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Factors Influencing the Density of Termite Mounds on Agricultural Land: An Evidence from the Pendjari Region (North-Benin)

Georges Pascal Codjovi Ogoudedji[1], Jacob Afouda Yabi[2], Rosaine Nerice Yegbemey[3]

[1] Laboratoire d'Analyses et de Recherches sur les Dynamiques Economiques et Sociales (LARDES), Universite de Parakou, Republique du Benin,

[2] Laboratoire d'Analyses et de Recherches sur les Dynamiques Economiques et Sociales (LARDES), Universite de Parakou, Republique du Benin

[3] Laboratoire d'Analyses et de Recherches sur les Dynamiques Economiques et Sociales (LARDES), Universite de Parakou, Republique du Benin

Abstract – In north Benin in general and particulary in the Pendjari region, smallholder farmers earn low incomes because their agricultural production has been confronted with both soil fertility declining and expensive chemical fertilizers. So they may find alternative to chemical fertilizer to mitigate the decline of the soil fertility. Then termite fertility effect becomes an option free of charge to be explored by the farmers. The objective of this study is to assess factors affecting the density of termite mound on a crop plot. For this purpose, a Hierarchical Multiple Regression (HMR) was estimated by using empirical data collected in the villages of Batia and Dassari in Tanguiéta and Matéri Districts, respectively. The sampling was in random, including 382 crop plots belonging to 152 farmers. The analysis revealed that the density of termite mound on a crop plot is mainly affected by the farming system data than the personal data. So, it appears important to advise farmers on termite mound fertility effect and management of termite mounds density on agricultural lands as a measure to improve soil fertility.

Keywords – Hierarchical Multiple Regression, Determinant, Factor, Termite, Pendjari, Benin.

I. Introduction

In Benin, agriculture is a major economic activity that contributes for about 37.9% to the GDP and is the source of income for nearly 70% of the country's labor force (PNUD, 2015). This sector which has to feed the urban population in permanent growth is characterized by its vulnerability to climate change and his low productivity. Nowadays, the main difficulty of the farmers in the Pendjari region in North-Benin is the decline of soil fertility. In consideration of the expensiveness of chemical fertilizer and the low level of the smallholder farmer's income it is possible to explore the conservation agriculture. One of the effective solutions available driving at conservation agriculture is the organic option which could satisfy simultaneously the low income state of the farmers and the improvement of soil fertility. Within the organic option, there is the fertility effect of the termite mounds. The Pendjari region, inside and outside the park, shows a particular richness in termites mounds. But this richness has been declining over the last decades. Termite fertility effect is an option free of charge which farmers can explore. Indeed, numerous ecosystem services are delivered by termites. Termites influence soil resource availability (Dangerfield, McCarthy, Ellery, 1998; Jouquet, Dauber, Lagerlo, Lavelle, Lepage, 2006). Soil nutrients concentrated

Corresponding Author: Georges Pascal Codjovi Ogoudedji

in the mounds by the termites are transferred to the soil through leaching (Congdon, Holt, Hicks, 1993). However, there are very few studies that investigated on termite mound in Benin and none of them addressed the factors influencing the termite mound population (Saliou, 2005; Nouhoheflin, 2006; Dossou-Yovo, 2007).

In the literature, many factors are found to influence the environmental resources degradation. Among these, one distinguish human factors depending on human activities, political factors depending on local, national or international political decisions and physical factors out off human control. Regarding human factors, the deforestation for agricultural goals, the importance of pastoralism, the irrigation of the agricultural land, the agricultural policy and the annual bush fire are shown to be the causes of environmental degradation which all consist in the land use depending on human actions (Southgate, 1990; Barbier, 2000; Feoli, Vuerich, Zerihun, 2002; Scherr, 2000). Recently, studies added factors to the list of human factors. A study in the Northern Benin has highlighted two determinants of natural resources degradation, the resource location and the ethnic affiliation of the population (Heubach, Wittig, Nuppenau, Hahn, 2013). Additionaly, study in Vietnam added to the factors, the neighboring forest which induce less land degradation in agriculture (Vu, Le, Frossard, Vlek, 2014). Regarding political factors, they cover a large range of measures. Indeed, a large number of studies have linked the environmental degradation to the poverty (Pinto, Coronel and Conte, 2014; Scherr, 2000; Duraiappa, 1998; Kelly and Gitinji, 1994) and the economic growth (Akpan and Chuku, 2011; Baland, Bardhan, Das, Mookherjee and Sarkar, 2006) in Least Developed Countries. But, some of the derived conclusions are somewhat surprising. Indeed, poverty is consistently associated with lower deforestation while deforestation in turn is associated with higher economic return to agriculture and pasture (Ferretti-Gallon and Busch, 2014). On the other hand, for Kelly and Gitinji (1994), the poor accepts high levels of pollution but poverty is associated with lower deforestation (Ferretti-Gallon and Busch, 2014) the linkage between the environmental degradation factors and the migration flows and the population are shown (Afifi and Warner, 2008; Zaman, Khan, Khan, Saleem, Nawaz, 2011). A linkage is established between public policy in term of social, economic and demographic policies and the environmental performance using cross-country data from low, middle and high-income countries (Grafton and Knowles, 2004).

Finally, the key factor for environmental resource conservation is the political factor which normally may influence all the other factors (human and physical) to follow the desired trends.

Thus, this study aims at contributing to the understanding of the factors influencing the density of termite mound on a crop plot (key indicator of environmental degradation), based on empirical data collected in the Pendjari region at the Northern part of Benin. It addresses more the human factors than the physical and political factors of environmental degradation.

II. Material And Methods

2.1 Study area

The Reserve of Biosphere of Pendjari (RBP) is located in the departement of Atacora (North-West of Benin) including the municipal areas of Materi, Tanguieta and Kerou (Figure 1). The area is located between 10°30’ and 11°30’ latitude North and 0°50’ and 2°00’ longitude East (Vodouhe, Adegbidi, Coulibaly and Sinsin, 2011). It is located in the north soudanian zone with a unimodal rainy season ranging from 750 to 1100 mm per year from which 60% falls between july and September. The rainy season begins in April, followed by a dry season from November to March (Montcho, Chikou, Lalèyè and Linsenmair, 2011). The geology of the area confers three (3) types of soils: the ferruginous tropical soils washed or less washed, hydromorph with intrusion of soils ferruginous tropical washed highly concretionned, the ferruginous tropical soils washed hydromorph on schist made of quartz or without concretion on micaschist made of quartz, and the soils boarding the rivers with alluvial contributions hydromorphic in fine sand material (Faure, 1977). The landscape is a width peneplain with an altitude between 150 and 513 m (Nago, Amahowe, Zannou, Houessou, Ahononga, N’Séra, Kouton, Kidjo, Sahilou and Sinsin, 2016). The only one river in the RBP is the Pendjari River (Houinato and Sinsin, 2000) with a total length of about 380 km. The vegetation, typically soudanian, is a mixture of open grass interspersed with tree savannahs and the forest vegetations (Verschuren, 1988; Oumorou, Natta, Adomou and de Foucault, 2013).

