques, bas fonds, vulnérabilité

INTRODUCTION

There is an increasing consensus in the scientific literature on the fact that in the next decades climate changes will generate yield decrease in many countries namely in low income countries where adaptation capacities are weak (Mahmud *et al*., 2008). In Benin, the agricultural sector employs 70% of active population (Kpangon, 2002). However, this sector depends essentially

on climate factors. Ogouwalé (2006) noticed that in the central region of Benin the small rainy season is disappearing giving way to a rainy season whose installation is later nowadays than before. Indeed, farmers do not remain unconcerned. According to Agossou (2008), they are adapting their agricultural systems to the new rain patterns and this according to the ecological and spatial entities. Gbetibouo (2009) claimed that climate changes impact studies often assume certain adaptations and little explicit examination of how, when, why, and under what conditions adaptation actually occurs in economic and social systems. Moreover, in Benin research on farmer's adaptation and vulnerability at household level is yet to start properly. Papy (1999) asserted that research on the agricultural practices through time and space constitutes a good way of understanding the logic behind the technical decision of farmers in such a risky environment.

Key concepts clarification

Vulnerability. Kasperson *et al.* (2001) define vulnerability as the degree at which a unity under risk is able to undergo damage after exposure to a perturbation or constraint and the capacity of that unity to face it in order to recover or disappear. In accordance with the above, vulnerability in this paper refers to the level at which a given farm with its socio economic traits (size, labour assets, farm geomorphology position…) is able to face successfully or not rain scarcity and extreme weather events of the region of Collines.

Adaptation to climate changes. In Benin, Aho (2006) reported that farmers are developing both curative and preventive practices to face climate risks in their region. Our choice to explore farmers own new land and crop management practices is motivated by a self innovation and sustainability concern which is key in such risky climate conditions. In fact, since the first steps of agriculture, farmers have been active in technology development to solve efficiently their problems long before fundamental innovative research. Endogenous adaptation here refers to farmers own adjustment of practices facing rain variability and scarcity.

Objective. This research aims at assessing the endogenous strategies developed by farmers in agricultural land and crop management systems facing rains variability and water scarcity, in order to identify constraints and enhancing factors.

METHODOLOGY

Study area. This research was conducted in "Collines" area in the central region of Benin. The region is characterised by a transition climate between coastal subequatorial climate and northern soudano-guineean climate. The average annual rain fall varies between 700 mm and 1200 mm. The relief is characterised by a very complex landscape of hills, inland valleys and plateau.

In fact the central region of Benin ("Collines") is divided into two main farming characteristics: its southern part represented by village of SOHEDJI is a historically cultivated land where land fertility is generally known as bad now. There, yam cultivation is done on short fallows not on firstly cleared lands. Its northern part represented by HOCO village is conversely a recent agricultural front.

Sampling and data collection

Sampling. Seventy farmers in two villages were selected by a stratified random sampling. Stratification of farmers took into account the prosperity level based on farmers' own local knowledge and following a participatory approach. In fact, according to DFID (1999), Individuals react differently when they are facing the instability of their livelihood. So we work on the general hypothesis that the more people have access to key production resources (capitals) the easier they can adapt. Then, the first step of this approach is to get an updated list of farmers. Next we give a number to each farmer randomly. The following step is to identify five (5) experienced farmers who know very well the village and ask them separately to categorise farmers and give a name to each category. Finally the key criteria of classification were explained. The three dominant criteria are: "access to adequate and sufficient land", "access to man labour services" and "possession of *Anacardium occidentale*

plantation". At the end of the exercise the classes made by the five farmers were compared in order to appreciate the coherence. All in all, 09 "very rich", 16 "rich", 20 "poor" and 25 "very poor" farmers were selected randomly according to their weight within both villages.

Data collection. Data collection started from a two weeks exploratory investigation. With an unstructured interview based on a guide line questionnaire, we collected general information on farmers' perception on climate changes, the history of their village and their livelihood as a whole. Then we went through each village following transect lines in order to have a clear idea about the geomorphology shape and land and crop distribution. Three ecological unities were identified as land characterisation criteria. There are: up lands, middle lands and low lands as described in Table 2.

