Climate Variability and Socio-Economic Management of NÉRÉ Parkland (*PARKIA BIGLOBOSA* (*JACQ.*) *G.DON.* in *DJIDJA TONWSHIP / BENIN*

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ABSTRACT

To assess the effects of humans' activities and climate variability on socio economic living of population and Néré parklands vulnerability in DjidjaTownship in Benin. Primary data on climate variability and socio-economic characteristics of farmers were collected through investigation of 72Néréparkland 'farmers and focus-group. Descriptive statistic and principal components analysis were performed with SAS 9.2, SPSS and Excel softwares. The mains results of the perceptions of populations about climate variability especially rain variability fit with climate data trend obtained from meteorological stations. 93% of famers notice this climate variability and 90.31% has developed adaptation strategies which are cultural practice (41.33%), adaptation of the cropping system (37.33%), diversification of agricultural activities (10.67%) and reforestation which is little practiced (8%). Economic performances analysis showed no significant difference between adaptation technics but based on income average, the adaptation of the cropping system seems to be the most profitable (339132±84135) whereas the less profitable is the reforestation (143667±39389).

Key Words: Perception, adaptation, climate variability, Néré parklands, socio-economy, Benin.

I- Introduction

Agro foresters' parklands are sensitive ecosystems but with great importance for natural resources protection and well-being of rural populations [1]These parklands are traditional lands exploitation systems where trees are conserved in association with crops and sometimes animals [2]. In Benin, these parklands are constitute in majority of *Parkiabiglobosa*or *Vitellariaparadoxa*[3]and represent for populations an excellent system of food crops production for their self-sufficiency, the improving of their incomes and protection of forests and lands [1; 4] . Studies lead in North of Benin by [5]showed that, Shea butter and Néré contribute for 26 to 46% to agricultural household's incomes. Unfortunately, these specifics ecosystems are in persistent degradation and even in disappearance due to the low adaptation capacity of agricultural practices to climate variability, to anthropogenic characteristics and to the mismanagement of resources [3; 6]. This situation has harmful consequences on the environment, naturals resources and populations existence. Like most of sub-Saharan African country, Benin is also exposed to the harmful effects of climate rise with great vulnerability to future climatic variability [7]. But the ignorance of the extend and frequency of these climatic risks decrease the adaptation capacity of populations. Furthermore, irrational exploitation of Néré tree as heating and work wood and medicinal plants and the inconvenience of its cohabitation with crops [1]accelerate Néré parkland degradation on Abomey' table land compromising natural regeneration of the specie.So, won't the protection and popularization of Néré agro-forester systems be interesting in Néré conservation and improvement of famers' life conditions?Many studies about efficiency and profitability of adaptation of climate change and protection of parklands in Benin were carried out [3; 8; 9]but were only based on shea butter parklands and the results were not well integrated. Consequently, parklands degradation is still continue and becomes alarming.This study aims to make a systemic analysis of parklands management by integrating agro-climatic conditionssocio-cultural and economics realities which characterizeDjidja's Township.

II- Materials and Methods

A. *Study area:*

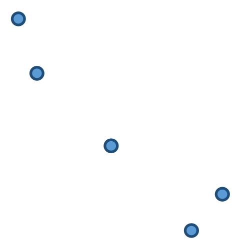


Fig 1: Djidja Township Map [10].

(The 5 blue Points inside represent the 5 boroughs concerned by this study)

Djidja is located in the south of Benin between 1°38' *to* 2°19' in longitude East and 7°08' to 7°47' in latitude North (Fig 1).With an area of 2315km² splited up into 79 villages, Djidja belongs to subequatorial climate region and the rainfall pattern but move towardunimodal.Djidja' annual temperature fluctuate from 24°C to 28°C with an average around 26 °C The two dominants types of winds are marine trade-wind and Harmattan.

B. Data collecting

Based on investigation and semi-structured interviews, socio-economics and demographics characteristics (age, gender, experience year number, matrimonial situation, academic standard, néré' incomes…) of 72 parklands famers have been determined. The size of the sample was obtained using Dagnelie's (1998) formula.

$$N = \frac{t^2 \times p\,(1-p)}{m^2}$$

P value (25%) has been determined at exploratory stage through investigation about 100 famers if 'yes' or 'no' they exploit Néré parklands.These 72 famers has been randomly chosen and investigated on their civil status, social conditions, perceptions and adaptations strategies to climate changes and some elements of their earnings reports. These information has been completed with directs observations, interviews with authority and technical services. Focus-groups has been organized.