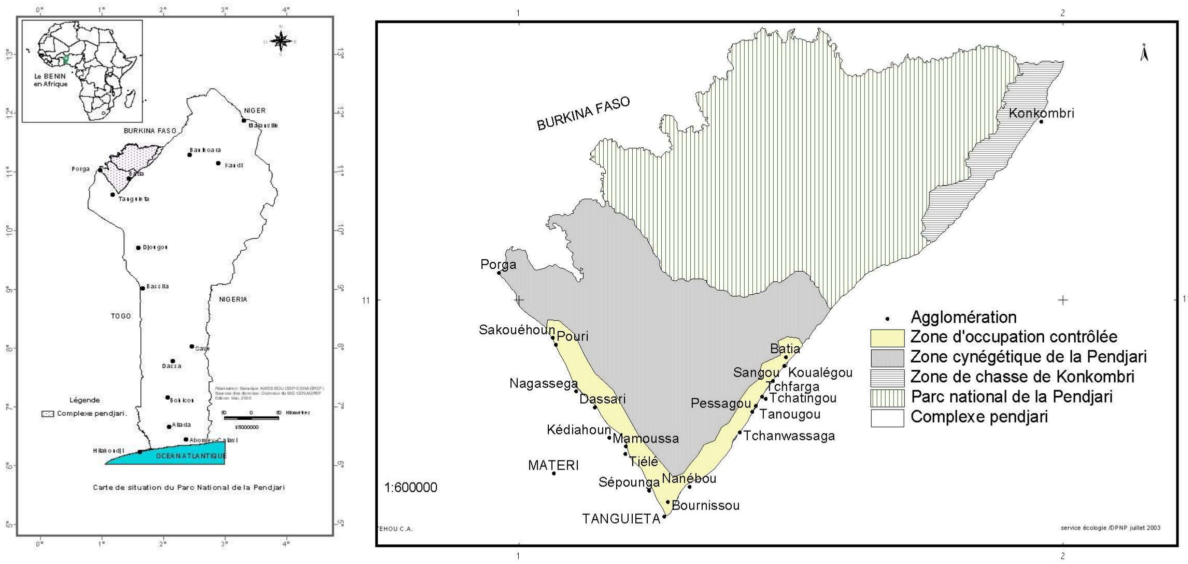

Fig. 1. Map of the Reserve of Biosphere of Pendjari

2.2 Sampling and data collection

The field research was conducted in the villages of Batia and Dassari in Tanguiéta and Matéri Districts, respectively. Data were collected three times. First, a sample of 36 farm households was selected in each village in 2009. This sample was completed with 40 more farm households per village in 2010. So, data were collected between 2009 and 2010 in the two villages and from 152 farmers, respectively 76 farmers in each village. Finally, the sampling was been in random including 382 crop plots belonging to the 152 farmers.

Data collected in this study concern the 382 crop plots and are related to (i) the farming system_data: appreciations on soil structure, soil slope and scale of fertility (ranking by farmers), land property, crops acreages, fallow duration, existence of cotton in the rotation, practice of bush fire for soil preparation and use of chemical products on the plot, village status (village position according to the main road) , density of termite mound (is collected directly on farm. On each crop plot, all the emerged termite mounds (height more than 0.5 meter) are registered) and (ii) the personal data: age, gender, education level, non-agricultural income of the farmer.

2.3 Model specification

In order to analyse factors affecting the density of termite mound on the plots, a multiple linear regression was used. Multiple regression is used to explore the relationships between set of independent variables or predictors and one dependent variable (usually continuous). There are two major types of multiple regression that could be used in the frame of this study: the standard multiple regression and the hierarchical multiple regression. The standard multiple regression is used to identify the personal data which affect the density of termite mound and the hierarchical multiple regression to identify the farming system data which affect the density of termite mound because the order of entry of the variables in the model is determined by the researcher himself.

2.3.1. Hierarchical multiple regression (HMR)

Hierarchical multiple regression approach is most of the time used in behavioral research. Its best description is made by Lewis (2007). In a hierarchical multiple regression:

- Independent variables are entered into equation in the order specified by the researcher based on theoretical grounds;
- Independent variables are entered in steps (blocks);
- Each independent variable is assessed in terms of what it adds to the prediction of dependent variable after the previous independent variables have been controlled for.

- Overall model and relative contribution of each block of variables is assessed

Hierarchical multiple regression is a popular method used to analyze the effect of a predictor variable after controlling for other variables. Hierarchical regression is a sequential process involving the entry of predictor variables into the analysis in steps. Unlike stepwise regression, the order of variable entry into the analysis is based on theory (Lautenschlager and Mendoza, 1986). Instead of letting a computer software algorithm "choose" the order in which to enter the variables, these order determinations are made by the researcher based on theory and past research. This "control" process is achieved by calculating the change in the adjusted R^2 at each step of the analysis, thus accounting for the increment in variance after each variable (or group of variables) is entered into the regression model (Lewis, 2007).

The current research uses the hierarchical multiple regression approach to identify the farming system data which affect the density of termite mound because a lot of field works have proved the termites role in soil structure improvement (Dangerfield, McCarthy, Ellery, 1998; Jouquet, Dauber, Lagerlo, Lavelle, Lepage, 2006; Congdon, Holt, Hicks, 1993). The dependent variable is the mound density and the predictors are the soil structure (***soilstru***), the soil slope (***soilslop***), the level of fertility of the soil (***soilfert***), the fallow duration (***fallow***), the land property right (***land***), the existence of cotton in the rotation (***cotton***), the use of chemical products on the plot (***chemical***), the crop acreage (***acr_crop***), practice of bush fire for soil preparation (***bush_fire***) and the village status (***village***). Accordingly, the mathematical empirical model describing the mound density for the i^{th} crop plot is:

$$tm_i = b_0 + b_1 soilstru_i + b_2 soilslop_i + b_3 soilfert_i + b_4 cotton_i + b_5 fallow_i + b_6 land_i + b_7 acr\_crop_i + b_8 bush\_fire_i + b_9 chemical_i + b_{10} village_i + \mu_i$$

Where the *b are the parameters to be estimated* and *μ the error term*.

III. RESULTS

3.1 DESCRIPTIVE STATISTICS

Descriptive statistic of personal data

The personal data concerned are the total acreage hold by the farmer, the non-agricultural income amount, the main activity of the farmer, the gender and the educational level.

Total acreage and non-agricultural income

The mean value of the acreage hold by a farmer in the sampling is about 3.17 ha, the maximum is 10 ha when the minimum is 0.5 ha (Table 1). The mean value of the income coming out of agriculture is estimated at 268 250 fcfa with a maximum of 2 000 000 fcfa.

Table 1. Distribution of the Farmers According to the Total Acreage and the Non-Agricultural Income Amount

Variables	Minimum	Maximum	Mean	Std. Deviation
Total acreage of the farmer (ha)	0.5	10	3.17	1.94
Non-farm income of the farmer (FCFA)	0	2000000	268250	367132

Main activity, Gender and Education

In the sampling, most of the farmer's (85.5%) main activity is agriculture when only 12.5% work in the private sector and 2% are civil servant. Seemingly, most of the farmer (82.9%) are men. In addition, half of the farmer (50.7%) have no formal education level with 31.6% having the primary education level 17.1% having secondary education level and only 0.7% having post-secondary education level (Table 2).

