American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-7, Issue-5, pp-272-280
www.ajer.org
Research Paper Open Access

Scope Of Rainfall Variability In The Shift Of The Cocoa Growing Area From The East Central Region To The Central West Of Cote D'Ivoire

Kouadio Zilé Alex[1*], Kouassi Kouakou Lazare[1], Djè Kouakou Bernard[2], Zoura Lou Nancy Théodora[1], Coulibaly Alama[2]
1 Université Jean Lorougnon Guédé, BP 150 Daloa (Côte d'Ivoire) ;
2 SODEXAM/Direction de la Météorologie Nationale, 15 BP 990 Abidjan 15- Côte d'Ivoire.
Corresponding Author: Kouadio Zilé Alex

ABSTRACT: *The thrust of this study aims to determine the part of rainfall variability in the shift of former cocoa growing area from central east to the central west regions, the new cocoa growing area. Two pilot localities known for their cocoa production were selected for this current paper. The first one is Abengourou and Dimbokro for the former cocoa growing area and the localities of Daloa and Divo as new coca growing area. The data used are rainfall (yearly and monthly) and the yearly production of cocoa. The software for statistical and cartographic analysis was utilized for data analysis. The results from the different localities show a decrease of the agricultural production in the former cocoa growing area and its increase in the new one from 1970S. The threshold rainfall of 700 mm per year to guarantee the productivity of cocoa tree is reached at 33% in the former cocoa growing area and 45% in the new one. Also, the minimum threshold of 70 mm per year to allow the survival of cocoa tree during dry season is reached at about 50% in the former area and more than 70% in the new cocoa growing area. The weak correlations between cocoa production and rainfall in both mean that rainfall is not the only reason that has contributed to the shift of the cocoa growing area from the central east to the west central area.*

KEYWORDS: *rainfall variability, cocoa production, cocoa growing area, Côte d'Ivoire*

Date of Submission: 27-04-2018 Date of acceptance: 12-05-2018

I INTRODUCTION

Cocoa farming has been introduced in Côte d'Ivoire in 1892 on the outskirts of the Cavally river [1]. This farming was previously done in the eastern and central east regions of Côte d'Ivoire and brought about a very fast development after 1950S [2]. Therefore, from 1922 to 1939 the production shifted from 2300 tons to 55000 tons. That fast and continuous growth of Côte d'Ivoire made it be the first world cocoa producer, which made the eastern and the central east regions be named the former cocoa growing areas [3]. With the depletion of forestry resources and the scarcity in rainfall in those areas, the growing of cocoa became a reality and boomed in the central east and western regions, that is why the areas were named the new cocoa growing area [4]. The results from the work of [5] show that an average drop of 15% in rain fall in most of the localities from the former growing cocoa areas. Some other similar works done by [6, 7] clarify the drop in rainfall in 1969 in that very cocoa growing area mainly in Abengourou and Dimbokro. There were drops in rainfalls in 1969 in Divo and in 1972 in Daloa.

Therefore, this drop in rainfall could replace the good productivity of cultures, namely cocoa-tree and this can justify the shift of the cocoa growing area. In effect, cocoa tree demands some agro climatic conditions which are not to be left out. It demands 1500mm on average of rain per year and can correctly vegetate with 1100-1200 mm in the regions with rich soil, deep and humid with a temperature of 28°C [10]. Cocoa tree also demands an average rainfall of 700 mm over four (4) consecutive months t o guarantee optimum production.

This current work aims at verifying the satisfaction or non-satisfaction of those demands in the former cocoa growing area (east central) to the new area (west central). Specifically, it highlights the determination of the part of rainfall variability within the change of the former cocoa growing area. The methodology used is the search for existing link between rainfall and cocoa production.

II PRESENTATION OF STUDY AREAS

The former cocoa growing area and the new one are to be seen in the east central and in the center-west of Côte d'Ivoire (Fig.1). The climate is tropical and humid in the former cocoa growing area with a rainfall regime of bimodal type: a big rainy season from March to June, a small dry season from July to August; a small rainy season from October to November, and a big dry season from November to February [5]. The climate of the new growing cocoa area from the west central of Côte d'Ivoire is too humid and has four seasons (from April to mid-July: a big rainy season; from mid-July to September: small dry season; from September to November: small rainy season; from December to March: big dry season [8, 9].

The hydraulic regime is of an equatorial type of slight transition within the former cocoa growing area which is tropical and humid in transition in the new one [4].