B. Dendrometrics data

Through an observation and sampling studies of Néré parklands, tree density (per ha and per class of diameter) has been calculated using small square sizes described by many authors [11; 12; 13]. So, 15 small square in 5 borough was consideredand Néré trees have been counted and gathered in 3classes of diameter as: d < 10cm (plant); 10< d < 50(juvenile plant) and d > 50cm (adult tree). This operation allowedto appreciate the natural regeneration of Néré in the study area.

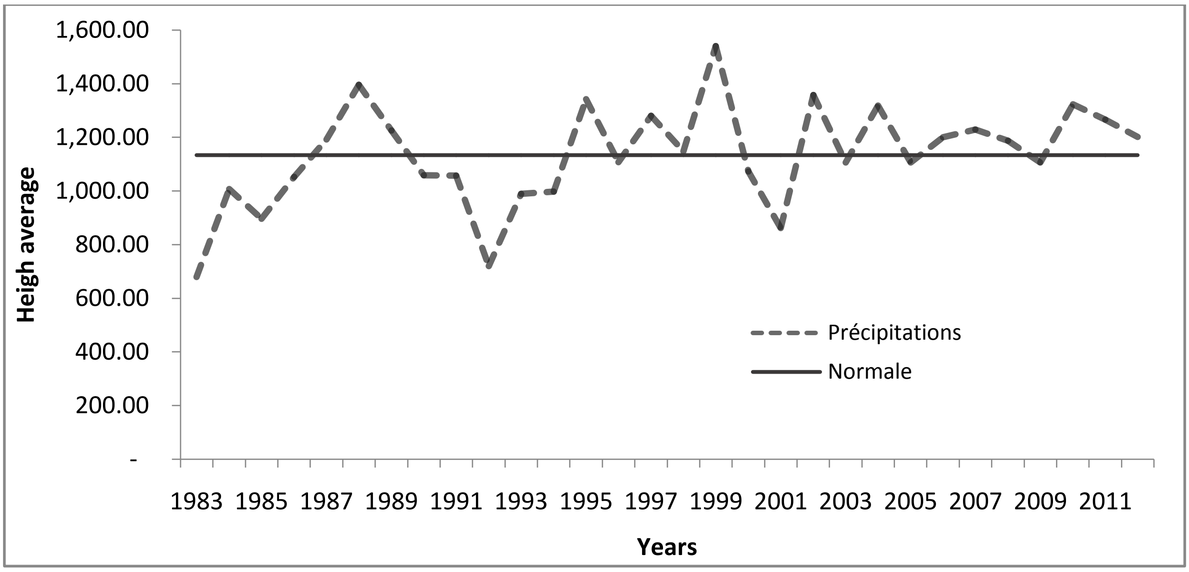
C. *Data processing*

Progressive trend study of climatic parameters using Excel software 2007 version was used to appreciate their temporal variations. Trend curves showing inter annual and monthly variations on the climatic standard (1983-2012).Dendrometrics and sociocultural data have been saved into Excel database and differenttreatments (relative frequency, average and standard deviation calculation). Perception and adaptation rates was calculated usingExcel. These data have been submittedto multifactorial analysiswithnumerical classification and factorial correspondences analysis (AFC) using SAS 9.2 in order to identify the most important. Khi² test has been used to highlight the rate of relationship between different parameters. The average income and standard of deviation have been calculatedfor each type of adaptation using Excel and result are presented on graphics and tables. The monthly average of brute marginfor each adaptation strategyhave also been submitted to comparison in order to appreciate statistical differences. Khi² test were also used.

III- RESULTS

A. Climatic data analysis

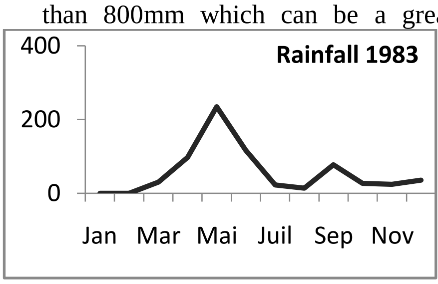
Climatic data (rainfall and temperature) have been collected for 30 years.