Table 2. Distribution of the Farmers according to the Main Activity, the Gender and the Education Level

Variable		Frequency	Percent	Cumulative Percent
Activity	Civil servant	3	2.0	2.0

	Private job	19	12.5	14.5
	Agriculture	130	85.5	100.0
	Total	152	100.0	
Gender	Female		17.1	17.1
	Man		82.9	100.0
	Total		100.0	100.0
Education level	no formal education	77	50.7	50.7
	primary	48	31.6	82.2
	secondary 1	21	13.8	96.1
	secondary 2	5	3.3	99.3
	university	1	.7	100.0
	Total	152	100.0	

Descriptive statistics of farming system data

1.1.1 Land property, soil characteristics, bush fire, village position, crop acreage and fallow

Within the sampled crop plots, Table 3 presents the distribution of plots according to the land property, the soil characteristics, the farming practices and village position according to the main road. The land property is 45.3% a personal property and at 54.7% a no personal property. As regard to the soil characteristics, 55.5% of the crop plots' soil are sandy soil, 29.3% are on ferruginous soil when 15.2% are on vertisol. Two variables (soil slope and soil fertility level) are grouped in tree classes. The class "Low" concern the values lower than 2, "Middle" is for the values which are lower or equal to 3 and higher or equal to 2 (in the interval class [2,3] and "High" is the class of values higher or equal to 4. The table 1 shows that for the majority of plots are in the middle class for the soil slope (71.2%) and for the soil fertility level (69.4%).

As regard to rotation on the crop plots, 36.9% of the crop plots have hosted cotton in their rotation during the last 5 years. The bush fire is practiced on 52.1% of the crop plots when chemicals products are used on 45% of the crop plots. As regard to the village status, 53.1% of crop plots are in a remote village and 46.9% in road village.

The crop acreage goes from 0.25ha to 6ha and the mean to all the plots is 1,27ha. The fallow duration goes from 1 year to 15 years and the mean to all the plots is 4.21 years (Table 4).

Table 3. Distribution of the Crop Plots according to the Land Property, the Soil Characteristics, the Farming Practices and the Village Position according to the Main Road

Characteristics	Modality	Frequency	Percent	Cumulative Percent
Land property	Personal property	173	45.3	45.3
	No Personal property	209	54.7	100.0
Soil structure	Ferruginous soil	112	29.3	29.3
	Vertisol	58	15.2	44.5
	Sandy soil	212	55.5	100
Soil slope	Low	44	11.5	11.5
	Middle	272	71.2	82.7
	High	66	17.3	100
Soil fertility level	Low	12	3.1	3.1
	Middle	265	69.4	72.5
	High	105	27.5	100
Cotton in the	Yes	141	36.9	36.9

Characteristics	Modality	Frequency	Percent	Cumulative Percent
rotation	No	241	63.1	100.0
Bush fire practice	Yes	199	52.1	52.1
	No	183	47.9	100.0
Use of chemicals Products	Yes	172	45.0	45.0
	No	210	55.0	100.0
Village status	Remote village	203	53.1	53.1
	Road village	179	46.9	100.0

Table 4. Mean Values of the Crop Acreage and the Fallow Duration

Characteristics	Crop acreage	Fallow duration
Minimum	0.25	1
Maximum	6	15
Mean	1.27	4.21
Standard deviation	1.02	3.06

3.2 PREDICTORS AND THE HYPOTHESIS EFFECTS

Through the present research, we cannot look for cause-effect relationships because we have not manipulated any of the variables and also because all the variables have been measured at the same point in the same time (Chan. 2003). Accordingly, we perform correlational analysis, especially hierarchical multiple regression analysis. The variables are entered in the regression model in an order determined by the past researches and expectations. So, for our analysis the variables are entered in so called blocks.

Block 1: the first block contains any predictors we expect to predict the termite mound density. These variables should be entered using *forced entry*. Only the variables related to soil characteristics (soil structure, soil slope, soil fertility level) are expected to predict theoretically the density of termite mound following the past research results.

Block 2: the second block contains the other predictors that we don't expect theoretically to predict the termite mound density. They are related to: farming practices (fallow duration, land property, cotton in the rotation, crop acreage, bush fire and use of chemicals products on the plot) and the village position. These variables should be entered using *forced entry* with the variable of block 1.

Based on the results of the past researches, it is expected that termite activity influences positively the soil fertility and other characteristics (soil stcruture and soil slope) and inversely the soil characteristics having positive impact on the termites activity (Dangerfield, McCarthy, Ellery, 1998; Jouquet, Dauber, Lagerlo, Lavelle, Lepage, 2006). As environmental resource, termite mounds may be subject to degradation as all the environmental resources through deforestation for agricultural needs (de Vliegher, 1993).

The table 5 presents the different predictors and their hypothesis effects on the density of termite mound.

Table 5. Predictors and the Hypothesis Effects on the Density of Termite Mound

Variable name	Variable category	Variable definition and codes	Hypothesis effect
soilstru	Farming system data	Soil structure (Ferruginous soil =0, Vertisoil = 1, Sandy soil = 2)	(-)
soilslop	Farming system data	Soil slope (Low = 1, Middle = 2, High = 3)	(-)

soilfert	Farming system data	Soil level of fertility (Low = 1, Middle = 2, High = 3)	(+)
cotton	Farming system data	Conventional cotton in the rotation on the crop plot (No = 0, Yes= 1)	(-)
fallow	Farming system data	Fallow duration (in years)	(+)
land	Farming system data	Land property right (Personal property =0, No personal property = 1)	(-)
acr_crop	Farming system data	Crop acreage (in hectare)	(+)
bush_fire	Farming system data	Practice of bush fire on the plot (No= 0, Yes= 1)	(-)
chemical	Farming system data	Use of chemicals products on the plot (No= 0, Yes= 1)	(-)
village	Personal data	Village status (Remote village = 0, Road village =1)	(-)
nainc	Personal data	Non-agricultural income (in fcfa)	(-)
school	Personal data	Education level (in years)	(+)
acr_tot	Personal data	Total acreage (in hectare)	(+)
gender	Personal data	Gender (0=woman, 1=man)	(-)
activity	Personal data	Activity of the farmer (0= civil servant, 1=private job, 2=agriculture)	(+)

3.3 CORRELATION ANALYSIS

The correlation coefficient is a number between -1 and 1 that indicates the strength of the linear relationship between two variables (Taylor, 1990). There are two main types of correlation coefficients: Pearson's product moment correlation coefficient and Spearman's rank correlation coefficient. Pearson's product moment correlation coefficient is denoted as ρ for a population parameter and as r for a sample statistic. It is used when both variables being studied are normally distributed. This coefficient is affected by extreme values, which may exaggerate or dampen the strength of relationship, and is therefore inappropriate when either or both variables are not normally distributed. Spearman's rank correlation coefficient is denoted as ρ_s for a population parameter and as r_s for a sample statistic. It is appropriate when one or both variables are skewed or ordinal and is robust when extreme values are present. The two coefficients require the same interpretation**.** For the analysis the classification adopted is taken from Taylor (1990) and Ratner (2009) as follow: the absolute values ≤ 0.3 are generally considered to represent low or weak correlations, 0.3 to 0.7 modest or moderate correlations, 0.7 to 1.0 strong or high correlations with r coefficients ≥ 0.9 very high correlations.