The vegetation in both cocoa growing areas is dominated by forest and savannah. The relief is composed of plateau with low altitudes and plains. The soils are not deep enough. They are ferralitic with gravels. The forest zones present deep soils with fine clayey and are sandy [8, 11]

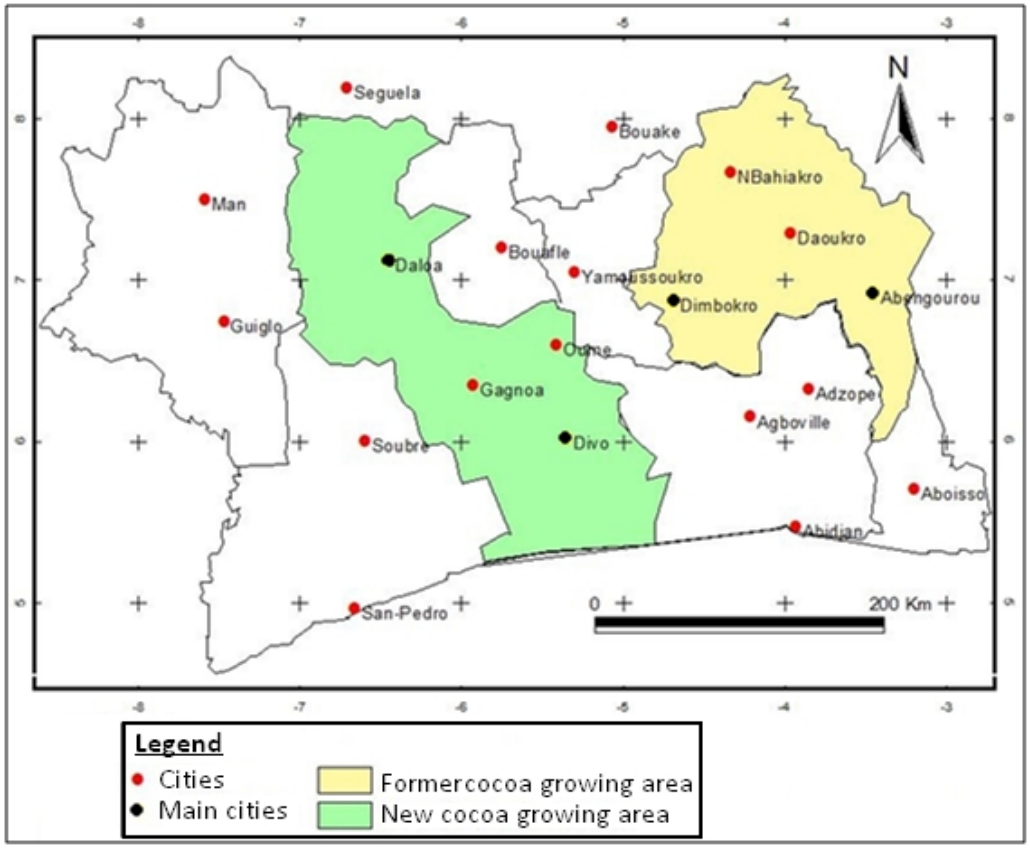


Figure 1 : Geographical location of the former and new cocoa growing area

III MATERIAL ET METHODS

3.1. Data and material

Data used in this study are annual rainfall from 1961-2015 periods and the annual production of cocoa from 1965 to 1986 from the localities of Abengourou and Dimbokro (former growing cocoa area), Daloa and Divo (former growing cocoa area). Rainfall data are from the Development and exploitation center for airport, aeronautics and weather forecasting (SODEXAM). Data from cocoa production are from statistics, documentation and information Center (SDIC).

3.2. Methods

3.2.1 Cacao production Analysis

An inter-annual analysis for cocoa production is done to follow the evolution of agricultural production. It is based upon a graphic representing cocoa production from the former and the new cocoa growing areas.

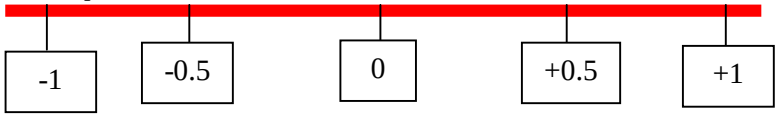
3.2.2. Relationship between rain and cocoa production

The rainy period from which cocoa-tree continuously needs water to grow up and guarantee a good production covers the months of April to July. The plurality of rain from that period must be on average of 700mm [12, 13]. Moreover, for cocoa tree to survive in dry season over three continuous months there must be a minimum rainfall of 70min [10]. These two limitations will be checked within the two cocoa growing areas from chosen rainfall stations (centers). On the second hand, the relation between rainfall and cocoa production is analyzed from the correlation coefficient [14]. This coefficient that varies between -1 and +1 permits to detect the presence or lack of a linear relationship between the two quantitative continuous characters X and Y where X and Y represent rainfall and cocoa production respectively. To calculate that coefficient, we must first and foremost calculate covariance (equation 2).

