Natural Resources for Human Health

visaga publishing house

Original Research

View Article Online

Check for updates

Received 21 July 2023
Revised 05 September 2023
Accepted 05 September 2023
Available online 22 November 2023

Edited by Barbara Sawicka

KEYWORDS:
durable management
Mayo-Kani
Reforestation.

Natr Resour Human Health 2023; 3 (4): 477-490
https://doi.org/10.53365/nrfhh/171902
eISSN: 2583-1194

Phytodiversity and sustainable Management status of Reforested Sites of the Soudano-Sahelian Zone of Cameroon

Kodji Paul [1,*], Tchobsala [1], Beyang Ware Guidakre [1], Haiwa Gilbert [1], Dieudonne Djackba Danra [2], Souare Konksala [1]

[1]University of Ngaoundere, Faculty of Science, Department of Biological Sciences, Laboratory of biodiversity and sustainable development, PO Box 454, Marouba, Cameroon
[2]University of Maroua, Faculty of Science, Department of Biological Sciences PO Box 814 Maroua, Cameroon

ABSTRACT: A study was carried out on the phytodiversity and the sustainable management situation of reforested sites in order to ameliorate the living conditions of the local population of three villages (Kilguim, Going I and Going II) of Kaélé in the Mayo-Kani division. The semi-structured and structured maintenance beside the 200 persons and the registration of the vegetation was done in three villages. Findings revealed higher bushfires practice in sites. Data analysis proved that the practice of bushfires in forbidden or restricted sites (83.50 ± 16.01), the lack of plausibility studies of reforestation projects associating local populations (78.50 ± 13.99), insufficiency of bore holes for constant water supply for the follow up of the reforestation (76.00 ± 19.10), lack of specialized structures in the reforestation domain (72.83 ± 13.03), the insufficiency of sensitization on the importance of reforestation (71.67 ± 27.55) and the cutting of wood (68.00 ± 12.17) are real problems that the reforestation sites faces. The confiscation of land for reforestation without any alternative measure taken for the assurance of alimentary security and firewood of the population is the major cause of the dissatisfaction of the riverine population. The death rate is pretty elevated in the Kilguim site (15%) because of the lack of maintenance in reforested sites. The Shannon index is very high in the Going I site (2.71bits) because it is less perturbed by anthropic activities. Vegetation presents a structure in the form of a bell or cloche in prohibited sites translate a heterogeneity of the milieu because of anthropic perturbations. The durable management plan was opted for the management of reforestation sites.

1. INTRODUCTION

Demographic explosion and over exploitation of protected or non-protected ecosystems are at the origin of forestry ecosystems and climate change (RIDDAC, 2016). Faced with this alarming situation, a vast campaign of tree planting has been proscribed in the workbook of the Ministry of the Environment and Nature Protection. In the Extreme- Nord region of Cameroon, the degradation of the ecological and socioeconomic situation is very advanced and preoccupying. This situation has caused the government of Cameroon to circumscribe this region as a zone of priority intervention N^{o} 1 in the National Action Plan for the Fight against Desertification (PAN/LCD). In the optic of resolving this problem, reforestation is carried out by institutions such as MINFOF, MINEPDED (local reforestation focal point in Cameroon), and the populations. However, in spite of the political will of the state, the global conscientization of the necessity of planting a tree, consequent financial means, results of great reforestation campaigns are lukewarm or unenthusiastic (Saleh et al., 2014). The problems of reforestation have been effectuated with the envisaging of socio-economic inquiry from the population, followed by the inventory of the different ligneous species encountered in the three sites of studies (Kilguim, Going I and Going II). Works were earlier carried out by Haiwa (2013) on the impact of deforestation on the dynamics of vegetation but no studies has been done as of now, on the problems faced by the reforestation of this zone. The main objective of this present work is to study the phytodiversity situation of operation green Sahel. Thus, we base on the justification of the economic, institutional, technical, traditional, historic (first project of this nature) constrains or ecological demonstrating that the development of tree covers could not be possible without intervention (Ruralter,

* Corresponding author.
E-mail address: paulkodji@yahoo.com (Kodji Paul)

2010). Specifically, it entails bringing out clearly the problems faced by reforestation in the Mayo-Kani and the structures that are implicated therein, evaluate anthropization indices and the mortality of trees in the reforested sites, study the ecological characterization and the structure of species of reforested sites, and to propose a plan of durable management of reforested sites.

2. MATERIALS AND METHODS

2.1. Description of Study Sites

Investigations were carried out in three sites belonging to the Mayo-Kani division in the Extreme-North region of Cameroon. These sites are notably: Kilguim, Going I, and Going I (Figure 1). The Soudano- Sahelian zone is characterized by fragile ecosystems, a high population density and intense pressure on land. It is subjected to the adverse effects of dryness exacerbated notably by deforestation and soil erosion. The different sites chosen belong to the great massive of the Extreme-North region and more precisely in the Mayo-Kani are submitted to the Soudano-sahelian climate which dominates the zone of Kaele. It is characterized by two unequally distributed reasons: one is the length of the dry season of about eight (08) months, from October to May and a short rainy season of four (04) months, spanning from the month of June to September. The dry season is characterized by a pendulous or oscillating temperature between cold (November to January) and canicular heat (February to May). The mean temperature is 28.1^{o}C with a minimum of 18^{o}C in January and a maximum of 40^{o}C in April and May. The amplitudes of average precipitations are 809 mm per year.

2.2. Socio-economic inquiry

Socio-economic, environmental and forestry inquiries were realized close to the populations of three (03) villages (Kilguim, Going I and Going II), delegations of the environment and NGOs. In each village, 50 persons where interviewed, 05 forest guards in each site and thus a total of 15 forest guards in the three sites, five (05) persons in each delegation (regional and departmental delegation) of Maroua, Kaele and equally (05) persons in each of the following organizations (GIZ and ABIOGeT) of Maroua. Inquiries or investigations also continued at the level of the council of Kaele through an interview granted by 10 council agents. A total of 200 persons were interviewed. The great rubrics exploited in the questionnaire are the knowledge of the population about the reforestation programs and its implementation, its implication in her management and its approbation, the difficulties faced by the parties engaged in the management of operation green-Sahel sites. The inquiry was semi-structured with questions of open, closed and oriented nature.

The methodology presents the demarche used to obtain teachings taken from the reforestation of Mayo- Kani as well as of Cameroon. For this reason, we based our research on the classical method of data collection which is an extended bibliography, investigations and interviews granted by parties engaged in reforestation and data collectors of the reforested sites. This present work is currently going on the field, in the North delegations of the environment, the Extreme-North, Mayo-Kani, ABIOGeT (Maroua) and in the sites at the level of forest guards. The inquiries carried out pivoted on ethno-botanic investigations (reforestation problem) and that carried out on the field consist of caring out botanic inventories of reforested tree species. These investigations took place in three sites, all belonging to a division of the Extreme-North region. These sites are notably: Kilguim, Going I and Going II. These three sites were established in 2013.