A time reference was also identified based on farmers' perception of rain pattern in their environment. Among other questions we asked farmers: *"since how many years did they notice a perceptible change in the climate patterns?"*. For that question, answers were nearly the same: *"Since 1992 or 1993 or 1994, we noticed that rain season starts lately and ends very soon, it rains abundantly in a very short period, temperature is higher and harmattan is less harsh…"* So two reference periods of time of real changes of rains patterns was defined based on farmers' perception and corresponds to the period before 1992 and period after 1992.

This exploratory investigation paved the way for a one month deep socio economic survey based on a structured questionnaire.

Analysis tools. Descriptive comparison of farmers' maps was used to show the adaptation operated by farmers through time and space to cope with climate effect. Descriptive analysis of calculated coefficients and means and comparative analysis were used to appreciate the dynamic use of agricultural lands and crops. The "R"- coefficient used by Tossou (1985) is calculated for descriptive analysis purpose.

$$R = \frac{number\ of\ cultivation\ years}{Land\ use\ cycle} \times 100$$

In this formula, « land use cycle » equals « fallow duration » + « number of cultivation years » and:

a) A "permanent cultivation system" is characterised by an R coefficient higher than 66,

b) A "shifting cultivation system" is characterised by an R coefficient lower than 33,

c) A "fallow system is characterised by an R coefficient between 33 and 66.

Finally, in order to test the relationship between vulnerability level and adaptation options of farmers we used the Khi square test.

TABLE 1. Sample structure according to farmers' prosperity level

Villages	Parameter	Farmers' categories				Total
		Very rich	Rich	Poor	Very poor	
Hoco	Sample size	5	7	10	13	35
	Frequence	14.3	20	28.6	37.1	100
Sohedji	Sample size	4	9	10	12	35
	Fréquence	11.4	25.7	28.6	34.3	100
All	Sample size	9	16	20	25	70
	Frequence	12.9	22.8	28.6	35.7	100

Source: Household surveys, 2009

TABLE 2. Description of ecological unities

Ecological unities characteristics	Low land	Middle land	Up land
Soil texture	Clay	clay and sand with concretions somewhere	Sand with concretions somewhere
Fertility level	Good or very good	Good	Bad
Water characteristics and rain effect	Is immerged for for 2 to 7 months, flood is the main, crop falling down is the main threat	Very well moisture conservation, rarely flooded, but erosion is evident	Low water retention capacity, rain water is wash down to middle and low lands, water stress and erosion are visible
Cultivated crops	Rice, vegetable, maize, yam	Rice, maize and cassava	Maize, soya bean and cassava

Source: Household surveys, 2009

RESULTS AND DISCUSSION

Socio economic characteristics of farmers. The socio economic characterisation of farmers gives a clear view of their level of access to key productive assets. It paves the way for further understanding of decisions taken by farmers in a risky environment.

Gender and age of heads of surveyed households. Results show that 81.43% of the heads of households are men and 18.57% are women. Generally in Benin's tradition, being head of household is tightly related to access to land and capability to manage it to feed adequately ones family. It means that in Hoco and Sohedji women have limited access to land. This is a first obstacle for real adaptation from a point of view of empowering women.

From the analysis of Table 3, it appears that the average age of the individuals sampled, regardless the gender, is 43.17. It shows that persons considered in the sample are in general experienced enough to give relevant information in the limit of the time reference defined above.

Household size in Sohedji and Hoco. The structure of the household is a key factor in the analysis of adaptation strategies, for it permits to understand the productive capacity given that man power is the main productive power in the study area and Benin in general. The structure of the households sampled is described in Table 4.

Active member is any member who has the age to work properly in the farm (generally between 15 and 65 years old). Any member out from this limit is inactive. The dependence rate expresses the number of inactive members that an active member has to support in a given

TABLE 3. Presents the age of surveyed head of households

Village	Age per gender (average age)	
	Men	Women
Sohedji	41.5	43.8
Hoco	42	45.4
Whole sample	41.75	44.6

Source: Household surveys, 2009

household. In the case of both villages under study, it is noticed that Hoco village has more active members than Sohedji but Sohedji has more inactive members than Hoco. This result can be explained by the fact that Hoco is a resent agricultural front, so it attracts more farmers due to the relative fertility of its lands. *Ceterus faribus*, Hoco may adapt more to climate risks than Sohedji because having sufficient workers equals to ability to farm large acres in a few period of time and stay out from water scarcity.