$$r(X,Y) = \frac{cov(X,Y)}{\sigma_x \sigma_y} \quad (2)$$

$$cov(X,Y) = \left(\frac{1}{N}\sum_{i=1}^{N} X_i.Y_i\right) - (\bar{X}.\bar{Y}) \quad (3)$$

Its interpretation is as follows:



If -1 < r < -0.5; there is therefore a significant negative correlation between rainfall and production.
If, -0.5 < r < +0.5; there is no relationship between rainfall and production.
If, +0.5 < r < 1; there is a strong positive correlation p between rainfall and production.
To check the significance of the coefficient of correlation, T-test of STUDENT was used [14]. This test better presents the relationship that could be effective between both variables (rainfall X and Y for the cocoa production) in comparison with a T calculated to a T indicated in the table of STUDENT. The significance limitation of α is set to 0.5%; the degree of freedom is (n-2); the text t is calculated from the formula (equation 4):

$$t_{calculated} = |r| \sqrt{\frac{n-2}{1-r^2}} \quad (4)$$

$t_{calculated}$: test of Student calculated
n: size of sampling
r: coefficient of correlation
if $t_{calculated}$ is higher to $_{lu}$, therefore a correlation between X and Y exists.
if $t_{calculated}$ is lower to t_{lu}, therefore the correlation observed between X and Y is due to chance.

3.3. Results

2.3.1. Cacao analysis production

The analysis of graphic representations of the figure 2 highlights that in the same period, there is a general trend to the drop of cocoa production within the former cocoa growing area. In the new area, this trend is on the rise. The coefficients of the adjustment lines justify the drop and the rise of production within both cocoa growing areas and vice versa. They are negative within the former area and positive in the new one.