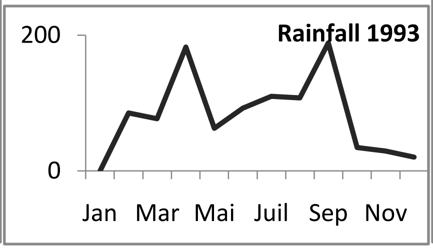


Data source: ASECNA, 2014

Figure 2: Interannualrainfall variations for climatic standard (1983-2012)

This figure 3 shows that between 1983 and 2012, the annual average of rainfall have greatly fluctuated. The most high value (1540 mm) is obtained in 1999 and the most low (680 mm) in 1983. The average on climatic standard is 1134.06 mm. So, we notice over the time a variation of more than 800mm which can be a great problem for agricultural previsions in the study area. Concerning the annual repartition of this precipitation, the figures 4, 5, 6, 7 and 8 which represent the monthly average of the rainfall respectively in 1983, 1993, 2003,2012 and in the climatic standard (1983-2012) present in large de situation of the variation during the time.





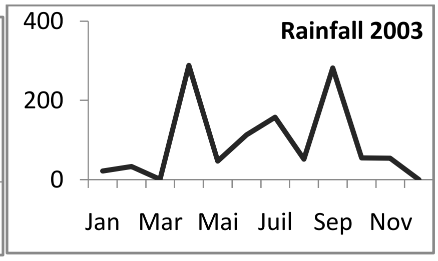
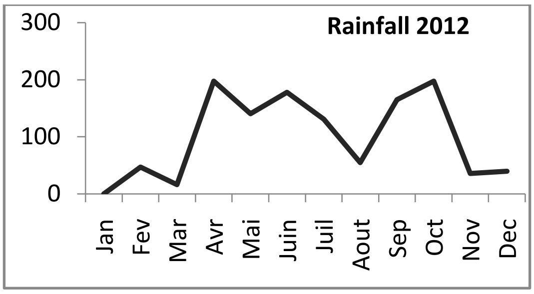


Fig 4: Monthly rainfall (1983)**Fig 5:** Monthly rainfall (1993) **Fig 6:** Monthly rainfall (2003)



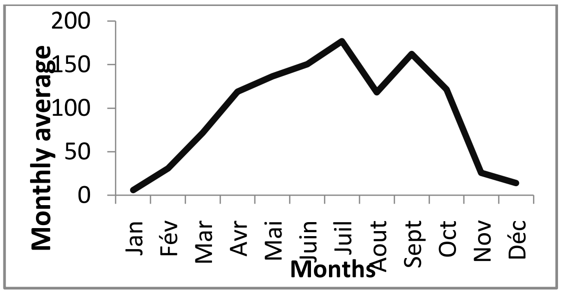
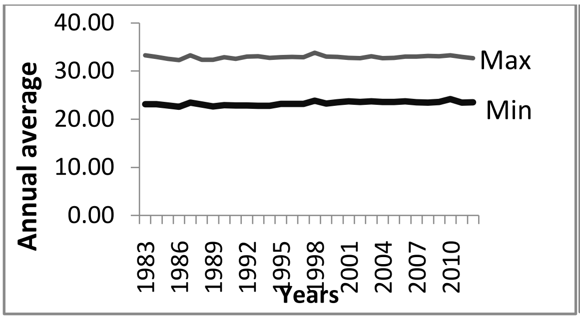


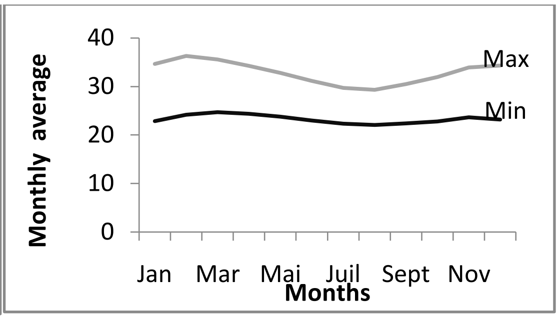
Fig 7: Monthly rainfall (2012)**Fig 8:**Monthly average rainfall for 1983 to2012

These figures shows a remarkable irregularity in the monthly precipitations repartition between 1983 and 2012.For example in 2003 and 2012, the two rains seasons recorded practically the same quantity of water with many peaks letting us believe that we have more than 4 seasons in the year. Furthermore, in 2003, we observe in May a remarkable waterfall like in dry seasons whereas we are fully in a rains season: this phenomenal is known later as « *pocket of drought* » with obvious consequences on agriculture

and sustainable natural's resources management. Nevertheless, on the climatic standard in general, even if the small dry season (August-September) seems less marked, we are still distinguishing the four seasons of the year. This reinforce us in our terminological choice of « climatic variability » instead of « climate change » So, rainfall data analysis reveals an irregularity and a light decreasing of rainfall on the climatic standard (1983-2012).