Access to land in Hoco and Sohedji. Land is the first and foremost production factor. In a condition of rain variability, both quantity and quality of land are determinant for a relevant adaptation.

It is known that Sohedji with its long tradition of agriculture has less fertile land than Hoco which is a more recent agricultural front.

In terms of land quality, it seems that having land in different ecological unities is an advantage because it permit for instance to grow crops on up lands in case of flood and on low lands in case of rain scarcity. Table 5 gives the proportion of farmers according to the numbers of ecological unities cultivated.

Table 5 analysis reveals that the majority of farmers have their land in more than one ecological unity. However, in Hoco village, 51.5% farmers have their land in three unities whereas only 36.6% in Sohedji have their lands in three ecological unities. It appears that risk spreading is easier in Hoco than Sohèdji when seen on the basis of land quality. Table 6 presents the land size owned by farmers in Sohedji and Hoco.

Quantitative access to land does not vary too much from the first village to the second. The whole sample have an average land size of 7.59 ha and Sohedji and Hoco farmers have respectively an average land size of 7.88 ha and 7.30 ha. With 5 as the average active members in the sample, it is easy to say that quantitative access to land is not the first limit for farmers' adaptation in both villages.

Farmers endogenous adaptation strategies. Given those assets and obstacles it's easy to describe and explain on a scientific basis how farmers in Hoco and Sohedji are adapting they farming systems facing rain variability and water scarcity.

Spatial dynamics of cropping: Towards a valorisation of unexploited lands. The oldest but simplest spatial description tool remains maps. They are more expressive when they are drawn participatively by targeted actors themselves and

TABLE 4. Household size according to members' activity status

Village	Activity status		
	Active members	Inactive members	Dependance rate
Sohèdji	4.486 ± 2.077	3.571 ± 1.650	79.60%
Hoco	5.514 ± 2.466	2.771 ± 0.973	50.25%
All	5.000 ± 2.322	3.171 ± 1.404	63.42%

Source: Household surveys, 2009

TABLE 5. Distribution of farmers according to numbers of unities used

Village	Ecological unities		
	Only one unity	Two unities	Three unities
Sohedji	7.2%	56.2%	36.6%
Hoco	5.6%	42.9%	51.5%

Source: Household surveys, 2009

TABLE 6. Distribution of farmers' according to land size classes

Villages	Land size classes			
	Average land size (ha)	S<7.6 ha	7.6≤S<10 ha	S≥10ha
Sohedji	7.88 ± 4.002	24.43%	17%	8.57%
Hoco	7.30 ± 3.745	21.57%	18.43%	10%
All	7.59 ± 3.873	46%	35.43%	18.57%

Source: Household surveys 2009

if it takes into account "time" factor. According to (Dubiez, 2006), such initiatives permit to bring out dynamics going on in the area. The following maps are drawn respectively by farmers of Sohedji and Hoco considering the reference year 1992. These maps show the dynamic of crops distribution through time.

A close observation of the couple of farmer drawn maps permit to notice that new crops such as soya bean and rice are more cultivated in the present farming system whereas cotton which was the main crop some years ago is quite absent. This reveals that farmers adopt new crop to face the new food constraints and rain variability. This is an anticipative strategy and it corresponds to the remark of (Burton, 1996) who noticed that despite the increasing climate risks, anticipative strategies are becoming more appropriated and efficient than reactive strategies only.