Table 6. Correlation Coefficients of Spearman

Variables	village	soilstru	soilfert	soilslop	cotton	bush_fire	chemical	land	fallow	acr_crop
village	1.000	0.367**	0.022	0.128*	-0.620**	-0.024	-0.133**	0.127*	-0.055	0.103*
soilstru	0.367**	1.000	-0.142**	0.071	-0.266**	-0.047	-0.070	-0.096	0.174**	-0.142**
soilfert	0.022	-0.142**	1.000	0.029	0.026	0.011	-0.016	0.055	-0.197**	0.095

soilslop	0.128*	0.071	0.029	1.000	-0.099	-0.003	0.024	0.081	0.059	0.075
cotton	-0.620**	-0.266**	0.026	-0.099	1.000	0.212**	0.191**	-0.089	0.084	0.120*
bush_fire	-0.024	-0.047	0.011	-0.003	0.212**	1.000	0.120*	0.212**	-0.116*	-0.026
chemical	-0.133**	-0.070	-0.016	0.024	0.191**	0.120*	1.000	0.242**	-0.167**	0.172**
land	0.127*	-0.096	0.055	0.081	-0.089	0.212**	0.242**	1.000	-0.209**	0.165**
fallow	-0.055	0.174**	-0.197**	0.059	0.084	-0.116*	-0.167**	-0.209**	1.000	0.100
acr_crop	0.103*	-0.142**	0.095	0.075	0.120*	-0.026	0.172**	0.165**	0.100	1.000

**. Correlation is significant at the 0.01 level

*. Correlation is significant at the 0.05 level

The table 6 shows the Spearman's rank correlation coefficients between the predictors of the model. Positive and modest correlation is found significant between village location and soil structure (+0.367) when negative and modest correlation is found significant between village status and the existence of conventional cotton in the rotation the last five years (-0.620); negative and low correlation is found significant between village status and the use of chemical products by the farmer (-0.133). Negative and low correlation is found significant between the soil structure and the soil fertility level (-0.142), between the soil structure and the existence of conventional cotton in the rotation the last five years (-0.266), and between the soil structure and the crop acreage. Positive and low correlation is found significant between the soil structure and the fallow duration (+0.174). Negative and low correlation is found significative between the soil level of fertility and the fallow duration (-0.197). Negative and moderate correlation is found significative between the existence of conventional cotton in the rotation the last five years and the village status (-0.620). Negative and low correlation is found significative between the existence of conventional cotton in the rotation the last five years and the soil structure (-0.266). Positive and low correlation is found significative first between the existence of conventional cotton in the rotation the last five years and the practice of bush fire (+0.212) and second between the existence of conventional cotton in the rotation the last five years and the use of chemical products (+0.191). Positive and low correlation is found sigificative between the practice of bush fire and the land tenure (+0.212). Positive and low correlation is found significative first between the use of chemical products and the land tenure (+0.242) second between the use of chemical products and crop a acreage (+0.172). Negative and low correlation is found significative between the use of chemical products and the fallow duration (-0.167). Negative and low correlation is found significative between the land tenure and the fallow duration (-0.209) when positive and low correlation is found significative between the land tenure and the crop acreage (+0.165).

Finally, the Spearman's rank correlation coefficient analysis shows low correlation between the descriptive variables of the model excepted the village status, the soil structure and the existence of cotton in the rotation during the last five years which correlations are found moderate.

3.4 Determinants of the density of termite mounds on a crop plot

Farming system data

The farming system data effects on termite mound density are explored through the hierarchical multiple regression analysis. The results are as follow.

Model summary

Table 7. Model Summary

Model	R Square	Adjusted R Square	Durbin-Watson
1	0.062	0.055	1.438
2	0.237	0.217	1.608
3	0.126	0.096	1.950

The model summary contains two (2) models (Table 7, Models 1 and 2). Model 1 refers to the first stage of the hierarchy when only soil characteristics variables are used as predictors. Model 2 refers to the second stage of the hierarchy when the others predictors related to farming practice and ecological data are added to the soil characteristics variables. The value of R^2 is the measure of much in the variability in the density of termite mound, is accounted for by the predictors. For the first model, its value is 0.062 which means that soil characteristics variables (soil structure, soil slope and soil fertility level) accounts for 6.2% of the variation of the density of termite mound. For the second model its value increases to 0.237 which means that predictors related to farming practice data accounts for 17.5% (0.237 – 0.062) of the variation of density of termite mound (Petrocelli, 2003; Tabachnick and Fidell, 2007).-The adjusted R^2 gives us an idea on how well our model generalizes and ideally we would like its value to be the same or very close to the value of R^2. For our last model, the difference between the values of R^2 and adjusted R^2 is 0.02 (0.237 – 0.217 = 0.02) and means that if the model were derived from the population instead of the sample it would account for approximately 2% less variance in the density of termite mound. The value of Durbin-Watson coefficient is 1.608 ≈ 2. One can conclude that no correlation (spatial autocorrelation) exists within the error terms of the model.

Analysis of variance (ANOVA)

Table 8. Anova

Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	79.662	3	26.554		
	Residual	1201.461	378	3.178	8.354	0.000a
	Total	1281.123	381			
2	Regression	303.847	10	30.385		
	Residual	977.276	371	2.634	11.535	0.000b
	Total	1281.123	381			

a. Predictors: (Constant), soilslop, soilfert, soilstru

b. Predictors: (Constant), village, bush_fire, soilfert, soilslop, acr_crop, chemical, fallow, land, soilstru, cotton

c. Dependent Variable: tm

ANOVA(b)						
Model			**Sum of square**	**ddl**	**F**	**Sig.**
	3	Regression	40.460	5	4.203	.001a
		Residual	281.060	146		
		Total	321.520	151		

a. Predictors : (constants), activity1, acr_tot, gender_, school, nainc

b. Dependent Variable: tm_farmer

The analysis of variance (ANOVA) tests whether the model is significantly better to predict the density of termite mound than using the mean as a best guess. Especially the *F-ratio* represents the ratio of the improvement in prediction that results from fitting the model (labeled *regression* in the table 8) relative to the inaccuracy that still exists in the model (labeled residual in the table 8). This table is split in two sections, one for each model (Models 1 and 2, Table 8).

If the improvement due to fitting the model is much greater than the inaccuracy within the model then the value of *F* is greater than 1 and the SPSS calculates the exact probability of obtaining the value of *F* by chance. For all the two models, the F-ratio are respectively 11.54 and 8.35 which are very unlikely to happened by chance ($p < 0.001$). We can interpret these results as meaning that the final model improves our hability to predict the value of the density of termite mound.