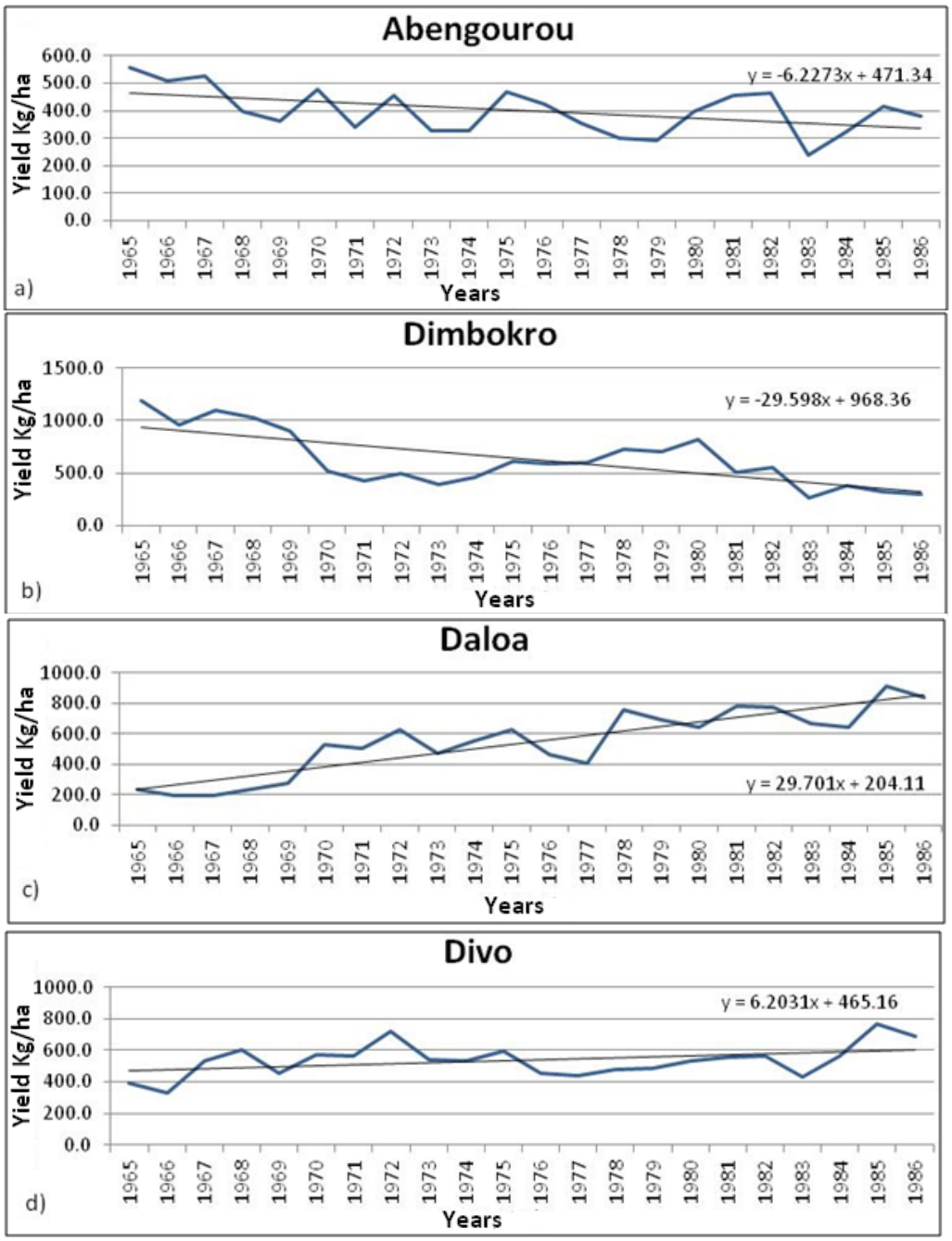


Figure 2 : Temporal evolution of cocoa production within the former cocoa growing area (Abengourou and Dimbokro) and the new cocoa growing area (Daloa and Divo)

3.2. Relation between rainfall and production

3.2.1. Satisfaction of rainfall threshold of 700 mm

Rainfall threshold of 700 mm to guarantee optimum production of cocoa tree (figures 3a and b) is not within the majority of cases reached within the former cocoa growing area. For the period of study, this threshold is reached at 51 % in Abengourou and 15% in Dimbokro only. Be it an average coverage of rain satisfaction within the former cocoa growing area by 33%.

In the new cocoa growing area, the threshold of 700 mm is reached in Daloa by 24%. In Divo, it is reached at 67%. Within the whole new cocoa growing area, the rate for average satisfaction is 45%