2.3. Floristic data collection and dendrometric measures

The sampling technic was used for the inventory of different reforested species is the quadrant method. This method permits us to collect floristic data and was applied by (Poissonnet & César, 1972) , for the survival of savanna vegetation on the permanent lines and Tchobsala (2011) on the peri-urban savanna vegetation of the Adamaoua (Cameroon). This technic was consisting of delimiting parcels or plots of 50mx50m for the inventory of the vegetation following layouts of 10m wide and 50m long one after the other. The experimental dispositive shows three (03) reforestation sites (Kilguim, Going I and Going II sites) and the numbers 1, 2, and 3 represents the number of repetitions. These floristic data collected has permitted the bringing out of: the circumferences at 1.30 from the soil; circumferences at 0.3 from the soil; the diameter of the trunk; the height of the plant; the number of death and living plants with the objective of evaluating the mortality rate; anthropic indices (cutting of wood, bush fire, grazing…).

In total nine (09) quadrants of 50mx50m were realized for all the three sites, with a total of 03 quadrants per site. A rob of 50m long was used to delimit these quadrants. In each site, a surface area of 3/4ha was exploited, thus a total of 2.25 ha for all the 09 parcels of a dimension of 50x50m each. In this surface area of 2025ha, reforested species will be marked. The diameter at the height of the chest level (dbh) and the diameter of the trunk of each plant will be evaluated with the help of a meter ribbon of 30m long. The height of the tree will be evaluated by a pole or stick of 4m long and for plants with heights greater than 4m tall, will be estimated. A brief description of the ecological milieu of reforested species will equally be in the quadrants, and thanks to a digital camera, snap shots or images will be taken.

2.4. Frequency of ligneous species

The absolute frequency of a species is the number is this number of individuals of that species counted in the site. According to Braun- Blanquet (1932), the relative frequency is the proportion expressed in percentage between the number collected that contain this species and the total number counted divided by 100. This method permits the determination of accidental, accessory, less frequent, frequent and most frequent species (Table 1).

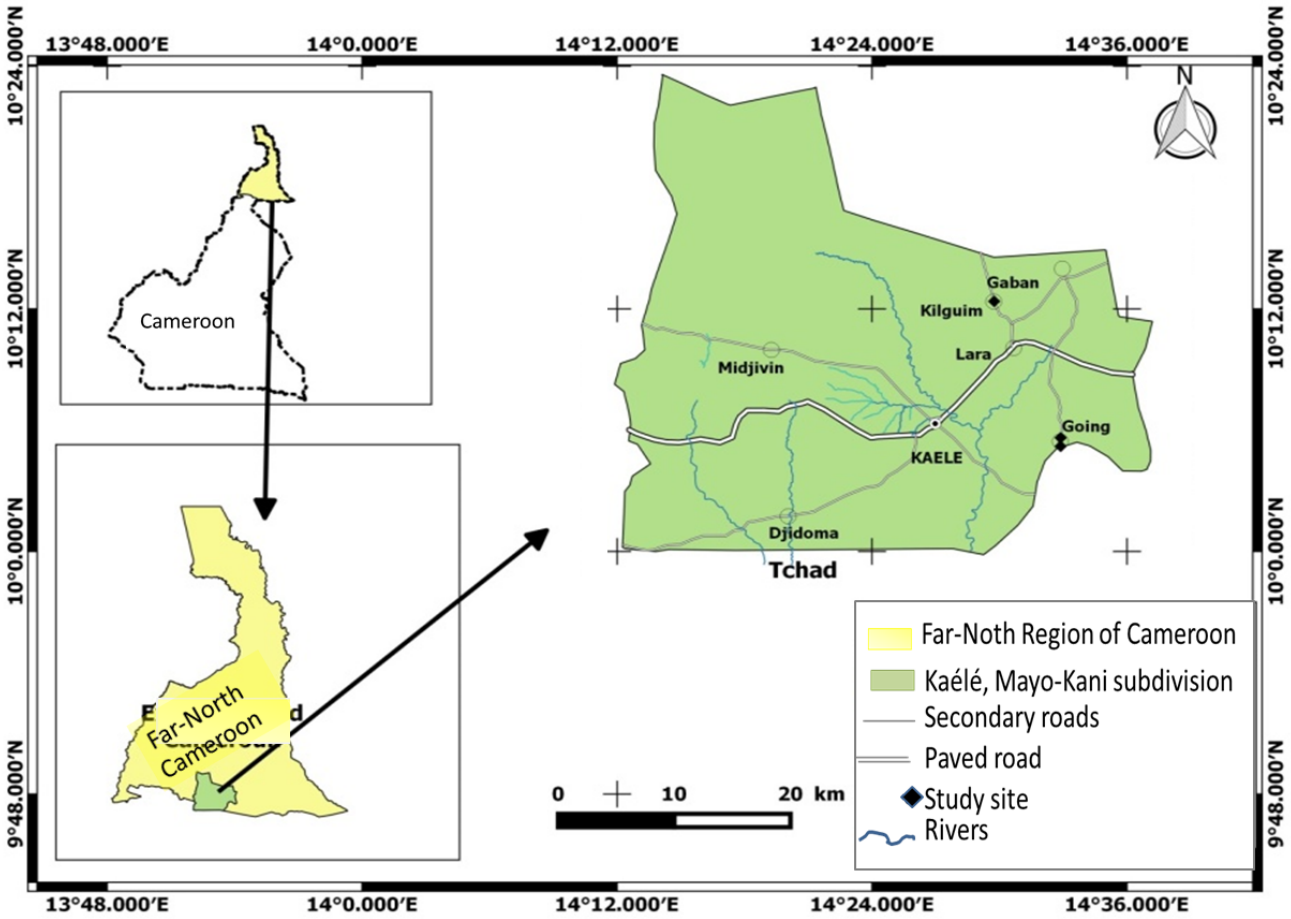

Figure 1. Study site localization

Table 1
Frequency index (Braun-Blanquet, 1932)

Indices	Frequency	Species type
I	F< 20	Accidental species
II	20 <F< 40	Accessory species
III	40 <F< 60	Slightly frequent species
IV	60 <F< 80	Frequent species
V	80 <F< 100	Most frequent species

2.4.1 *Relative density*

The relative density (Dre) or relative abundance is the relationship between the number of individuals of a species and the total number of individuals of all other species encountered in the considered surface area multiplied by 100.

2.4.2 *Relative dominance*

Dominance expresses the influence exerted by a species in a community. Relative dominance (Dre) is the ration of the land surface area to the basal surface (Sb) of a species on the entire terrestrial surface area on all encountered individuals. $Sb=\pi D^2/4$; where D is the diameter of the trunk, importance of Curtis Value. The three statistical data (frequency, dominance and relative density) are commonly used together and their sum is equal to the "Value of Curtis Importance".

2.4.3 *Density*

Density is given by the formula: **D= N/S** where **N**= number of species in a study milieu and **S**= surface area occupied by the species. To this effect, the terrestrial surface area is calculated.

2.4.4 *Surface area*

It is given by the formula: $\mathbf{Gi = \pi\ DH^2\ /4}$ where Gi is the species (i) terrestrial surface area, DH is the diameter of the tree trunk of the species.

2.4.5 Index of Shannon and Piélou equitability

The Shannon-Weaver or Shannon-Wiener index is an index that serves for the measurement of biodiversity. This index is an indicator of specific richness of a site.

Shannon index of diversity: **ISH= ∑Ni/Nln (Ni/N)** where **Ni** is the effective of the species and **N** is the total effective of all species found at the site of study.

Piélou (1966) equitability (EQ): **EQ= ISH/lnN**; it corresponds to the ratio between observed diversity and maximal possible diversity of the number of species **N**.

2.4.6 Simpson diversity index

Simpson diversity index: D = Σ Ni (Ni-1)/N (N-1)

D: Simpson index;

Ni = Number of individuals of a given species;

N: Total number of individuals.