Temperature: Temperature is also an important factor to take into account in the evaluation of climatic variability because of its importance in matter cycles and process.





Data source: ASECNA; 2014

Fig 9: Interannual variation of max temperature and min temperature from 1983 to 2012

Fig 10: Monthly variation of temperature average (1983 to 2012)

These figures show that, contrary to the rainfall, the annual average of temperature max and min are relatively stable with time. Indeed, only low variations(22.6 to 24.15 for minima)and(32.28 à 33.78 for maxima) have been observed. So, temperature didn't record significant variations as well as in it repartition and copiousness.

B. Characterization of Néré parklands and their farmers

Differents socioculturals groups were considered in this study. The table 1 presentfarmer's main characteristics.

Table 1:MAIN CHARACTERISTICS OF INVESTIGATED FARMERS

Quantitative variable	Mode	Relative frequency (%)	Qualitative variable	Average	Standard deviation
Gender	Male	92,59	**Age**	39	11,94
	Female	7,41			
	Total	100			
Matrimonial situation	No married	14,81	**Household size (number of persons)**	8	4,25
	Married	85,19			
	Total	100			
Socio-cultural groups	Fon	61,73	**Experience (years)**	19	10,85
	Agou	38,27			
	Total	100			
Academic standard	None	69,13	**Total area cultivated (ha)**	9	5,66
	Primary	28,40			
	Secondary	2,47			
	Total	100			
Access to land	Legacy	65,44			
	Renting	33,33			
	Buying	1,23			
	Total	100			
Training	Trained	64,2			
	No trained	35,8			
	Total	100			

Data source: Investigations results (2014)

93% of interviewed farmers are men probably because our target group is cheif of farm who are most of the time men. This study took into account the most active part of farmers' populations (between 25 and 45 years old). 85% are married and 70% have none academic level. Though the access to land is mainly by legacy (65.44%), the renting of land practiced by more than 33% of farmers create between the owner and the tenant misunderstanding about the right usage of Néré products. This situation didn't motivate the tenant to protect Néré trees.

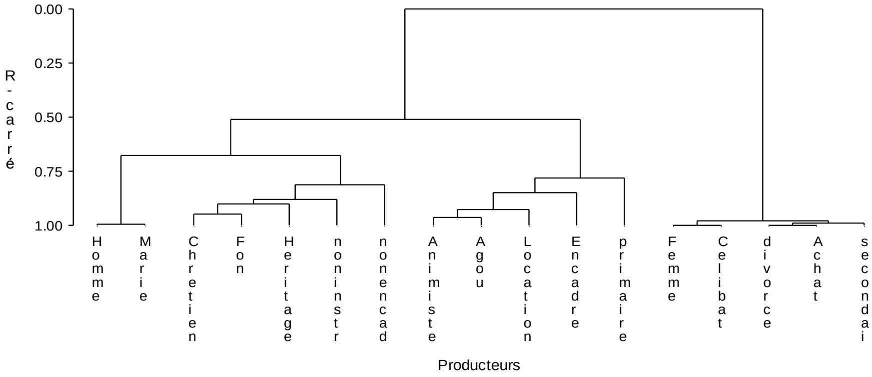


Fig 11: Dendrogram of characteristicsof farmers (SAS 9.2)

C. *Natural regeneration of Néré*

Dendrometrics datacollected on an area of 500m² allowed us to assess natural regeneration of Néréas well as in parklands and fallows at different development steps.