Model parameters

Table 9. Model Parameters

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta (β)	t	Sig.
1	(Constant)	1.889	0.337		5.597	0.000
	soilstru	-0.502	0.105	-0.242	-4.794	0.000
	soilslop	0.112	0.172	0.032	0.650	0.516
	soilfert	0.128	0.186	0.035	0.688	0.492
2	(Constant)	3.048	0.389		7.827	0.000
	soilstru	***-0.322***	***0.106***	***-0.155***	***-3.036***	***0.003***
	soilslop	0.277	0.158	0.081	1.748	0.081
	soilfert	0.185	0.171	0.050	1.078	0.282
	cotton	0.270	0.236	0.071	1.146	0.253
	fallow	***-0.075***	***0.030***	***-0.125***	***-2.518***	***0.012***
	land	-0.254	0.184	-0.069	-1.386	0.167
	acr_crop	***-0.353***	***0.086***	***-0.197***	***-4.128***	***0.000***
	bush_fire	-0.114	0.178	-0.031	-0.638	0.524
	chemical	***-0.732***	***0.181***	***-0.199***	***-4.041***	***0.000***
	village	***-0.941***	***0.235***	***-0.256***	***-4.009***	***0.000***

Coefficients(a)

Model		Unstandardized Coefficients B	Standard Error	Standardized Coefficients Beta	t	Sig.
3	(Constante)	3.072	.663		4.631	.000
	gender_	-.409	.321	-.106	-1.274	.205
	school	-.015	.034	-.041	-.455	.650
	acr_tot	-.181	.061	-.240	-2.966	.004
	nainc	-6.437E-7	.000	-.162	-1.807	.073
	activity	-.563	.305	-.167	-1.847	.067

a. Dependent Variable: *tm_farmer*

We are interested in the second model (Model 2) because it includes all predictors that make a significant contribution to predicting the density of termite mound. In a multiple regression, the model takes the form of an equation that contains a coefficient (***b***) for each predictor. The unstandardized coefficients give us estimates of these (***b***) values and these values indicate the individual contribution of each predictor to the model. The ***b*** values tell us about the relationship between the outcome and the predictors and to what degree each predictor affects the outcome if the effects of all the others are held constant. Each of these ***b*** values has an associated standard error indicating in what extent these values would vary across different samples and these standard errors are used to determine whether or not the ***b*** value differs significantly from zero (using the *t-statistic*). Therefore, if the *t-statistic* associated with a ***b*** value is significant (if the value in the column labeled *Sig.* is less than 0.05) then the predictor is making a significant contribution to the model. The smaller the value of *Sig.* (and the larger the value of *t*) is, the greater the contribution of that predictor is. For the second model of the table 9, the soil structure $t\ (382) = -\ 0.322$, $p < 0.01$; the fallow duration $t\ (382) = -\ 0.075$, $p < 0.05$; the crop acreage, $t\ (382) = -\ 0.353$, $p < 0.001$; the use of chemical products on the plot, $t\ (382) = -\ 0.732$, $p < 0.001$ and the village status $t\ (382) = -\ 0.941$, $p < 0.001$ are significant predictors of the density of termite mound. From the magnitude of the *t-statistic* we can remark that the village status has slightly the most impact on the density of termite mound in the case of this study.

The ***b*** values (unstandardized coefficients) and their significance are important statistic to look at; however the standardized coefficients are easier to interpret because they are not depend on the units of measurement of the predictors. The standardized values tell us the number of the standard deviations that the outcome will change as a result of one standard deviation change in the predictor. The standardized values ***β*** are all measured in the unit of the standard deviation and so are directly comparable. Therefore they provide more insight into the importance of a predictor in the model. The standardized values for the predictors are - 0.155, -0.125, - 0.197, - 0.199 and - 0.256 respectively for soil structure, the fallow duration, the crop acreage, the use of chemical products on the plot and the village status. This result confirms that village status has more impact in the model.

Farmer characteristics

The personal data effects on the density of termite mound are explored through the simple multiple regression analysis.

Model summary

For the simple multiple regression model (Model 3, Table7), its value is 0.126 which means that the farmer characteristics (education level, non-agricultural income, total acreage, gender and first activity) accounts for 12.6% of the variation of the density of termite mound. The difference between the values of R^2 and adjusted R^2 is 0.02 (0.126 – 0.096 = 0.03) and means that if the model were derived from the population instead of the sample it would account for approximately 3% less variance in the density of termite mound.

The value of Durbin-Watson coefficient is 1.950 ≈ 2 (Table 7, Model 3). One can conclude that no correlation (spatial autocorrelation) exists within the error terms of the model.

Analysis of variance (ANOVA)

The analysis of variance (ANOVA) tests whether the model is significantly better to predict the density of termite mound than using the mean as a best guess. Especially the *F-ratio* represents the ratio of the improvement in prediction that results from fitting the model (labeled *regression* in the table 13) relative to the inaccuracy that still exists in the model (labeled *residual* in the table 14). For our simple multiple regression model, the F-ratio is 4.203 which is very unlikely to happened by chance ($p < 0.05$).

Model parameters

For our simple multiple regression model of the table 9 (Model 3), the total acreage $t\ (152) = -\ 2.966$, $p < 0.01$ is the significant predictor of the density of termite mound. The standardized value for the predictor ***acr_tot*** is - 0.240.

IV. Discussion

The determinants of the density of termite mounds are analyzed throught two ways; first one determine the scale of contribution of the predictors to the explanation of the variation of the density of termite mound, and second one determine the predictors that influence the density of termite mound.

According to the scale of contribution to the explanation of the variation of the density of termite mound, the farmer characteristics (education level non-agricultural income, total acreage, gender and first activity) account for 12.6% of the variation of the density of termite mound, when the soil characteristics (soil structure, soil slope and soil fertility level) account for 6% of the variation of the density of termite mound and the predictors related to farming practices data account for 17.5% of the variation of density of termite mound. Finally, all the predictors of the model account for 36.1% of the variation of the termite mound and the farming practices and the farmer characteristics explain more the variation than the soil characteristics. The Farming practices and the personal data account respectively for the three times and the twice of the termite mounds density variations explaned by the soil characteristics.

The current research identifies statistically significant relationships between the density of termite mound on a crop plot and the plot soil structure, the fallow duration, the crop acreage, the total acreage of the household, the use of chemical fertilizer and chemical pesticide on the plot and the village status.

As referred to tables 5 and 9, the research hypothesis are confirmed for the soil structure (**B** = -0.322), the use of chemical products (**B** = -0.732) and the village status (**B** = -0.941) when they are rejetted for the farmer total acreage (**B** = -0.181), the crop acreage (**B** = -0.353) and the fallow duration (**B** = -0.075).

The current discussion after analyzing the scale of density of termite mound encountered in the Pendjari region focuses on the analysis of each of the determinants of the density of termite mounds.