Index varies between 0 and 1. The more it gets closer to 0, the more the chances of obtaining different species are elevated (Begon et al., 1987).

2.4.7 Statistical analysis of data

Data were collected, treated and analyzed with the help of the Statgraphic software plus 5.0 which has permitted the comparison of data and parameters such as height, size, diameter of the trunk. The numbers became objects of variance analysis (ANOVA). Excel is used for histograms, XLstat pro for principal components analysis (ACP).

3. RESULTS AND INTERPRETATION

3.1. Problems of Mayo-Kani division reforested sites

Inquiries, has shown that the local population (67.56±25.95), delegations of MINEDEP (55.56±29.55), NGOs (50.56±23.88), and councils (52.59±32.41) noticed eighteen (18) reforestation problems (Table 2). These problems include bush fires (83.50±16.01), lack of plausibiity studies (78.50±13.99) and lack of bore holes (76.00±19.10), the lack of specialised structures in the domain of reforestation (72.83±13.03) and insufficiency of sensitisation of the local population on the importance of reforestation (71.67±27.55). These results shows that the reforestation of the Mayo-Kani zone is faced with numerous problems both from the environmental and social domain. These results are similar to that of R RIDDAC (2016), which shows that many factors render the results of the different reforestation programs less visible.

3.2. Anthropization index in reforested sites

Table 3 shows(82.67±6.43) of burns observed in the three (03) different study sites. This practice of bush fire is translated by the discontent of forest guards and most especially on the ignorance of the local population on the importance of reforestation. The cutting of wood (68.00±12.17) within the sites is the dominant activity after the practice of bush fires followed by pruning (64.00±9.17). These activities show that the reforested sites are accessible despite its access prohibition. This variability is confirmed by variance analysis which discovered the existence of a significant difference between the anthropization indices (P<0.001).

Man's action influences the natural milieu. In the sites of study, cutting of trees, burning, pruning and trimming were remarkably observed. Bush fire is one of the dominant practices in the sites. These results are similar to that of Tchobsala (2011) in the peri-urban zone of the Adamaoua region, on the impact of deforestation.

3.3. Regeneration capacity of species of reforested sites

3.3.1 Mortality of species in reforested sites

our (04) shows the mortality of tree species in different sites. Mortality is very elevated in the Kilguim site (2.79±5.38), due to the soil quality (Figure 6) and lack of maintenance linked to lack of bore holes for watering or to frequent bush fire actions. In the other sites Going I and Going II, it is averagely (1.62±2.23) and (1.38±1.78b) respectively. These rates are equally considerable and shows negligence and lack of follow up of reforestation activities. These results corroborate with that of Saleh et al. (2014) which shows that 60% of reforestation sites fails today in the Extreme- North region is because of lack of follow up or inappropriate follow up.

3.3.2 Mortality rate of plant species according to reforested sites

Figure 2 shows the mortality rate of plant species on different sites. This rate is very high (15%) in the Kilguim site. It is more elevated in this site because of the soil quality, lack of maintenance because of lack of bore holes for watering or because of activity of bush fires. In the Going I and Going II sites, the mortality rate is respectively 6036 and 8.79. These rates are equally considerable and indicates negligence in the maintenance, follow up of reforestation activities, these results corroborate with that of the Sahel (2014) which shows that 60% of reforested sites fail now our days in the Extreme- North region because of lack or inappropriate follow up.

.

3.3.3 Evaluation of percentages of living and dead plant individuals

The success rate of the Going I, Going II, and Kilguim sites is at an average 80%. Figure 3 below translate this perception. This result is close to that of Sahel et al., 2014 in the Mayo-Kani division, which shows that these results are all below 78%. These results are comparable to a few close exceptions. Despite these success rates in the Mayo-Kani division and the collective consciousness, the Mayo- Kani populations recusant to reforestation activities. This thus reflects a problem of mentality which necessitates reeducation. In the reforested site of Going I, Figure 3 shows 38.16% of living plants, 31.67% in Going II and 30% in Kilguim with respect to the total number of individual plants of the three sites. The percentages of living

Table 2
Reforestation problems

Problems	villages	delegations	NGO	Council	Av/Sd
Land	30	33,33	10	80	38.33±29.631
Financing (late)	10	93.33	20	86.67	52.50±43.58:
Lack of bore holes	74	86.67	50	93.33	76.00±19.10h
Lack of legislations	46	20	20	73.33	39.93±25.481
Lack of plausibility studies	94	80	60	80	78.50±13.99b
Lack of follow up expertise after reforestation	92	13.33	50	20	43.83±35.89
Death of plants	78	53.33	30	33.33	48.67±22.10h
High cost of reforestation for payable	36	93.33		13.33	
Bushfire	94		60	93.33	83.50±16.01a
Lack of reforestation follow up	64	46.67	50	13.33	43.50±21.4711
Escape of the population	80	26.67	20	26.67	38.33±27.951
Fraudulent exploitation of reforested species	88	73.33	40	13.33	53.67±33.56:
Unavailability of seeds for nurseries	76	86.67	60	20	60.67±29.24e
Agliculture	48		50	66.67	41.17±28.69h
Reticence of the population towards the reforestation program	42	53.33	90	26.67	53.00±26.98:
Ignorance ofreforestation sites	96	66,67	60	33.33	64.00±25.74d
Awareness campaign on the importance of reforestation	90	33.33	70	93.33	71.67±27.55C
Lack of specialized stlucture in the field of reforestation	78	53,33	so	so	72.83±13.03’
Av/Sd	67.56±25.95^a	55.56±29.55^b	50.56±23.88^c	59±32.41^b	

Values designated or given the same letter has no significant differences at a threshold of 0.05.

Table 3
Anthropization indices in reforested sites

Indices	Going I	Going II	Kilguim	Av/Sd
Cutting	76	74	54	68.00±12.17b
Burning	80	78	90	82.67±6.43a
Skinning	24	26	28	26.00±2.00^e
Pruning	22	10	18	16.67±6.11f
Trimming	66	72	54	64.00±9.17c
Trampling	46	48	40	44.67±4.16d
Agriculture	4	2	0	2.00±2.00g
Av/Sd	45.43±29.66a	44.29±31.88a	40.57±29.21a	

individuals vary in relation to the villages as well as the death percentages 9.61% in Kilguim, followed by 6.22% in Going II and 4.55% in Going I. these results corroborate to that obtained by Tchobsala (2011) in the peri-urban zone of the Adamaoua region, which found the number of living individuals more elevated than the number of dead individuals. This variability is explained by the analysis of variables which shows that there exists a significant difference between the percentage of living individuals and percentage of dead individuals with P= 0.0007.

3.4. Floristic composition, indices of floristic diversity

The floristic record presents 864 ligneous individuals distributed in 30 species, 20 genus and 13 families (Table 5). The Going I site is richer in species diversity with 322 species, while the Kilguim and Going II presents 286 and 246 individuals. But only the Going II is rich in family diversity with 13 families. However, the Shannon-Weaver index varies considerably from one site to the other. It varies between 1.92 and 2.71 bits in the different reforested study sites. It is more elevated when a great number of species participate in the occupation of the soil. It is expressed in bits per individual, and varies from the weakest diversity (0 bits) to the most elevated (4.5bits) (Frontier et al., 1995). This result shows that the Going I (2.71 bits) of Shannon diversity calculated to a more elevated diversity of the other two sites Going II and Kilguim.