Table 2:NÉRÉ DENSITY IN PARKLAND AND FALLOW AT DIFFERENT GROWING STEPS BY BOROUGH

Boroughs	Fallow				Parkland			
	adult/ha	Young plant/ha	Plantule /ha	Rejection /ha	adult/ha	Young plant/ha	Rejection /ha	rejet/ha
Agouna	**20**	**33**	**27**	**13**	**20**	**0**	**0**	**7**
Outo	**27**	**93**	**80**	**38**	**13**	**20**	**13**	**22**
Monsourou	**27**	**33**	**27**	**0**	**13**	**7**	**0**	**13**
Djidja-centre	**13**	**13**	**33**	**7**	**7**	**0**	**7**	**0**
Dan	**33**	**47**	**67**	**0**	**20**	**7**	**0**	**7**

Source : Study data 2014

Analysis shows that Néré density for all growing steps fluctuate with the borough and the location (fallow or parkland). Adult Néré trees are numerous in parkland whereas in fallow, the young plant are most abundant. ExeptHounto borough where we have all the three steps of growing, some steps of growing of the species are absent in studied parklands compromising the natural regeneration of Néré in the area. According to interviewees,Néré tree has never been planted; it's the birds and bat thatdisseminate the fruits (seeds).

Photo 1: Natural regeneration of Néré in Fallow (Boko, 2014)

Photo 2: Degraded Néré Parkland in Djidja (Boko, 2014)

D. Perception and management of climatic variability

i) Perception and manifestation

Data analysis shows that climatic variability is perceived by 93% of interviewees. This perception is expressed by some events which frequencies are presented on the figure below:

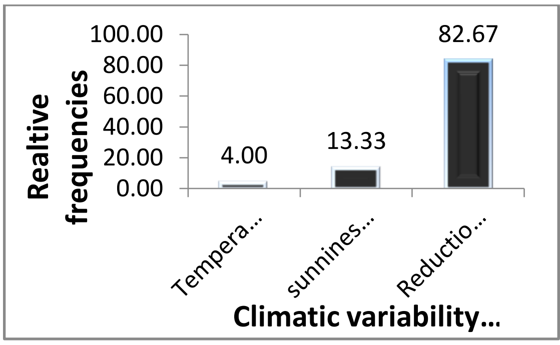


Fig 12: Perceived manifestations of climatic variability

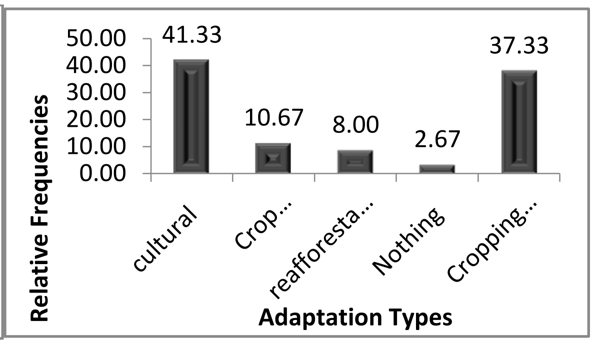


Fig 13: Relative frequency of adaptation techniques

Reduction and irregularity of rain were revealed to be the most important manifestations and were identified by 82,67% of parklands farmers followed by the sunniness decreasing which was also related, according to them, to rainfall law such as shortening of the small rain season and the overlapping of the two rains seasons obliging them to cultivate long cycle crops. The temperature rise has been evocated by only 4%.

Adaptation strategies to climatic variability.

To face annoyance of climatic variability, Djidja' Township farmers have developed different adaptation technics presented in the figure 13. Four adaptations techniques are identified after survey. **(1)** Adaptations of « cropping system »practiced by 37.33% which consist in changing the sowing date, the ploughing techniques, crop rotation and required crops association etc...; **(2)** Cultural" adaptation like prayers, fetichism, appeal for native doctors etc., is the most practiced (41.33%); **(3)**Cropping diversification (10.67%) and**(4)** Reforestation(8%). We noticed that cropping diversification and reforestation are the less practiced adaptation techniques against climatic variability. This results show that only 2.67% has no adaptation technique.

ii) Impacts of adaptation techniques on farmers' incomes

iii) Adaptation techniques developed by farmers aimed to reduce harmful effects of climatic variability and to improve their earnings.The figure 14below presents the averages of brute margins and their standard of deviation with each adaptation technique. Brute margin is the result between product prices (sale incomes or output) and production cost (input).