4.1 Termite mound abundance on the agricultural lands in the Pendjari region

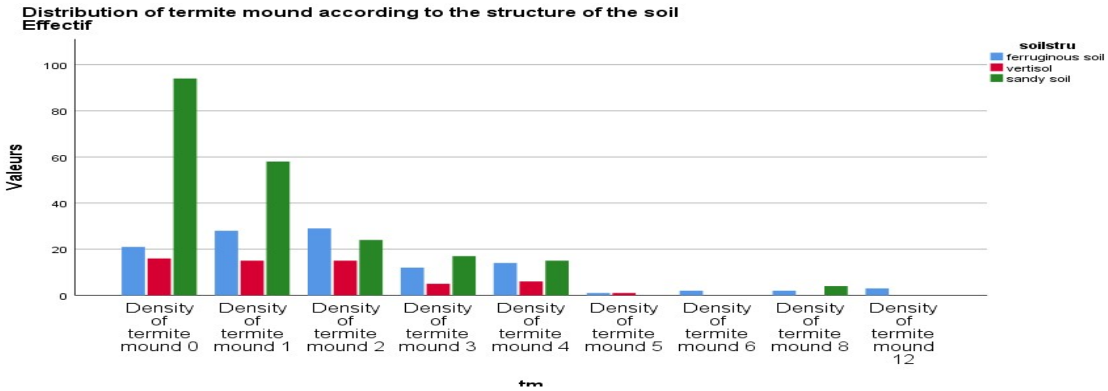

Fig. 2. Distribution of the Termite Mounds according to the Soil Structure

The mean value of termite mound density in the Pendjari region is 1.53 per hectare on agricultural land, varying from 0 to 12 mound per hectare with more concentration between 0-4 mounds per hectare (Figure 2). This result is not so far from the one found in Uganda where the densities are ranged from 0 to 8 mound per hectare with more concentration between 0-4 mounds per hectare (Pomeroy. 1977). The work undertaken by Grohmann, Oldeland, Stoyan, and Linsenmair (2010) in the central Namibian Savannah on the relationship between the densitiy of termite mound and the soil properties derived a mean density around 4.8 mounds per hectare. The recent work in the Katanga, D. R. Congo generated density of *Macrotermes* termite mound ranging from 2.6 to 3.1 mounds per hectare (Mujinya, Adam, Mees, Bogaert, Vranken, Erens, Baert, Ngongo, Van Ranst, 2014) in perfect agreement with the one discover in the Pendjari region.

In South Africa savanna, the sensity of termite mounds turn around 0.42 to up to 2 mounds per hectare, lower than the one in the north africa due to the less optimal conditions being cooler with stronger seasonality (Davies, Levick, Asner, Robertson, van Rensburg and Parr, 2014).

4.2 Soil structure relation with the termite mound abundance

The existence of soil structure among the predictors related to the termite mound density confirms Kelly and Sandways (2011) results according to the most important environmental variable related to the termite mound density and Pringle, Doak, Brody, Jocque and Palmer, (2010) researh according to the linkage between spatial pattern of termite mounds and production activity through ecosystem services which on the soil are shown through its physical and chemical properties.

Figure 2 shows that all the three soil structures host the lowest termite mound density when the ferruginous soils are hosting the highest density of termite mound. That means that even if one can expect the termite mounds on all the three soil structures, the highest densities may appear on the ferruginous soils. This relation is in agreement with the one fund by Pomeroy (1977) and Pomeroy (1978) fundings according to the relatonship between physical and chemical properties of the soil and the termite mound abundance. Mando and Van Rheenen (1998) research in Burkina-Faso on termites agreed on a significant effect of termites on soil structure. According to Konaté, Le Roux, Tessier and Lepage (1999), the presence of termite mound make changes in soil texture and structure.

The weakness of our conclusion on to the relationship between the soil structure and the density of termite mound could be related to the nature of termite mound. Indeed, the mounds concerned include the alive and the dead one. Knowing that alive mounds are the one hosting termites, all the dead and alive mounds contribute to the surronding soil structure through the mound erosion (Abe, Kotegawa, Watanabe, Wakatsuki 2011) and the alive one especially through the ecosystem services delivered in the surronding soil by the termites (Jouquet, Dauber, Lagerlo, Lavelle and Lepage, 2006). We recommend for further researches on the termite mound determinants to distinguish the alive mound from the dead one in order to determine separately their effects.

4.3 Fallow practice relation with the termite mound abundance

As regards to the regression model results the fallow duration has a negative effect on the density of termite mounds on the crop plot. Here, the results of the model suggest a spatial view of a temporal phenomenon. Consequentely, the results are in contrary with the expectation (Ayuke, Pulleman, Vanlauwe, de Goede, Six, Csuzdi and Brussaard, 2011). Indeed, in the sampling crop plots, 83% of them have a fallow duration less than 7 years when the maximum fallow duration is 15 years. Furthermore, the third of the crop plots are termite mounds free and 62% of the crop plots host 1-4 termite mounds per hectare when the highest termite mound density observed is 12 (Table 10). The spatial distribution pattern of the termite mounds shows that the lowest densities of termite mounds are observed on the crop plot with lowest fallow duration. One possibility is that the density of termite mounds is determined by others predictors related to the farming system. We suggest for more detail on the relationship between termite mound density and the fallow duration that other experimental works focus on the real determinants of the termite mound density after a fallow practice combining more predictors related to farming system such as use of machine for tillage, use of chemical pesticide.

Table 10. Fallow Duration and Termite Mound Density

Frequency		**Termite mound density (mounds/ha)**									**Total**
		0	**1**	**2**	**3**	**4**	**5**	**6**	**8**	**12**	
Fallow duration (years)	**1**	19	9	14	4	4	2	0	0	2	54
	2	31	22	13	7	9	0	1	4	0	87
	3	23	15	12	2	5	0	1	1	1	60
	4	16	18	10	9	5	0	0	0	0	58
	5	9	10	2	1	1	0	0	1	0	24
	6	18	7	5	2	2	0	0	0	0	34
	7	1	1	1	2	0	0	0	0	0	5
	8	2	5	1	2	1	0	0	0	0	11
	9	0	0	0	0	2	0	0	0	0	2
	10	10	11	7	3	6	0	0	0	0	37
	12	1	1	1	0	0	0	0	0	0	3
	13	1	1	0	1	0	0	0	0	0	3
	15	0	1	2	1	0	0	0	0	0	4
Total		131	101	68	34	35	2	2	6	3	382

4.4 Agricultural land relation with the termite mound abundance

As regards to the regression model results the crop acreage undependentely to the crop has a negative effect on the density of termite mound on the crop plot. That means that the plot acreage is negatively associated with the mound density. This finding is in contrary with the results in Brazilia where the highest densities of termite mounds are found in annual crops (Barros, Neves, Blanchart, Fernandes, Wandelli and Lavelle, 2003) but in agreement with the results of the research in Amazonia where the annual crops were negatively associated with the termites species due to tillage and pesticide use (Hidayat, Endris and Dwiyanti, 2018; Costa-Milanez, Lourenço-Silva, Castro, Majer and Ribeiro, 2014; Vasconcelos, Leite, Vilhena, Lima and Magnusson, 2008).

4.5 Chemical products relation with the termite mound abundance

As regards to the regression model results the use of chemical product seems to have negative influence on the density of termite mound on the crop plot. These findings are in agreement with the results of the research in

Amazonia where the annual crops were negatively associated with the termites species due to tillage and pesticide use (Costa-Milanez et al., 2014; Vasconcelos et al., 2008).

4.6 Human actions relation with the termite mound abundance

Under the assumption that any effect of man on termite mound such as destruction may be proportional to the population (Downer, 1967 *in* Pomeroy, 1978), the geographic position of village hosting the crop plot according to the main road is chosen to indicate the level of human action (destruction) on the termite mounds.