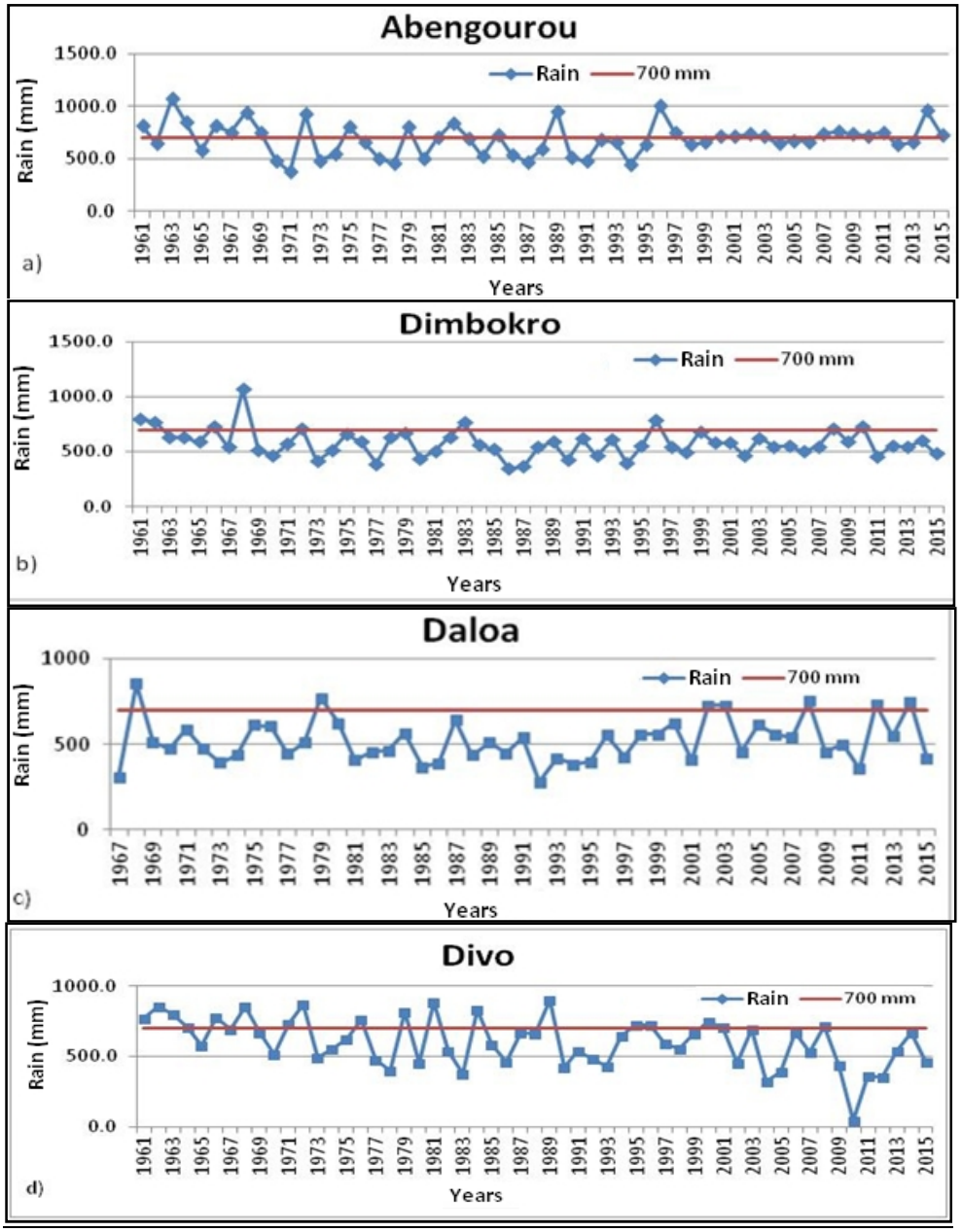


Figure 3: Seasonal evolution of rainfall with regards to the threshold of 700 mm within the former cocoa growing area : a) Abengourou, b) Dimbokro and within the new area c) Daloa and d) Divo

3.2.2 Satisfaction for rainfall threshold of 70 mm

During the dry season, the height of minimal rainfall threshold of 70 mm to permit the survival of cocoa tree (Figure 4 a, b, c and d) is globally satisfied. Within the former cocoa growing area (Abengourou and Dimbokro), the rate of satisfaction is on average 53% over the study period. In the new cocoa growing area (Daloa et Divo), the dry season guarantees the minimum rainfall of 70 mm by 69% and 76% respectively for the period of study.