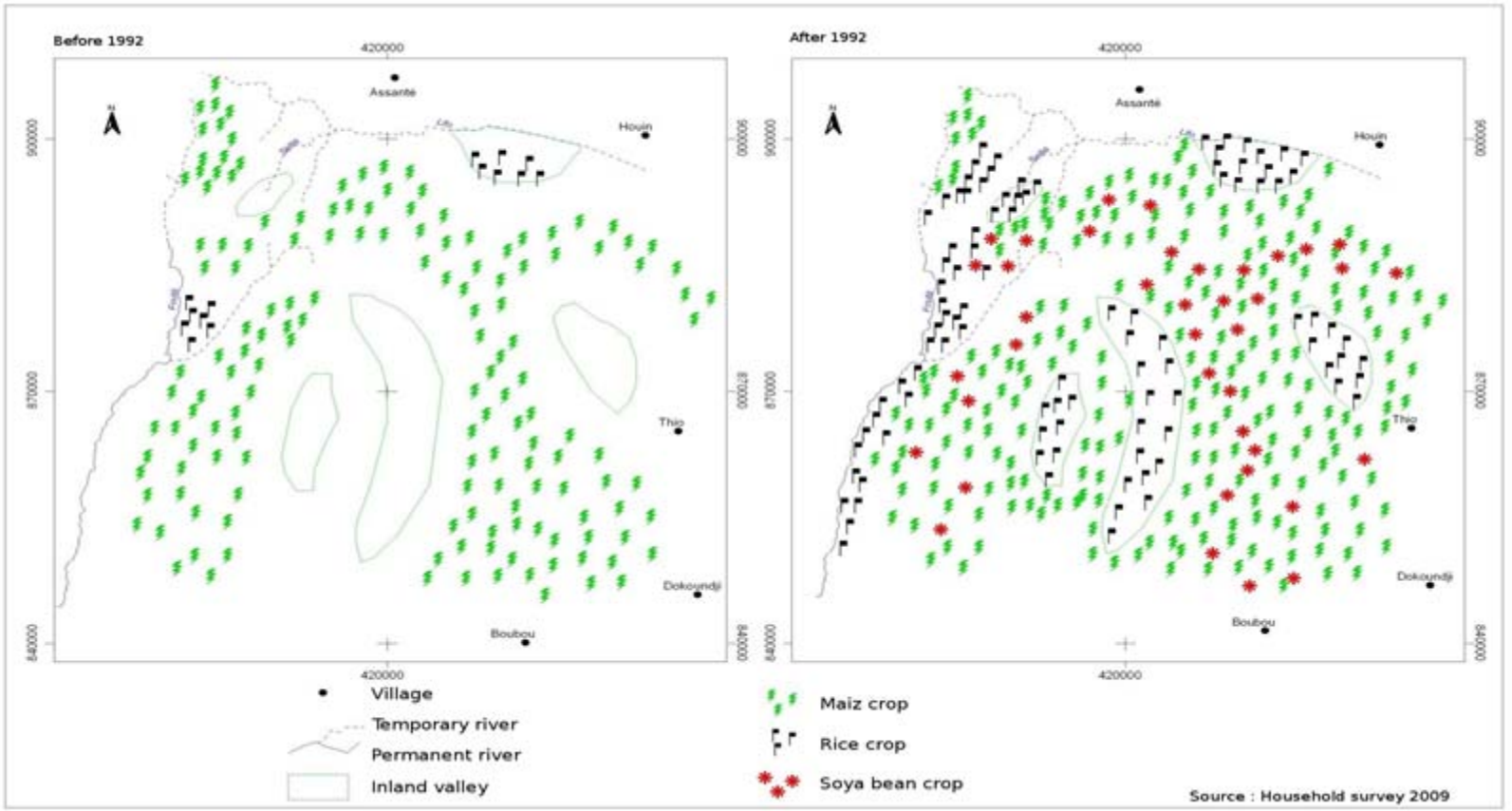
Secondly we can notice that inland valleys and the riversides (marked on the maps by irregular lines) are cultivated now. In fact, changing the spatial distribution of crops is one of the coping strategies adopted by farmers to face water stress. Inland valleys are cultivated in the beginning of the rainy season so that crop can be harvested before the occurrence of flood. This ecological unity can receive only crops which have their production system out of the soil: that is for instance rice and maize. Cultivation cost is higher because of the difficult management features of the soil. Its cultivation has started recently to avoid water scarcity in uplands. Middle lands are the intermediate between up and low lands. Most farmers produce in this ecological unity to stand out of flood risks in low lands and water scarcity in uplands. Crops such as ground nut and cassava are specific to that zone. Up lands are the most exploited formerly. The fertility level is the lowest one. The physical structure of the soil is not water conserving due to its long history of cultivation. Its upper position also favors surface water washing down to low lands. Then, crops suffer often from water stress. Table 7 gives the values of R-coefficient which measure dynamics of farming systems according to ecological unities.