As regards to the regression model results the position of the crop plot according to the main road influence negatively the density of termite mounds on the crop plot. Our research recognize the human action effects on the termite mound density. This finding agreed with Grohmann et al. (2010) results in Namibian savanna where regular spatial distribution of *Macrotermes* mounds are shown in constrary with the following studies results which have concluded the spatial distribution patterns of *Macrotermes* termite mounds to be at random (Mujinya et al., 2014). The role of human actions on termite mounds density is recognized by a lot of authors (Pomeroy, 1978).

V. Conclusion

The current research has enabled to identify the potential factors that determine the density of termite mound on agricultural lands.

First, the correlation analysis shows low correlations between the descriptive variables of the model excepted the village status, the soil structure and the existence of cotton in the rotation during the last five years which correlations are found moderate.

Second, the results of the regression model indicate that all the predictors of the model account for more than the third of the variation of the termite mound density and the farming practices and the personal data explain more the variation than the soil characteristics. In addition, the analysis revealed that the factors affecting significantly the density of termite mound on a crop plot are the soil structure, the fallow duration, the use of chemical products on the plot, the crop plot acreage and the village status.

Finally, the research hypothesis are confirmed only for the soil structure, the use of chemical products and the village status.

Advises to farmers on fertility effect and conservation practices of termite mounds are found to be good practices to improving the soil fertility through reducing the pressure on the termite mound on their crop plots.

References

[1] S. S. Abe, T. Kotegawa, T. Onishi, Y. Watanabe and T. Wakatsuki, "Soil particle accumulation in termite (Macrotermes bellicosus) mounds and the implications for soil particle dynamics in a tropical savanna Ultisol", *Ecol Res*, vol. 27, pp. 219 – 227, 2012.

[2] T. Afifi and K. Warner, "The impact of environmental degradation on migration flows across countries", *UNU-EHS working paper* No.5/2008.

[3] U. F. Akpan and A. Chuku, "Economic Growth and Environmental Degradation in Nigeria: Beyond the Environmental Kuznets Curve", A Revised Paper Presented at the 4th Annual NAEE/IAEE International Conference, held at Sheraton Hotels and Towers , Abuja, Nigeria, April 27th – 29th, 2011, Munich Personal RePEc Archive (MPRA) Paper No. 31241, 2011.

[4] F.O. Ayuke, M.M. Pulleman, B. Vanlauwe, R. G. M. de Goede, J. Six, C. Csuzdi and L. Brussaard, "Agricultural management affects earthworm and termite diversity across humid to semi-arid tropical zones", *Agriculture, Ecosystems and Environment*, vol. 140, pp. 148 – 154, 2011.

[5] J-M. Baland, P. Bardhan, S. Das, D. Mookherjee and R. Sarkar, "Managing the environmental consequences of growth: Forest degradation in the Indian mid-Himalayas", Revised version of paper presented at the India Policy Forum 2006-07 at NCAER New Delhi: pp. 215 – 277, 2006.

[6] E. B. Barbier, "Links between economic liberalization and rural resource degradation in the developing regions", *Agricultural Economics*, vol. 23, pp. 299 – 310, 2000.

[7] E. Barros, A. Neves, E. Blanchart, E. C. M. Fernandes, E. Wandelli and P. Lavelle, "Development of the soil macrofauna community under silvopastoral and agrosilvicultural systems in Amazonia", *Pedobiologia*, vol. 47, no. 3, pp. 273 – 280, 2003.

[8] Y. H. Chan, "Biostatistic 104: Correlational Analysis", *Singapore Med J*, vol. 44, no.12, pp. 614 – 619, 2003.

[9] R. A. Congdon, J. A. Holt and W. S. Hicks, "The role of mound-building termites in the nitrogen economy of semi-arid ecosystems", Proceeding 6th Australasian Conference on Grassland Invertebrate Ecology, 1993.

[10] C. B. Costa-Milanez, G. Lourenço-Silva, P. T. A. Castro, J. D. Majer and S. P. Ribeiro, "Are ant assemblages of Brazilian veredas characterized by location or habitat type?" *Braz. J. Biol*, vol. 74, pp. 89 – 99, 2014.

[11] J. M. Dangerfield, T. S. McCarthy and W. N. Ellery, "The moundbuilding termite Macrotermes michaelseni as an ecosystem engineer", *J. Trop. Ecol*, vol.14, pp. 507 – 520, 1998.

[12] A. B. Davies, S. R. Levick, G. P. Asner, M. P. Robertson, B. J. van Rensburg and C. L. Parr, "Spatial variability and abiotic determinants of termite mounds throughout a savanna catchment". *Ecography (Cop.)*, vol. 37, pp. 852 – 862, 2014.

[13] C. H. O. Dossou-Yovo, "Diversité des plantes en relation avec les termitières dans le Parc National de la Pendjari et les terroirs riverains", These d'Ingenieur Agronome, Aménagement et Gestion des Ressources Naturelles, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi (Bénin), 87 p, 2007.

[14] A. K. Duraiappah, "Poverty and Environmental Degradation: a Review and Analysis of the Nexus", *World Development*, vol. 26, no. 12, pp. 2169 – 2179, 1998.

[15] E. Feoli, L. G. Vuerich and W. Zerihun, "Evaluation of environmental degradation in northern Ethiopia using GIS to integrate vegetation, geomorphological erosion and socio-economic factors", *Agriculture, Ecosystems and Environment*, vol. 91, pp. 313 – 325, 2002.

[16] P. Faure, "Carte pédologique de reconnaissance de la République Populaire du Bénin à 1/200000, feuille de Natitingou et Porga", ORSTOM. Note Explicative N°66 (6 et 8), 75 p, 1977.

[17] K. Ferretti-Gallon and J. Busch, "What Drives Deforestation and What Stops It? A Meta-Analysis of Spatially Explicit Econometric Studies", Center for Global Development. Working Paper 361. CDG Climate and Forest Paper Series # 2, 24 p, 2014.

[18] R. Q Grafton and S. Knowles, "Social Capital and National Environmental Performance: A Cross-Sectional Analysis", *Journal of Environment and Development*, vol.13, no. 4, pp. 336 – 370, 2004.

[19] C. Grohmann, J. Oldeland, D. Stoyan and K. E. Linsenmair, "Multi-scale pattern analysis of a mound-building termite species", *Insect. Soc*, vol. 5, pp. 477-486, 2010.

[20] K. Heubach, R. Wittig, E-A. Nuppenau and K. Hahn, "Local Values, Social Differentiation and Conservation Efforts: The Impact of Ethnic Affiliation on the Valuation of NTFP-Species in Northern Benin, West Africa", *Human Ecology*, vol. 41, no.4, pp. 513 – 533, 2013.

[21] M. R. Hidayat, W. M. Endris and Y. Dwiyanti, "Effect of a rubber plantation on termite diversity in Melawi, West Kalimantan, Indonesia", *Agriculture and Natural Resources*, vol. 52, pp. 439 – 444, 2018.

[22] M. Houinato and B. Sinsin, "La pression agropastorale sur la zone riveraine de la Reserve de Biosphere de la Pendjari", *Tropicultura*, vol. 18, no. 3, pp. 112 – 117, 2000.

[23] P. Jouquet, J. Dauber, J. Lagerlo, P. Lavelle and M. Lepage, "Soil invertebrates as ecosystem engineers: intended and accidental effects on soil and feedback loops", *Appl. Soil. Ecol*, vol. 32, pp. 153 -164, 2006.