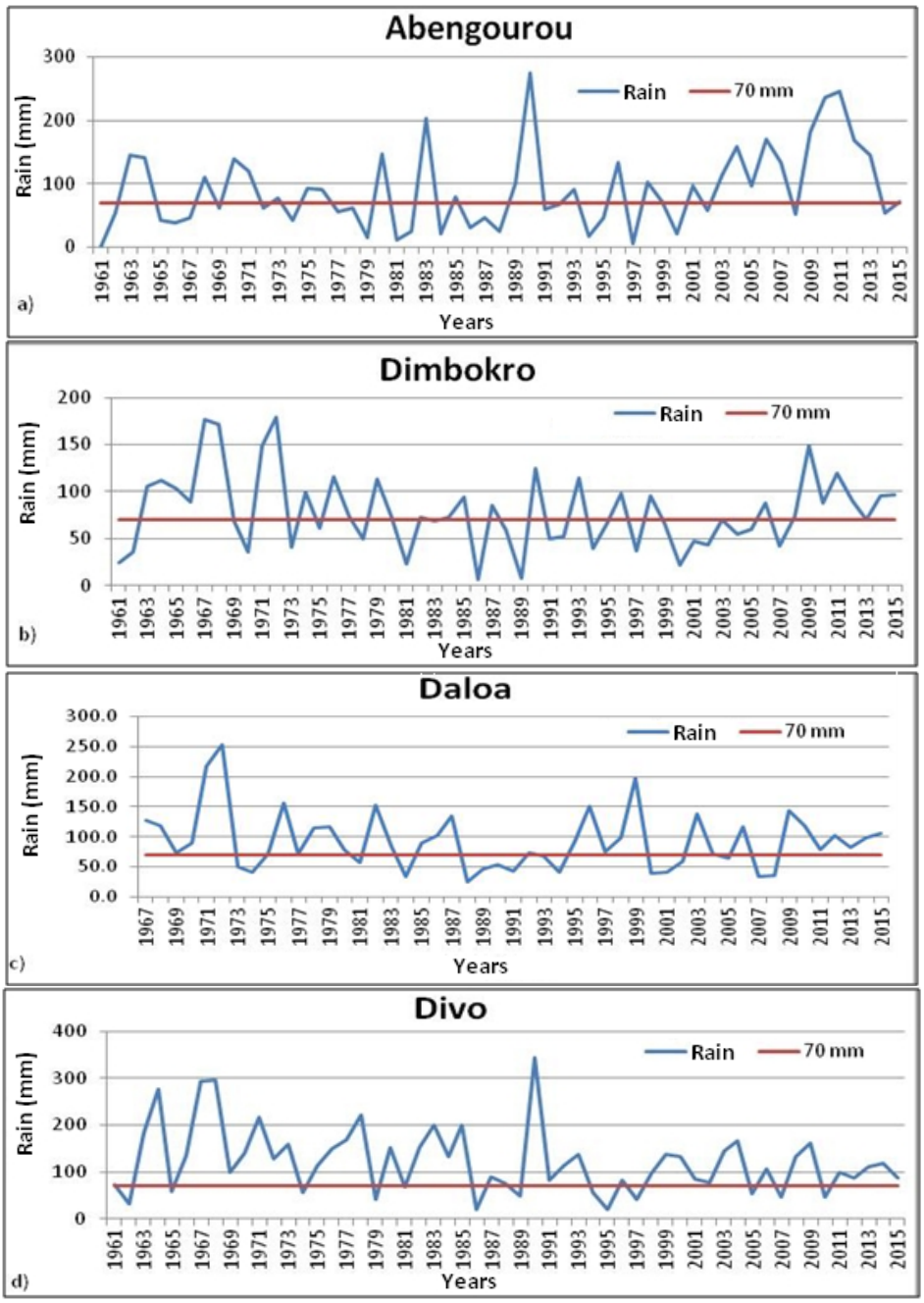


Figure 4: Seasonal evolution of rainfall with regards to the threshold of 70 mm within the former cocoa growing area: (Abengourou and Dimbokro) and the new area (Daloa and Divo)

3.2.3 Search for correlation between rainfall and agricultural production

Correlation analysis between rainfall and agricultural production in both cocoa (Figures 5 a, b, c and d) growing areas reveal a weak correlation. The coefficients of correlation from the former cocoa growing area are 0.33 in Abengourou, 0.32 in Dimbokro and within the new cocoa growing area (-0.20) in Daloa and 0.11 in Divo. Therefore, we notice a similar evolution of rainfall and agricultural production within the three localities (Abengourou, Dimbokro and Divo) except Daloa.

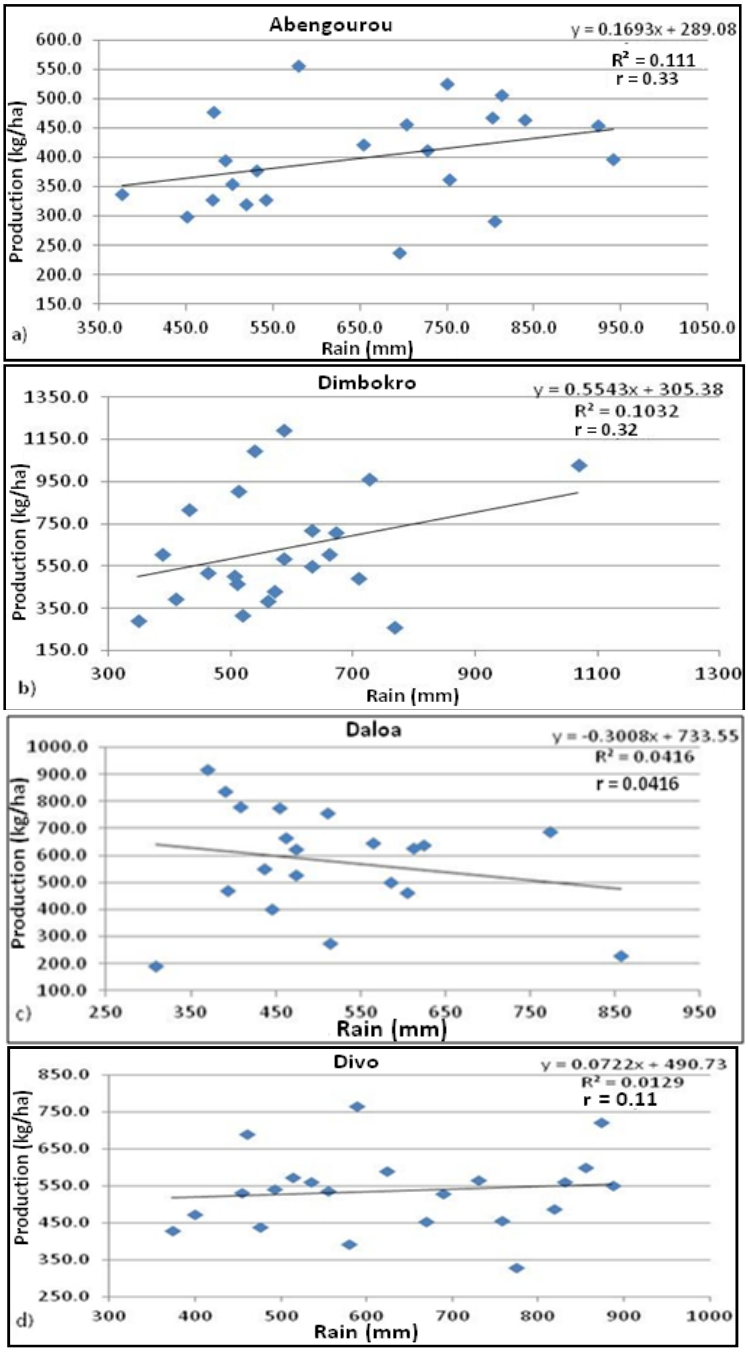


Figure 5: Relationship between rainfall and cocoa production within the former cocoa growing area: (Abengourou and Dimbokro) and the new area (Daloa and Divo)