Table 4
Mortality of species in reforested sites
Values designated or given the same letter has no significant differences at a threshold of 0.05.

Dead individuals	GoingI	GoingII	Kil-guim	Moy/Ecart	Dead individuals	GoingI	GoingII	Kilguim	Moy/Ecart
Acacia ataxacantha	0	0	3	1,00±1,73^{e}	Combretum acumuleatum	1	0	2	1,00±1,00^{e}
Acacia hockii	0	0	1	0,33±0,58^{f}	Combretum collinum	2	4	0	2,00±2,00^{d}
Acacia nilotica	6	5	2	4,33±2,08^{c}	Combretum glutinosum	3	0	0	1,00±1,73^{e}
Acacia polyacantha	0	0	1	0,33±0,58^{f}	Commiphora africana	4	0	0	1,33±2,31^{e}
Acacia senegal	1	3	3	2,33±1,15^{d}	Dichrostachys cinera	0	3	0	1,00±1,73^{e}
Acacia seyal	0	0	4	1,33±2,31^{e}	Feretia apodanthera	0	0	0	0,00±0,00
Acacia tortilis	3	5	12	6,67±4,73^{b}	Grewia barteri	1	3	0	1,33±1,53^{e}
Albizia lebbeck	0	0	3	1,00±1,73^{e}	Guiera senegalensis	1	0	2	1,00±1,00^{e}
Anogeissis leiocarpus	1	0	0	0,33±0,58^{f}	Piliostigma thonningii	9	5	15	9,67±5,03^{a}
Azadirachta indica	4	3	23	10,00±11,27^{a}	Scleocarya birrea	0	1	1	0,67±0,58
Balamites aegyptiaca	0	0	0	0,00±0,00^{g}	Tamarindus indica	2	2	9	4,33±4,04^{c}
Bridelia ferruginea	3	0	0	1,00±1,73e	Ziziphus moritiana	1	0	0	0,33±0,58^{f}
Cadaba farinosa	0	2	0	0,67±1,15f	Gardenia aqualla	0	0	0	0,00±0,00^{g}
Cadaba glandilosa	5	0	0	1,67±2,89^{e}	Callotropis procera	0	2	0	0,67±1,15^{f}
Capparis faxicularis	0	2	0	0,67 ±1,15^{f}	Moy/Ecart	1,62 ±2,23b	1,38 ±1,78b	2,79±5,38a	

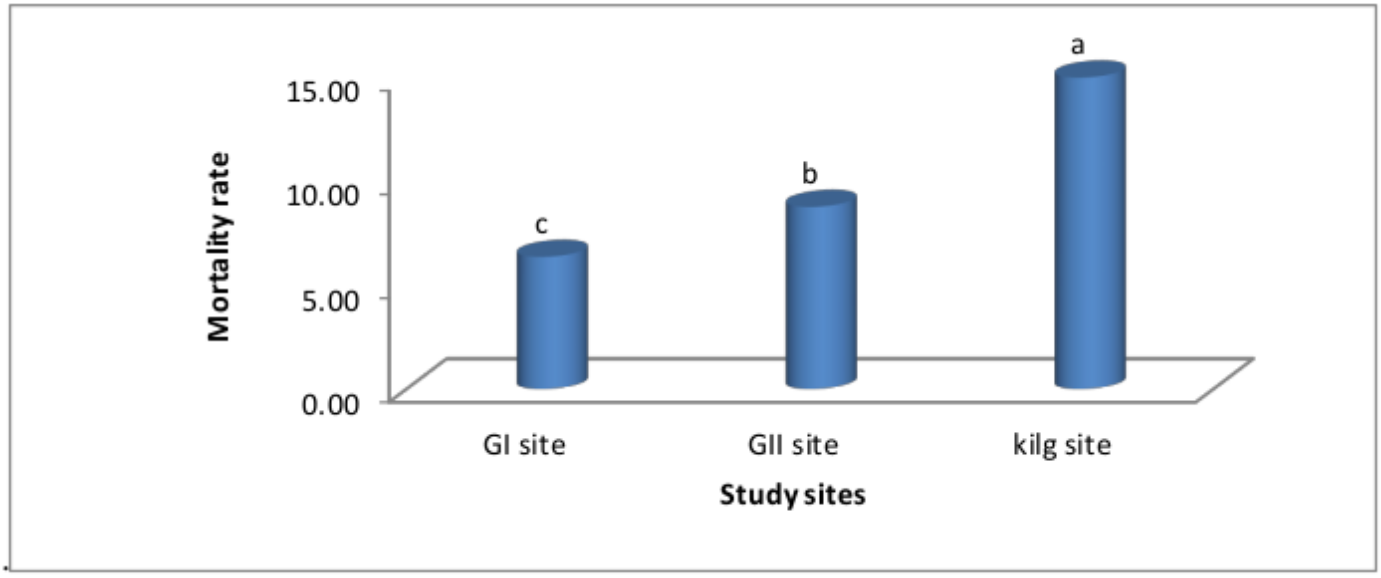

Figure 2. Percentages of mortality rate of species.

Table 5
Floristic composition and floristic diversity index of reforested sites

Sites	GoingI	GoingII	Kilguim
Individuals	332	286	246
Families	10	13	12
Genuses	12	11	8
Species	18	25	24
ISH	2,71	2,55	1,92
EQ	0,48	0,46	0,33
ISH/EQ	5,81	5,66	5,51
D	0,25	0,09	0,11