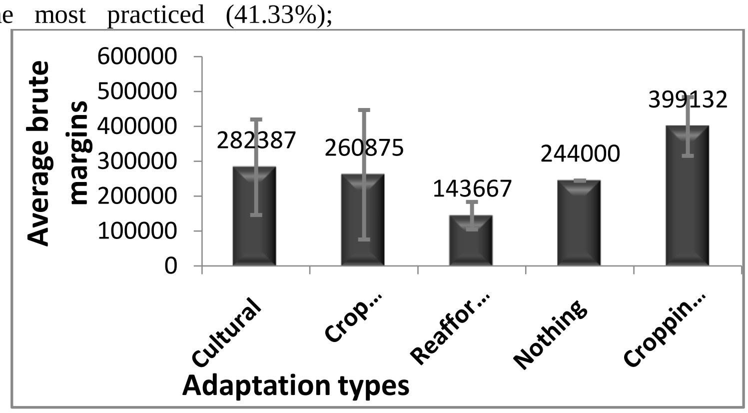


Fig 14: Average of brute marginsper type of adaptation (survey results, 2014)

The analysis of this figure shows no significant difference (SNK test at 5% rate) between the techniques but, based on the average of brute margins, cropping system adaptation seems to be the most economically efficient (339132±84135) and reforestation the less efficient (143667±39389).

IV. Discussion

A. ClimaticVariability and perception

Interannual variability of rains in the study area is characterized by high frequencies fluctuations in opposite in Sahel where low frequencies occurred [5]. Farmers' perceptions about climatic variability fit with climatic data trend mainly the rain parameter. This result is in agreement with results obtained by [14; 15; 16]. The farmers' access to popularization services favored their perception of climatic variability with statistically significant rate of 1% and 5 % according to SNK test. This result is comparable to those of[16]which concluded that the access to popularization services increase the probability of perception of climate variability. Socio-cultural groups havedifferent perceptions andadaptations strategies according to their gender, age and socio-professional categories and also to their work experiences. These results fit with those obtained by [15] who suggested that it better to consider farmers' experience than their age.

B. Adaptation strategies to climatic variability

93% understand the climatic risks and 90% develop adaptations techniques. This rate, although widely higher than those obtained by [3; 16]which was respectively of71% et 30% confirm them.But, the types of cropping practices identified are still less mastered to be an effective measure against climatic variability consequences. Furthermore, according to farmers, adaptations techniques relative to cropping systems aim mainly the conservation of soils for yield increasing than the management of climatic variability. Though it is mentioned by farmers and others authors [3; 16], the cultural adaptation strategyis still difficult to be assessed and popularized because of the lack of scientific proofs. Further studies can be carried out with people of different belief to really assess the effectiveness of cultural adaptation techniques.

C. Natural regeneration of Néré

Natural regeneration of Néré and Shea butter trees are difficult in cultivated areas becausethese species require four years before expressing very welltheirthrowing out capacity [4]. So, these species can't support repetitive cutting that timber rejection are submitted to during field keeping. So, we can conclude that only fallows periods can allow regeneration in felds. Concerning the cropcover, in opposite of [4]'s works in 2008, fallows present aNéré density higher than fields.That can be probably due to the no cultivation of fallows which allow Néré tree to grow. Indeed, the continuous ploughing and weeding in field prevent youngNéré trees from growing.

D. Impacts of adaptation techniques in farmers' incomes

Djidja' farmers have widely perceived the climatic variability and have developed many adaptation techniqueswith varying effects on some elements of their earnings report. Nevertheless, statistical analysis reveals no significant effect between adaptation strategies even if adaptation of cropping system seems to be the most profitable basing on the brute margins average. This result can be explained by the short period of the study that didn't allow the real assessment of all the required parameters of earnings report. Furthermore, most of these adaptation techniques are still in experimentation and require a long time of observation before coming to dependable conclusions.

V. Conclusions

Researches carried out on parklands' management showed that they are rational systems of lands use initiated by farmers throughout many generations to diversify their production in order to improve their livelihood and to reduce ecological risks of the climatic variability. Statistical analysis of pluviometrical data from 1983 to 2012 show a great inter-annual variability and remarkable decreasing of rains quantity with consequences on rains law and good planning of farm activities in Néré parklands. Farmers' perceptions of climatic variability fit with climatic data collected from meteorological station. More than 90% of farmers have developed four '04) adaptation technique but without significant effect on their incomes.So, in the context where the farmer accommodates himself to climatic variability to maximize his income, cropping system can be an appropriate adaptation strategy. For significant progress in parklands management, we must pay more attention to local responsibility, carry out research focused on management and give more important place to agroforestry in agricultural policies. To make it short, we must pass a holistic and integrated approach where actions are reciprocally strengthening themselves.