3.2.4 Coefficicient of correlation significance

The calculated coefficient of correlation is weak and positive in Abengourou, Dimbokro and Divo except in Daloa. That means that the coefficient of correlation between rainfall and production is not statistically significant within the localities from the former and from the new cocoa growing areas (Table 1).

Table I : Significance Test for rainfall and cocoa productions within both areas

	coefficient of correlation (r)	Sampling size (n)	Degree of freedom (n-2)	Error α (%)	significance	
					Calculated test	test read
Abengourou	0.33	22	20	5	0.687	1.725
Dimbokro	0.32	22	20	5	1.569	1.725
Daloa	-0.20	20	18	5	1.512	1.734
Divo	0.01	22	20	5	1.424	1.725

IV DISCUSSION

The impact of rain variability about the new cocoa growing region from the former region was to verify the threshold of 700 mm during the rainy season and 70 mm during the dry season, on one hand, and on the other hand on the relation between rainfall and agricultural production. The threshold of 700 mm is reached on average to 33% within the former cocoa growing area and to 45% in the new cocoa growing area. From these results, cocoa production highlights a drop in production in the former cocoa growing zone, and a rise in the new cocoa growing area. Therefore, the lack of rain could be part of the noticeable causes in the shift in the new cocoa growing area.

The needs in water for cocoa tree are not fully set. As for the threshold of 70 mm during the dry season to ensure cocoa tree's survival, it reaches about 50% and more than 70% in the new zone. This condition for satisfaction for cocoa tree in the former cocoa growing zone confirms the disappearance of some orchards within the new cocoa growing area of the country.

The results from the relationships between rainfall and cocoa production indicate some coefficients of correlation which are comparatively weak within both cocoa growing areas and are not meaningful to a threshold of 5%. Similarly, [15] highlight the same results in their research studies within the central and northern areas of Côte d'Ivoire. Besides, their results have shown a relatively weak coefficient between agricultural production (maize and yam) and cultural seasons' period. Thus, [11, 16] confirm that climatic parameters partly control cocoa production. Despite the contribution of rain variability from the former cocoa growing area to the new one, many factors could be the reasons: it is the reliability of data from DSDI which do not take into account the real size of farms, enclosed localities, and varieties of cocoa grown and the channel of distribution which is not mastered well. The rain cannot show a real influence on a plant as rain is not always used for it. According to [15], the relationship between rain and agricultural production is not always linear. Moreover, rainfall is not uniform on a spatial basis from one locality to another and within the same locality. Consequently, the drop in rainfall is not the only factor for the fall of agricultural production within the former cocoa growing area. Other factors like: pedology (dampness and depth of soil) and techniques for agriculture (fertilizers, techniques for agriculture and maintenance of land) should not be left out. The climatic parameters are not the unique guarantee for a good cocoa production.

V CONCLUSION

The thrust of this paper was to determine the implication of rainfall as a factor in the shift from the former cocoa growing area to the new one from the east central to the west central regions. The conclusions from the different analyses are:

-cocoa production dropped in the former cocoa growing area and increased in the new area.

-rainfall threshold of 700 mm to easy cocoa production was reached on an average of 33% within the former cocoa growing area and 45% within the new one.

-the threshold of 70 mm required to permit cocoa's survival in dry season was reached at more than 50% in the two cocoa growing areas.

-the week correlation between rainfall and cocoa production shows that rainfall is not the only reason for drop in cocoa production.

-some other factors like: pedology, agronomy, parasitic pressures and cocoa varieties (sensitive or resistant) can impact production.

REFERENCES

[1]. N'Goran K., Réflexions sur un Système de Production Durable du Cacaoyer: Cas de la Côte d'Ivoire. Smithsonian museum, 8 p, 1998.

[2]. Affou Y. et Tano K., La boucle du cacao en Côte d'Ivoire : une situation migratoire inversée, Communication aux 3èmes journées démographiques de l'ORSTOM, Paris, vol. 12 p, 1988.