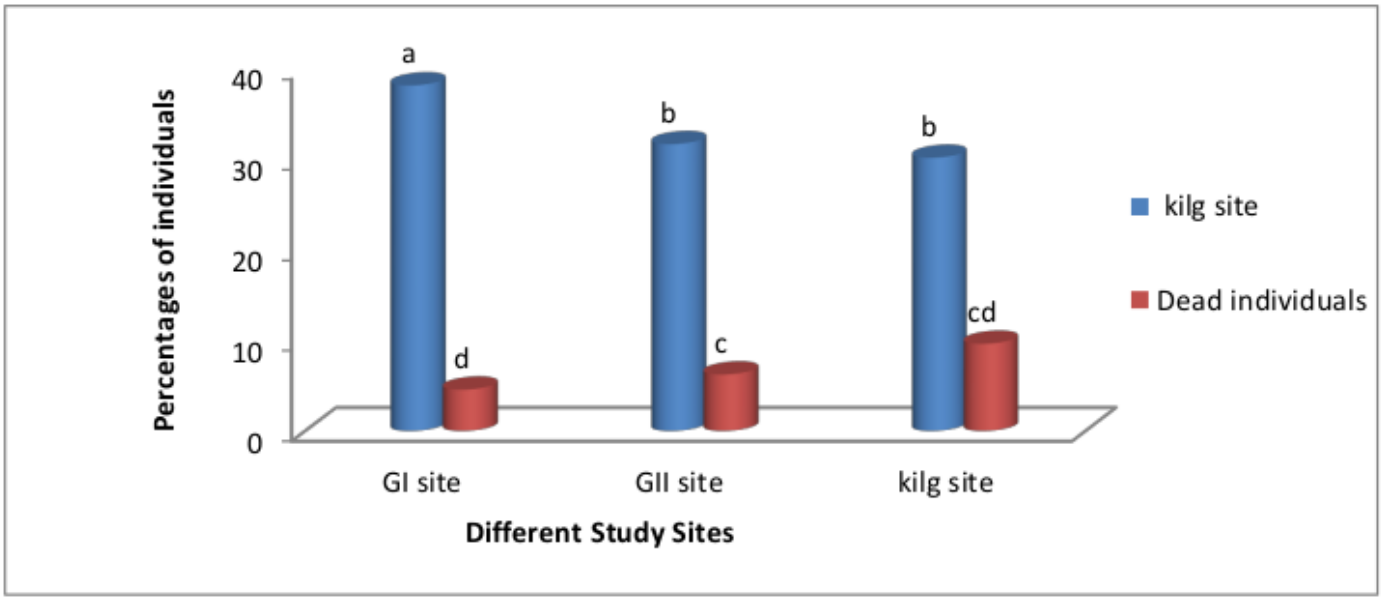

Figure 3. Percentages of living and dead individuals

The calculations of Piélou's equitability attached to the Shannon index confirms the fluctuations between the values of diversity index. In effect, the equitability values vary between 0.33 and 0.48 and the ratio of the index of Shannon to that of equitability, is almost constant as well as that Simpson diversity (D) index are almost identical. In a general manner, there is thus more chance that equilibrium exists in the distribution of reforested species.

3.5. Ecogical repartition of species in the reforested sites

Figure 4 illustrates the histogram frequency of ligneous species inventoried in different sites. Rare species (06.67%) is the case of the species index (I) with a total of 11 species, (36.67%) of species having a frequency index equal to (II) and are termed accessory species. Species whose frequency index is equal to III, represents 13.33% of the inventoried flora. Species with index of IV represents 30%, 09 species of the inventoried flora are species said to be frequent and very frequent species are those with index equal to V, representing 13.33% with 04 species. The result presents in the form of a deformed M. the frequency index equal to II, accessory species (36.67%) are more represented followed by frequent species of index IV (30%). This structure of the vegetation translates a certain heterogeneity of milieu because of reforestation and the prohibitio Tchobsala (2011) of the sites. This result is different from that of$ in the peri-urban savanna of Ngaoundere which is in the form of an L and which shows that the vegetation represents more accidental species of index I (84%).

i. Floristic family diversity of different study sites

In this study, 864 individuals were encountered, they belong to 13 botanical families. The percentages of families vary in relation to sites, figure 5. Notwithstanding, certain families are present in certain sites but absent in others. Families of species present in the Going I site: in this site, we encountered 220 species for 10 families: Anacardeaceae (10), Balamitaceae (22), Caesalpiniaceae (149), Capparaceae (2), Combretaceae (85), Meliaceae (16), Ramnaceae (5), Minosaceae (20), Rubiaceae (19) and Ascléapidaceae (01).

The Going II site presents for 13 families: Anacardeaceae (03), Balamitaceae (21), Barsenaceae (17), Caesalpineaceae (25), Capparaceae (2), Combrétaceae (52), Euphorbiaceae (2), Meliaceae (28), Mimosoceae (72), Rhamnaceae (8), Rubiaceae (26), Tilliaceae (16) and Asclepiadaceae (1). The Kilguim site presents 260 individuals and 59 species, 12 families: Balaniteaceae (30), Burseraceae (1), Caesalpipeaceae (40), Capparaceae (30), Burseraceae (1), Casalpipeaceae (40), Caparaceae (10), Compretaceae (12), Euphorbiaceae (1), Miliaceae (54), Mimosaceae (99), Rhamnaceae (1), Rubiaceae (4), Tilliaceae (5) and Asclepidaceae (3).

In the Kilguim represents 260 individuals, 59 species and 12 families.

Family floristic diversity shows that the Mimosaceae and Caesalpineaceae are the most abundant thus the dominant families of the study sites, followed by the Combretaceae and Meliaceae which are more or less represented in the different study sites. It contributes to the floristic richness of ligneous plants. This result shows that Mimosaceae, Caesalpineaceae and Combretaceae are the most adapted families in the Mayo-Kani zone. This result corroborates with that of Boubacar (2010) at the Faculty of Science/ UAM in Niamey Niger that the most represented families in reverdis are the Mimosaceae (17.39%), Cesalpineaceae (13.04%) and Combretaceae (13.04%). For (P= 0.5147), there exist no significant statistical effect on the number of families recorded in the three sites of study at a confidence level of 95.0%.