Acknowledgment

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References

[1] Gutierrez M.L. et Juhé-Beaulaton D., « Histoire du parc à Néré sur le plateau d'Abomey (Bénin) », *Les Cahiers d'Outre-Mer*, 220 | 2002, 453-474.

[2] Boffa, J.M. 2000a. Les parcs agroforestiers en Afrique de l'Ouest: clés de la conservation et d'une gestion durable. *Unasylva* 51, 200: 11-17.

[3]Gnanglè, P.C., Yabi, J.A., Yegbemey N. R. GlèlèKakaï, R. L., et Sokpon N. 2012. Rentabilité économique des systèmes de production des parcs à karité dans le contexte de l'adaptation au changement climatique du nord-bénin.

[4]Akouehou G. S., 2008. Agrosystèmes forestiers et gestion du karité (*Vitellariaparadoxa*) et du néré (*Parkiabiglobosa*) dans les terroirs villageois de Partago au Nord-Bénin. *Bulletin de la Recherche Agronomique du Bénin Numéro 62 – Décembre 2008.*

[5]Gnanglè, P.C. 2010. Management of shea butter in the context of climate change. *InternationalInnovation. Disseminating science, researchand technology*. Environment: October 2010. ISSN 2041-4552. pp. 54-55.

[6]Gbedji, E.K.Y., 2003: Caractérisation morphologique et structurale des parcs à néré (*Parkiabiglobosa*(Jack.) R. Br. Ex. G. Dom.) au Bénin. Thèse d'Ingénieur Agronome. Université d'Abomey-Calavi, Abomey-Calavi, Bénin, 124 p.

[7]Boko, M. Niang, I. Nyong, A. Vogel, C. Githeko, A. Medany, M. Osman Elasha, B. Tabo, R. and Yanda, P. 2007. Climate change: Impacts, Adaptation and Vulnerability. pp. 433–67.

[8]Sokpon N., &Yabi J.A. 2006. Gestion des systèmes de production, de commercialisation et de Sturm HJ. Les parcs agraires: reflet de l'histoire du peuplement. *Berichte des sonderforschungsbereichs* 2000; 268: 405-

[9]Gnanglè P. C., Glèlèkakaï R., Assogbadjo A.E., Vodounon S., Yabi J., Sokpon N. (2011). Tendances climatiques passées, modélisation, perceptions et adaptations locales au Bénin. *Climatologie,* 8 :26-40.

[10]Arouna, O.; 2010. Cartographie et modélisation prédictive des changements spatio-temporels de la végétation dans la Commune de Djidja au Benin: implications pour l'aménagement du territoire. Thèse de doctorat unique. Faculté des Sciences et Techniques / Université d'Abomey-Calavi. Bénin. Pp 246.

[11]Sinsin B., 1993. Phytosociologie, écologie, valeur pastorale et capacité de charge des pâturages naturels du périmètre Nikki-Kalalé au Nord-Bénin. Thèse de Doctorat en sciences agronomiques, Section interfacultaire d'Agronomie et de Phytosociologie, Université Libre de Belgique, 390 p.

[12]Oumorou M., 2003. Etudes écologique, floristique, phytogéographique et phytosociologiquedes inselbergs du Bénin. Thèse de doctorat, Université Libre de Bruxelles, 210 p + annexe.

[13]Djego J. G. M., 2006. Phytosociologie de la végétation de sous-bois et impact écologique des plantations forestières sur la diversité floristique au Sud et au Centre du Bénin. Thèse de Doctorat, Université d'Abomey-Calavi, 388 p.

[14]Belliveau S. B., Bradshaw B., Smit S., Reid D., Ramsey M, Tarleton, and Sawyer B.2006. Farm-level adaptation to multiple risks: Climate change and other concerns. Occasional paper No. 27. Canada: University of Guelph

[15] Maddison D. 2006. The perception of and adaptation to climate change in Africa. CEEPA Discussion Paper No. 10. Centre for Environmental Economics and Policy in Africa, University of Pretoria, South Africa.

[16]Gbetibouo G.A. 2009. Understanding famer's perceptions and Adaptations to Climate Change and vaiability. The case of the Limpopo Basin, South Africa. IFPRI Discussion Paper 00849. 41 p.

[17]O'Brien, K.L. et F., Wolf, 2010, A values-based approach to vulnerability and adaptation to climate change, *Wiley Interdisciplinary Reviews, Climate Change,* 1, 2, pp. 232-242.