Analysis of this table reveals that (i) Cultivation systems shifted from a shifting cultivation to a permanent cultivation system in low lands. (ii) Cultivation system shifted from a fallow system to a permanent cultivation system in middle lands.

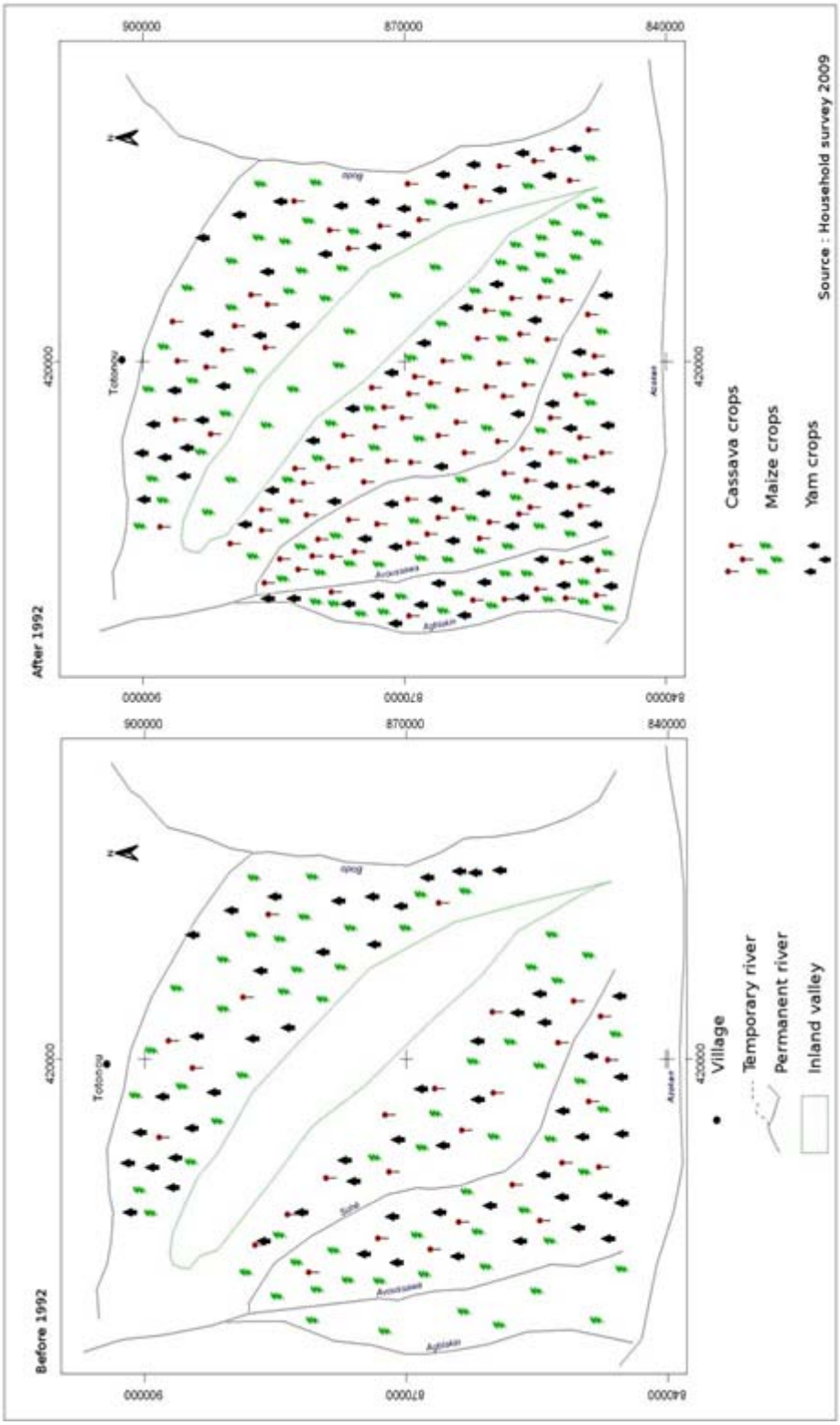
And cultivation system remains a fallow system but with a reduction of the fallow duration and an increasing of the cultivation duration nowadays in uplands.