ii. Specific diversity of vegetation of sites

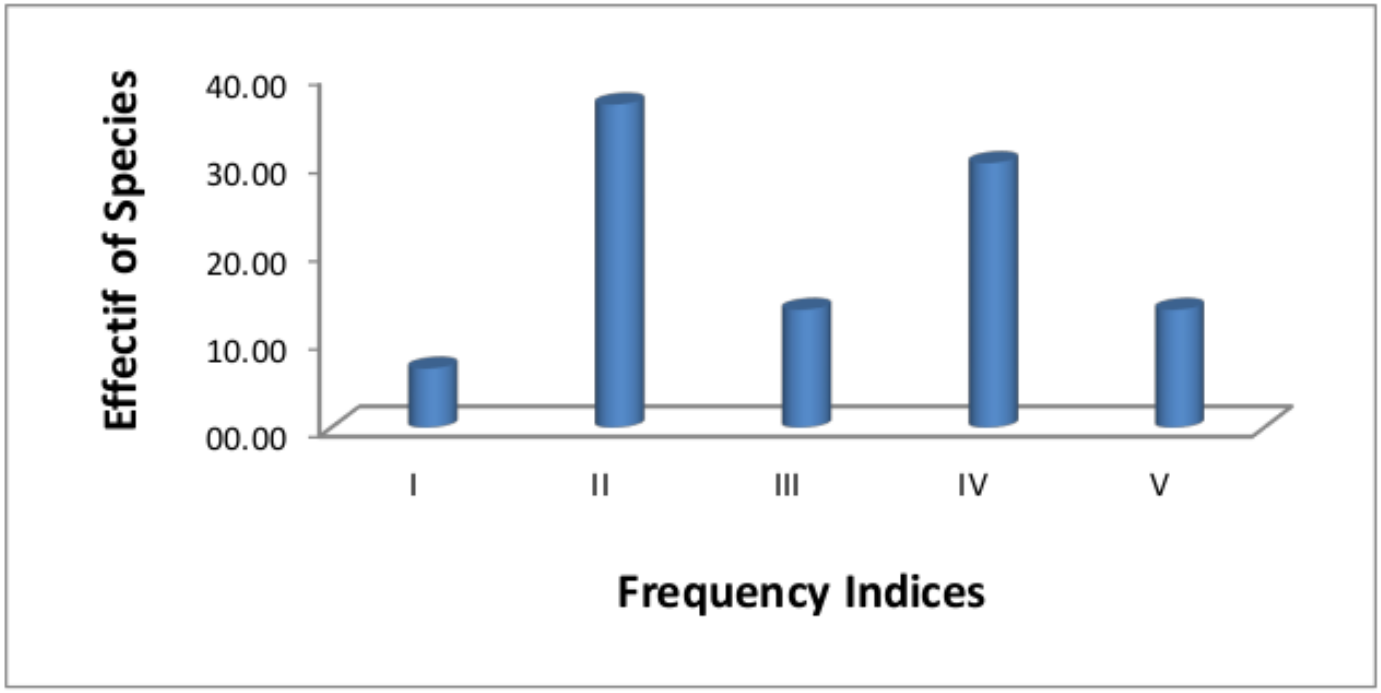

Figure 4. Effect of species according to frequency indices

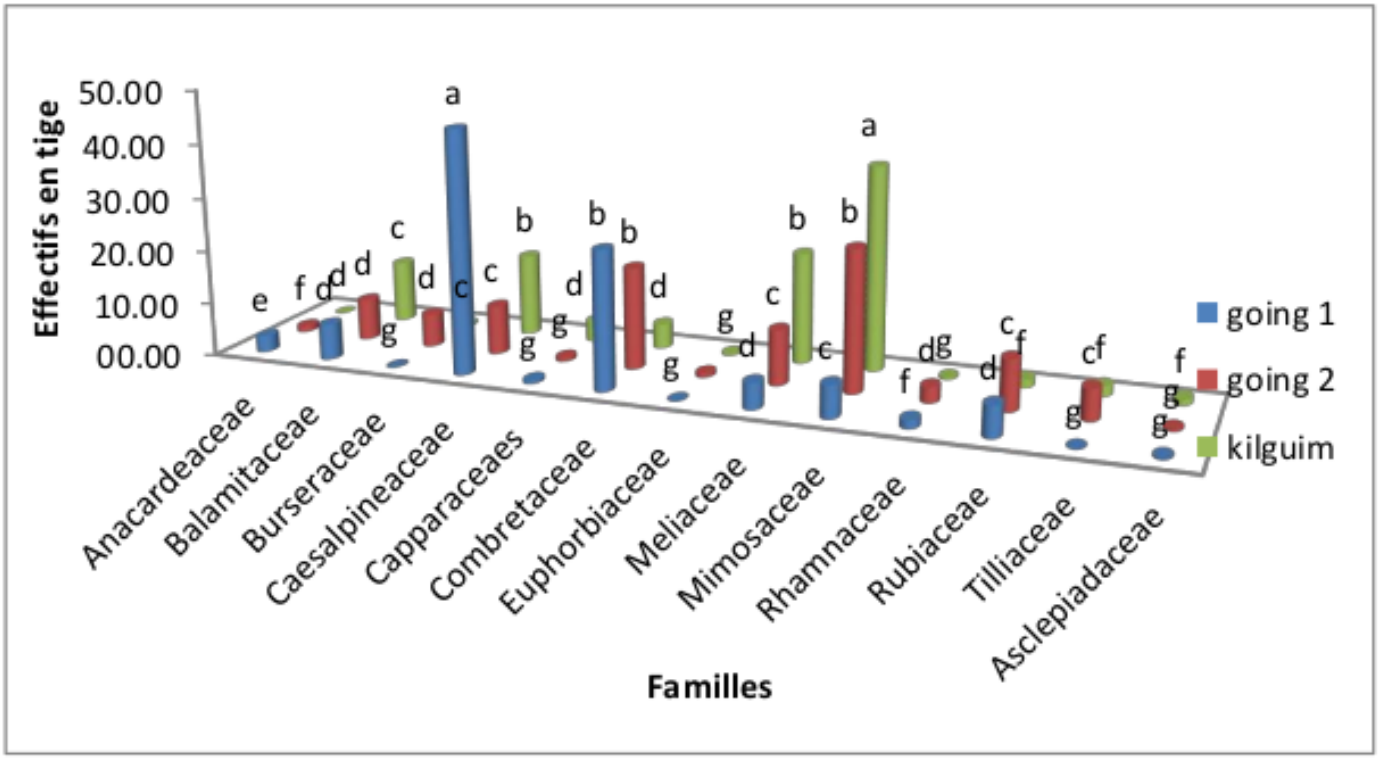

Figure 5. Families of the vegetation of sites with respect to stem effectif

Analysis of floristic richness has permitted the identification of 30 species in all the sites. Table 6 shows the list of inventoried species; the most frequent species are: Balanites aegyptiaca with 135 individuals and a relative frequency of 4.49% followed by Piliostigma thonningii with 124 inventoried individuals with a relative frequency of 4.49% followed by Anogeissus leiocarpus with 93 individuals.

Inventoried species are repartition in 13 familiesTable 7. Certain families are represented by a great number of species like the Caesalpineaceae family with 214 species, followed by the Mimosaceae and Combretaceae with 191 and 149 species respectively.

iii. Structure of the vegetation in relation classes of height

Figure 6 represents the structure of the vegetation in relation to the different classes of height in all the three sites put together. The vegetation presents a structure in the form of a cloche translating a homogeneity, more or less acceptable of the ligneous strata. The numbers of stems are more elevated in the class of 1 to 1.50m length and averagely elevated between the classes of 0.5 to 1m and 1.50 to 2m in the three sites of study. The increase in the number of stems in the class 1 to 1.50m shows that the vegetation of reforested sites is impotant. These results are justified by the fact that these three sites were all reforested in the same year, 2013.

iv. Distribution of plant vegetation in classes of DBH

All the trees of the three reforestation sites in the three villages presents a structure in the form of a cloche «^», translating a good regeneration of plant species used. In the reforested sites, there is a reduction in the number of individuals when the diameter of the trunk of trees increases (Figure 7). In a general manner, reforestation impacts the structure and repartition of species in reforestation sites. The vegetation presents a structure in the form of cloche "^" because of reforestation and the prohibition of reforested sites. These results do not corroborate with that of Mbolo (2005) on the typology and cartography of Dja Biosphere Reserve of Cameroon, which shows that the vegetation presents an "L" structure because of the high pressure mounted on it by the cutting of trees.

3.6. Distribution of the vegetation in function of trunk diameter

The vegetation presents a structure in the form of a cloche, with many individuals which develop instantaneously because of reforestation process and the prohibition of these sites (Figure 8). Such a structure generally translates from a good development of arborescent strata of plant communities. Reforestation effectively impacts the structure and distribution of species in the natural savanna. Variance analysis shows that there exists a highly significant difference ($0.001 < 0.05$) between the classes of trunk diameter. These results are similar to those of Anonymous (1987) on the valorization of arid territories and the fight against desertification.

3.7. Analysis of variables of principal components

Analysis of variables of principal components (ACP) shows that the Going I village and Going II are positively correlated between them and are opposite to that of the Kilguim village with respect to the abscissa axis (Figure 9). Species such as *Piliostigma thonningii, Balanites aegyptiaca*, *Anogeissis leiocarpus*, *Combretum glutinosum* and *Azadirachta indica* are the most represented in the study zone. Species dispersed in more dense parts are does that we have the chance of at least encountering them in all the study zones. The other species which are less represented forms clouds around the two (f1 and f2 axis: 92.48%). Species represented in the form of clouds are less dense thus we cannot encounter them in all the study sites.

3.8. Durable exploitation of reforested sites

The protection and restoration of nature, has to be essentially looked after by a rational organization, targeting the deletion of causes of degradation and to reassure the regeneration of the vegetation with both ligneous and herbaceous species alike (Ferlin, 1981). With respect to data of inquiries and those of floristic recordings, it becomes possible for us to make a certain number of remarks and then envisage an organization plan. To better preserve and conserve biodiversity of reforested sites, Table 8 shows seventeen (17) propositions on the organizational plan, were chosen by the population and the organizations that take part in reforestation programs. The sensitization of the local populations on the role of trees (68.57), presents a very elevated mean, followed by implication of communities in decisions affecting their environment (67.14) and finally sensitize the community and the decentralized collectivity on the great environmental problems to which the community and decentralized collectivity are faced with in the Septandrion zone (54.29). According to Sahel et al., 2014, the outcome of community and decentralized collectivity sensitization in the framework of reforestation is indispensible for the setting up of sylviculture activities in the context of durable management of natural resources.