[24] T. J. Kelly and M. w. Githinji, "Enviromental Degradation and Poverty in Less Industrialized Nations". *FRONTERA NORTE,* NUM. ESPECIAL, POBREZA.77 – 89, 1994.

[25] J.A. Kelly and M. J. Samways, "Mound-Building Termite (Blattaria: Isoptera) Mound Density and Ecological Correlates in a Southern African Savanna Reserve", *African Entomology*, vol. 19, no. 1, pp. 156 – 164, 2011.

[26] S. Konaté, X. Le Roux, D. Tessier and M. Lepage, "Influence of large termitaria on soil characteristics, soil water regime, and tree leaf shedding pattern in a West African savanna", *Plant and Soil*, vol 206, pp. 47 – 60, 1999.

[27] G. J. Lautenschlager and J. L. Mendoza, "A step-down hierarchical multiple regression analysis examining hypothesis about the bias in prediction". *Applied Psychological Measurement*, vol 10, no. 2, pp.133 – 139, 1986.

[28] M. Lewis, "Stepwise versus Hierarchical Regression: Pros and Cons", Paper presented at the annual meeting of the Southwest Educational Research Association. February 7, 2007, San Antonio: pp. 1 – 30, 2007.

[29] A. Mando and T. Van Rheenen, "Termites and agricultural production in the Sahel: from enemy to friend?" *NJAS*, vol. 605, pp. 1 – 7, 1998.

[30] B.B. Mujinya, M. Adam, F. Mees, J. Bogaert, I. Vranken, H. Erens, G. Baert, M. Ngongo and E. Van Ranst, "Spatial patterns and morphology of termite (Macrotermes falciger) mounds in the Upper Katanga, D.R. Congo". *Catena*, vol 114, pp. 97 – 106, 2014.

[31] S. G. A. Nago, I. Amahowe, O. Zannou, L. Houessou, F. Ahononga, P. N'Séra, M. Kouton, F. Kidjo, S. Sahilou and B. Sinsin, "Diversité, abondance et densité des populations de faune dans la Réserve de Biosphère

de la Pendjari (Nord Bénin) ", *Ann. UP, Série Sci. Nat. Agron,* vol 6, no. 1, pp. 10 – 25, 2016.

[32] B. Y. Nouhoheflin, "Diversité, rôles culturel et cultuel des termites et termitières dans la forêt classée de la Lama et les localités environnantes", Thèse d'Ingénieur Agronome, Aménagement et Gestion des Ressources Naturelles, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi (Bénin). 128 p, 2006.

[33] M. Oumorou, A. K. Natta, A. C. Adomou and B. de Foucault, "Caractéristiques écologiques et phytosociologiques des galeries forestières de la Réserve de biosphère de la Pendjari (nord-ouest du Bénin) ", *Acta Botanica Gallica*, vol. 158, no. 1, pp. 125 – 139, 2013.

[34] J. V. Petrocelli, "Hierarchical Multiple Regression in Counseling Research: Common Problems and Possible Remedies". *Measurements and Evaluation in Counseling and Development*, vol. 36, pp. 9 – 22, 2003.

[35] N. G. M. Pinto, D. A. Coronel and B. P. Conte, "Mapping of environmental degradation in regions and states of Brazil". *WSEAS Transactions on Business and Economics*, vol. 11, pp. 442 – 453, 2014.

[36] PNUD, "Rapport National sur le développement humain 2015: Agriculture, Sécurité Alimentaire et Développement Humain au Bénin". PNUD Benin, 114 p, 2015.

[37] D. E. Pomeroy, "The distribution and abundance of large termite mound in Uganda". *The Journal of Applied Ecology*, vol. 14, pp. 465 – 475, 1977.

[38] D. E. Pomeroy, "The abundance of large termite mound in Uganda in relation with their environment". *The Journal of Applied Ecology*, vol. 15, pp. 51 – 63, 1978.

[39] R. M. Pringle, D. F. Doak, A. K. Brody, R. Jocque and T. M. Palmer, "Spatial Pattern Enhances Ecosystem Functioning in an African Savanna", *PLoS Biology*, vol. 8, no. 5, pp. 1-12, 2010.

[40] B. Ratner, "The correlation coefficient: Its values range between + 1 / − 1, or do they ?" *Journal of Targeting, Measurement and Analysis for Marketing*, vol. 17, pp. 139 – 142, 2009.

[41] A. R. A. Saliou, "Roles socioculturels et environnementaux des termites et termitières chez les peuples riverains de la Reserve de la Biosphere de la Pendjari", Mémoire de DESS, Aménagement et Gestion des Ressources Naturelles, Faculté des Sciences Agronomiques, Université d'Abomey-Calavi, (Bénin), 71 p, 2005.

[42] S. J. Scherr, "A downward spiral? Research evidence on the relationship between poverty and natural resource degradation". *Food Policy*, vol. 25, pp. 479 – 498, 2000.

[43] D. Southgate, "The cause of land degradation along spontaneously expending agricultural frontiers in the third world". *Land Economics*, vol. 66, no. 1, pp. 93 – 101, 1990.

[44] B.G. Tabachnick and L.S. Fidell, Using Multivariate Statistics, Fifth Edition. Boston: Pearson Education, Inc, 2007.

[45] R. EDD. RDCs. Taylor, "Interpretation of the correlation coefficient: A basic review". *Journal of Diagnostic Medical Sonography*, vol. 6, no. 1, pp. 35 – 39, 1990.

[46] H. L. Vasconcelos, M. F. Leite, J. M. S. Vilhena, A. P. Lima and W. E. Magnusson, "Ant diversity in an Amazonian savanna: relationship with vegetation structure, disturbance by fire, and dominant ants". *Austral. Ecol*, vol. 33, pp. 221 – 231, 2008.

[47] J. Verschuren, "Notes d'Ecologie, principalement des mammiferes, du Pare National de la Pendjari, Benin". *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, BIOLOGIE*, vol. 58, pp. 185 – 206, 1998.

[48] B. M. de Vliegher, "Environmental degradation caused by man. A case study for Southern Euboia (Central Greece) based upon thematic mapper data in combination with topographical and statistical documents". *EARSeL Advances in Remote Sensing*, vol. 2, no. 3, pp. 45-55, 1993.

[49] F. G. Vodouhe, A. Adegbidi, O. Coulibaly and B. Sinsin, "Parkia biglobosa (Jacq.) R. Br. ex Benth. harvesting as a tool for conservation and source of income for local people in Pendjari Biosphere Reserve", *Acta Bot. Gallica*, vol. 158, no. 4, pp. 595 – 608, 2011.

[50] Q. M. Vu, Q. B. Le, E. Frossard and P. L. G. Vlek, "Socio-economic and biophysical determinants of land degradation in Vietnam: An integrated causal analysis at the national level", *Land Use Policy*, vol. 36, pp. 605 – 617, 2014.

[51] K. Zaman, H. Khan, M. M. Khan, Z. Saleem and M. P. Nawaz, "The impact of population on environmental degradation in South Asia: application of seemingly unrelated regression equation model", *Environmental Economics*, vol. 2, no. 2, pp. 80 – 88, 2011.