These results are in line with factual observations. Inland valleys are permanently cultivated nowadays, whereas they have been neglected for long until 15 years ago. Such a result was reported also by Some (2006) who noticed in Burkina Faso that farmers, facing water scarcity, opted for the spatial reorganisation of crops. Obviously, the cultivation of lower lands is very labor and time demanding. Moreover, profitability in cultivating lowlands demands innovative planning of the sowing periods for floods avoidance purposes.

Nature of adaptation: relationships between endogenous strategies and vulnerability level of farmers. The general assumption on the relationship between adaptation and vulnerability is that the more a household has access to key production resources the more it can cope with climate changes effects. A comparison between the famers' own qualitative categorisation and



Map 1. Crop kinds and crops location on Sohedji territory according to farmers' perception. The left side map shows crops distribution before 1992. Right side crop shows crops distribution after 1992.



Map 2. Crop kinds and crops location on Hoco territory according farmers' perception. The left side map shows crops distribution before 1992. Right side crop shows crops distribution after 1992.

the quantitative data based on the three critical criteria shows a clear coherence between both approaches. Table 8 presents the different vulnerability classes defined.

The Khi square test carried out indicates that the sowing period depends on the level of vulnerability with 5% of significance according to Table 9.

In Sohedji and Hoco, maize is the staple cereal food. The dependence of the sowing period to farmers' vulnerability level can be explained by the fact that farmers who have easy access to labor adopt a late sowing of maize to stand out from water stress risks which characterises the first months of the rain season. Conversely, "vulnerable farmers" adopt an attitude of risk

TABLE 7. Comparing R- coefficients according to ecological entities and periods of time

Entities/periods	Inland valleys	Middle lands	Uplands
Before 1992	9.09	42.86	53.33
After 1992	66.67	66.67	61.53

Source: Household surveys, 2009

TABLE 8. Description of vulnerability classes

Criteria vulnerability level	Land size and location	Owning of Anacardium plantation	Access to labour
Very rich or not vulnearble	Total owned land size equals to 10.06 ha spread from uplands to low lands	Anacardium plantation size equals to 3.7 ha.	Number of active labour force in the household equals to 4.6
Rich or less vulnarable	Total owned land size equals to 7.4 ha spread from uplands to low lands	Anacardium plantation size equals to 1.83 ha.	Number of active labour force in the household equals to 1.35
Poor or vulnarable	Total owned land size equals to 5.86 ha spread at most over two ecological units	Anacardium plantation size equals to 1.095 ha.	Number of active labor force in the household equals to 5.85
Very poor or very vulnerable	Total owned land size equals to 4.5 ha spread at most over two ecological units	Anacardium plantation size equals to 0.6 ha	Number of active labor force in the household equals to 1.2

Source: Household surveys, 2009

TABLE 9. Farmers' maize sowing period according to their vulnerability level

Sowing periods	Vulnerability levels			
	Not vulnerable	Less vulnerable	Vulnerable	Very vulnerable
Early	1	3	9	17
Spread out	2	4	4	3
Late	6	8	6	5

Source: Household surveys, 2009

takers because they don't have enough financial resources to cope with labor peak time. This result is on line with the one of Agossou (2008) who noticed that access to key production resources help farmers to avoid climate risks. With the same logic, Belliveau *et al*. (2006) have shown that in condition of extreme climate risks, small farmers are more likely to take risks than rich farmers.

CONCLUSION

This paper shows that poor farmers of the central region of Benin are developing endogenous coping strategies to face climate changes, namely: adopting new crops and permanently cultivating low lands. However, cultivating low lands demands a good planning of sowing periods, which in turn are determined by the level of vulnerability. Thus, it is being suggested here that:

(i) Research institutions and extension services provide farmers with short vegetative period and drought resisting varieties through co-research initiatives
(ii) Farmers' management and valorisation skills of lowlands are enhanced through training sections.

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