Values designated or given the same letter has no significant differences at a threshold of 0.05.

4. CONCLUSION

This present study was a question of researching and bringing out the problems of reforestation in the Mayo-Kani division, more precisely the Going I, Going II and Kilguim reforestation sites, all established in 2013. At the end of our different investigations, many reforestation problems were encountered with the most sited amongst others being: bush fire (83.50 ± 16.01), lack of plausibility studies (78.50 ± 13.99), lack of boreholes (76.00 ± 19.10), lack of specialised structures in the reforestation domain (72.83 ± 13.03) and insufficient sensitization on the importance of reforestation (71.67 ± 27.55). The anthropization indices are remarkable. Burning was observed in the three (03) study sites (82.67 ± 6.43). The practice of bush fire is translated by the dissatisfaction of forest guards and more especially the ignorance of the population on the importance of reforestation. The felling of trees for wood (68.00 ± 12.17) in the sites is an activity that dominates after that of bush fire and then followed closely by pruning

Table 6
Frequency, Density, Dominance, Curtis Importance Value and Number of Individuals of Species

Species	Ne	DeR	DR	Fre	IVIE
Acacia ataxacantha	15	1.73	1.58	3.23	6.53
Acacia hockii	12	1.39	0.28	3.87	5.53
Acacia nilotica	27	3.12	0.82	3.87	7.81
Acacia polyacantha	2	0.23	0.21	1.94	2.38
Acacia senegal	1	0.12	0	1.29	1.41
Acacia seyal	16	1.85	0.42	3.23	5.49
Acacia torticolis	99	11.43	6.81	4.52	22.76
Albizia lebbeck	6	0.69	0.09	4.52	5.3
Anogeissus leiocarpus	1	0.12	0.05	0.65	0.81
Azadirachta indica	96	11.09	1.6	4.52	17.2
Balan ites aegyptiaca	69	7.97	2.74	5.81	16.51
Bridelia ferruginea	2	0.23	0.09	1.29	1.61
Cadaba farinosa	7	0.81	0.35	3.23	4.38
Cadaba glandilosa	6	0.69	0.16	13.55	14.4
Capparus faxicularis	16	1.85	0.71	4.52	7.07
Combretum accumulaetum	80	9.24	2.52	5.16	16.92
Combretum adenogonium	12	1.39	0.66	3.23	5.29
Combretum collinum	16	1.85	0.43	1.94	4.21
Combretum glutinosum	52	6	1.19	4.52	11.71
Commiphora africana	18	2.08	0.65	1.94	4.66
Dichrostachys cinera	6	0.69	0.02	1.94	2.65
Feretia apodanthera	32	3.7	63.91	3.87	71.47
Grewia barteri	21	2.42	1.26	1.29	4.98
Guiera senegalensis	10	1.15	0.14	1.29	2.58
Piliostigma thonningii	210	24.25	2.77	5.16	32.18
Scleocarya birrea	13	1.5	10.05	1.94	13.49
Tamarindus indica	3	0.35	0.1	0.65	1.09
Ziziphus mauritiana	11	1.27	0.25	3.87	5.39
Gardenia aqualla	2	0.23	0.16	1.29	1.68
Callotropis procera	5	0.58	0	1.94	2.51
	866	100	100	100	300

NI= Number of individuals, FR= Relative frequency, DeR= Relative density, DR= Relative dominance, IVCR= Curtis relative importance value.

Table 7
Frequency, Density, Dominance, Curtis Importance Value, Number of Species and Genus of Families

Families	Ni	DeR	DR	Fre	IVIE
Anacardeaceae	13	1.5	10.05	1.94	13.49
Asclepiadaceae	5	0.58	0	1.94	2.51
Balanitaceae	73	7.97	2.74	5.81	16.51
Burseraceae	18	2.08	0.65	1.94	4.66
Caesalpiniaceae	214	24.6	24.6	24.6	24.6
Capparaceaes	14	4.04	1.36	34.84	40.23
Combretaceae	149	19.63	4.94	16.13	40.7
Euphorbiaceae	3	0.23	0.09	1.29	1.61
Meliaceae	98	11.09	1.6	4.52	17.2
Mimosaceae	191	21.25	10.23	28.39	59.87
Rhamnaceae	14	1.27	0.25	3.87	5.39
Rubiaceae	49	3.93	64.06	5.16	73.15
Tiliaceae	21	2.42	1.26	1.29	4.98
	862	100	100	100	300

NG= Number of genus, FR= Relative frequency, DeR= Relative density, DR= Relative dominance, IVCR= Curtis relative value of importance.