[3]. Assiri A. A., Kacou E. A., Assi F. A., Ekra K. S., Dji K. F., Couloud J. Y. et Yapo A. R. Rentabilité économique des techniques de réhabilitation et de replantation des vieux vergers de cacaoyers (*Theobroma cacao* L.) en Côte d'Ivoire. *Journal of Animal & Plant Sciences*, vol. 14, no. 2, pp. 1939-1951, 2012.

[4]. Brou Y. T. Climat, mutations socio-économiques et paysages en Côte d'Ivoire. Mémoire de synthèse des activités scientifiques (mémoire d'Habilitation à Diriger des Recherches). Université des Sciences et Technologies de Lille (USTL), 226 p, 2005.

[5]. Noufé D., Bruno L., Gil M., Eric S., Brou Y. T., Koli B. Z. et Chaléard J-L., Variabilité climatique et production de maïs en culture pluviale dans l'est Ivoirien. *Hydrological Sciences Journal*, vol. 6, no. 1, pp. 152-167, 2011.

[6]. Paturel J. E., Servat E., Kouamé B., Boyer J. F., Lubès H. et Masson J. M., Procédures d'identification de ruptures dans des séries chronologiques Modification du régime pluviométrique en Afrique de l'Ouest non sahélienne. *International Association of Hydrology Sciences*, vol. 234, pp. 99-110, 1996.

[7]. Soro T.D., Soro N., Oga Y.M.S., Lasm T., Soro G., Ahoussi K.E. et Biémi J. - La variabilité climatique et son impact sur les ressources en eau dans le degré carré de Grand-Lahou (Sud-Ouest de la Côte d'Ivoire). *Physio-Géo - Géographie Physique et Environnement*, vol. 5. no 5, pp. 55-73, 2011. DOI : 10.4000/physio-geo.1581.

[8]. Kouadio Z. A., Dynamique de l'occupation du sol et comportement hydrologique : cas des bassins versants côtiers de l'Agneby et du Boubo (Côte d'Ivoire). Thèse de doctorat de l'Université Nangui Abrogoua, Abidjan, Côte d'Ivoire (Option : géosciences et environnement), 167 p, 2011.

[9]. Yao A. B., Evaluation des potentialités en eau du bassin versant de la Lobo en vue d'une gestion rationnelle (centre-ouest de la Côte d'Ivoire). Thèse de doctorat de l'Université Nangui Abrogoua, Abidjan, Côte d'Ivoire, 193 p, 2015.
[10]. Dian B., Aspect géographique du binôme café-cacao dans l'économie ivoirienne, *Nouvelles Editions Africaines*, Abidjan-Dakar, 95 p., 1978.
[11]. Kouakou K. E., Impacts de la variabilité climatique et du changement climatique sur les ressources en eau en Afrique de l'Ouest : Cas du bassin versant de la Comoé. Thèse de doctorat de l'Université Nangui Abrogoua, Abidjan, Côte d'Ivoire (Option : géosciences et environnement), 186p, 2011.
[12]. Mian k. A., Contribution à l'analyse agro-climatique de la zone de culture du cacaoyer en Côte d'Ivoire. Mémoire d'ingénieur en agro-météorologie. Centre régionale Agrhymet, 100 p, 2007.
[13]. Kassin K. E., Doffangui K., Kouamé B., Yoro R. G. et Assa A. (2008). Variabilité pluviométrique et perspectives pour la replantation cacaoyère dans le Centre Ouest de la Côte d'Ivoire. *Journal of Applied Biosciences*, vol. 12, pp. 633 - 641.
[14]. Dagnelie P., *Théorie et méthodes statistiques: Applications agronomiques*. Les presses agronomiques de Gembloux, Belgique, Tome I, 2ème édition, 378p., 1984.
[15]. Noufé D., Kouadio Z. A., Soro G. E., Wayou P. T., Goula B. T. A. et Savané I., Impact de la variabilité climatique sur la production de maïs et de l'igname en zone centre et nord de la Cote d'Ivoire. *Agronomie Africaine, vol.* 27 no.3, pp. 241-255, 2015.
[16]. Kanohin F., Saley M. B., Aké G. E. et Savané I., Variabilité climatique et productions de café et cacao en zone tropicale humide : cas de la région de Daoukro (Centre-est de la Côte). International Journal of Innovation and Applied Studies, vol. 1, no. 2, pp. 194-215, 2012.

Kouadio Zilé Alex. " Scope Of Rainfall Variability In The Shift Of The Cocoa Growing Area From The East Central Region To The Central West Of Cote D'ivoire ”American Journal of Engineering Research (AJER), vol. 7, no. 5, 2018, pp.272-280.