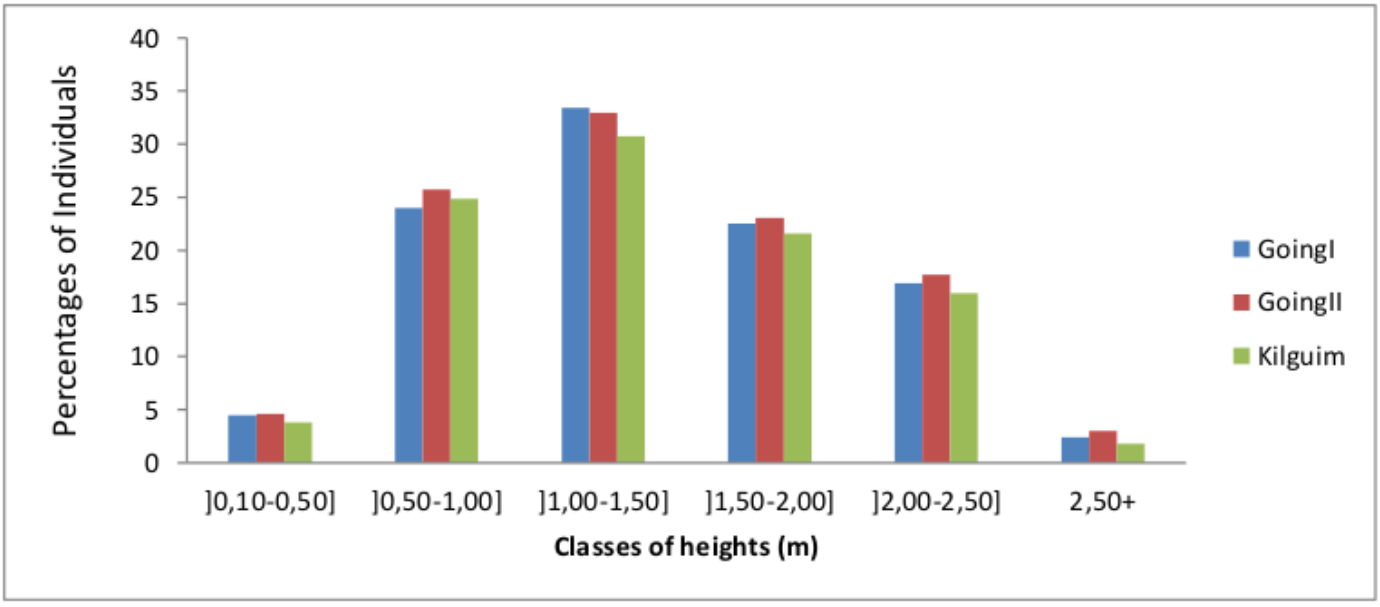

Figure 6. Structure of vegetation in relation to classes of height

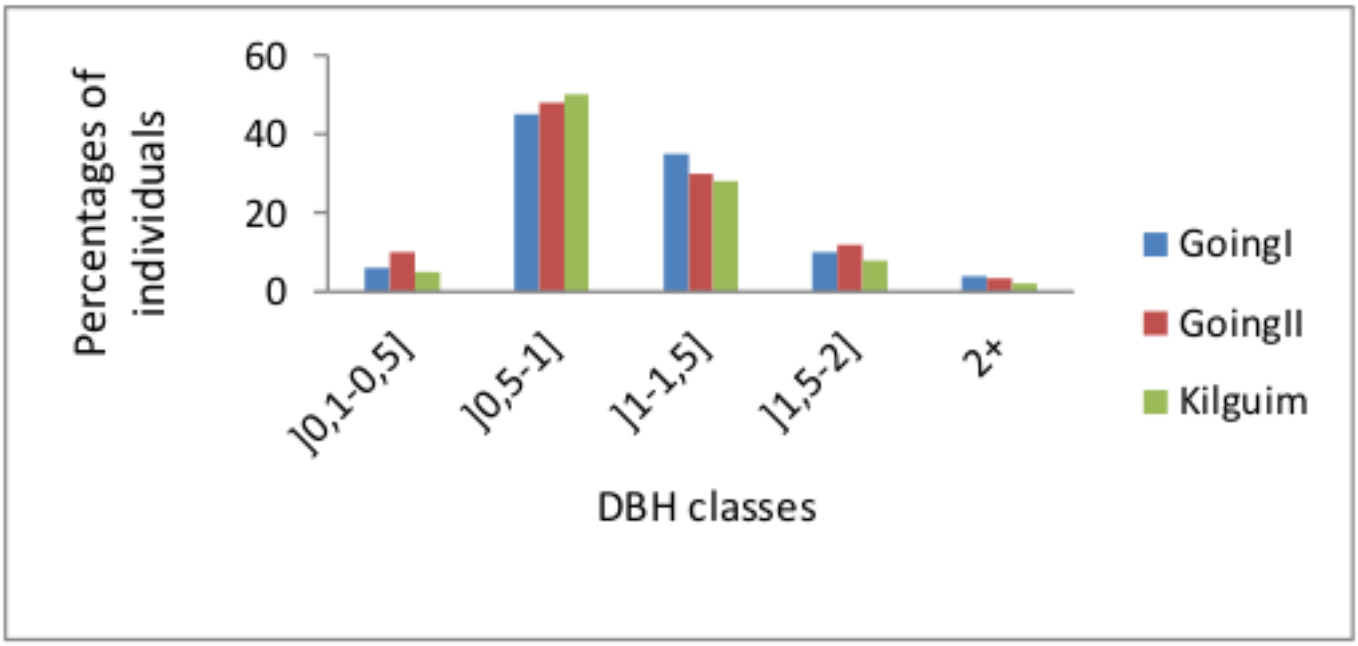

Figure 7. Structure of the vegetation in relation to the classes of DBH

(64.00±9.17). These activities show access to the reforested sites despite its prohibition. The mortality rate is 15% in the Kilguim site, 6.36% in the Going I site and 8.79% in the Going II site. This rate is too elevated in the Kilguim site because of its soil quality (Figure 6), lack of maintenance, caused either by a lack of boreholes for watering or by the passage of bush fire. The result of the floristic inventory shows that the Going I site (2.71 bits) of Shannon's diversity calculated has the most elevated diversity than the Going II and Kilguim sites, Mimosaceae, Caesalpineaceae and Combretaceae are the most adapted families in the Mayo- Kani zone. Accessory species (frequency index II) (36.67%) are mostrepresented. The vegetation presents a cloche structure. This structure of the vegetation translates a certain heterogeneity of the milieu because of reforestation and the prohibition of the sites. The problems of reforestation are due to population's ignorance of the hidden treasures of reforestation (environmental, socio-economic importance…). A good reforestation program necessitates a good plausibility study from the onset. According to ANAFOR, the creation of forestry plantations is a long-

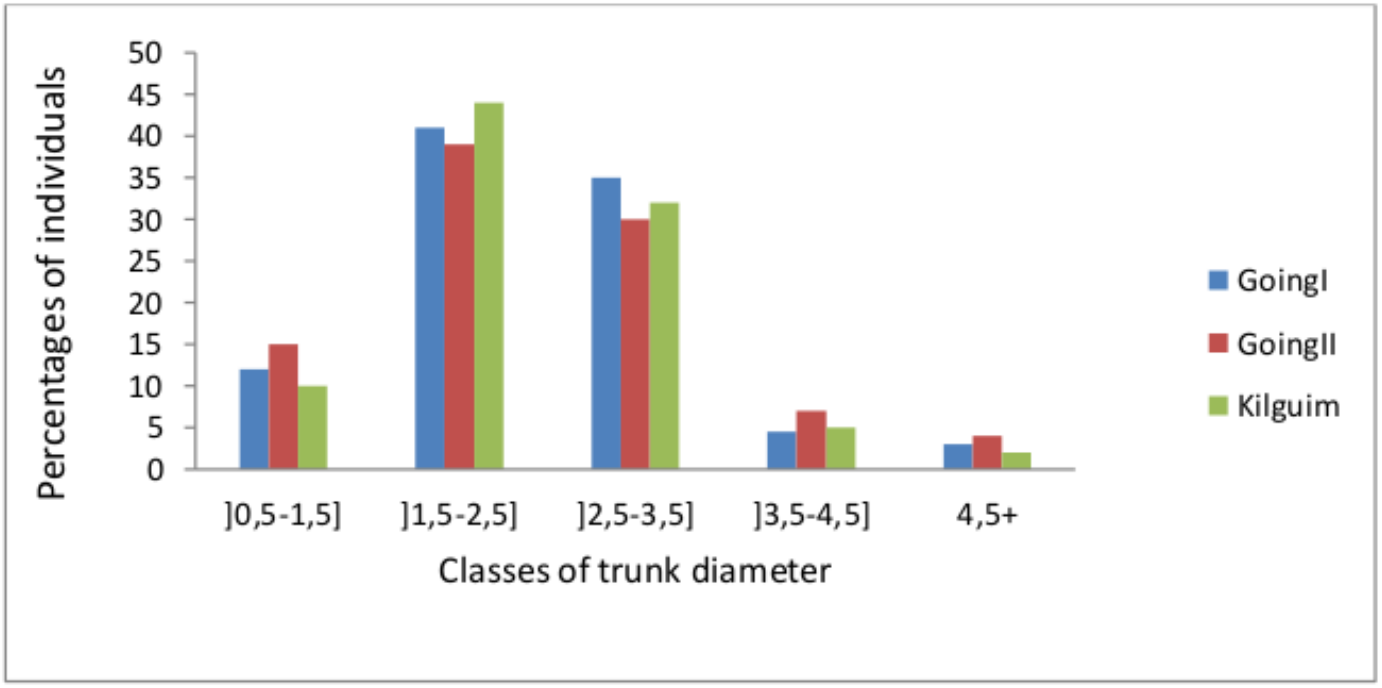

Figure 8. Vegetation structure in relation to trunk diameter

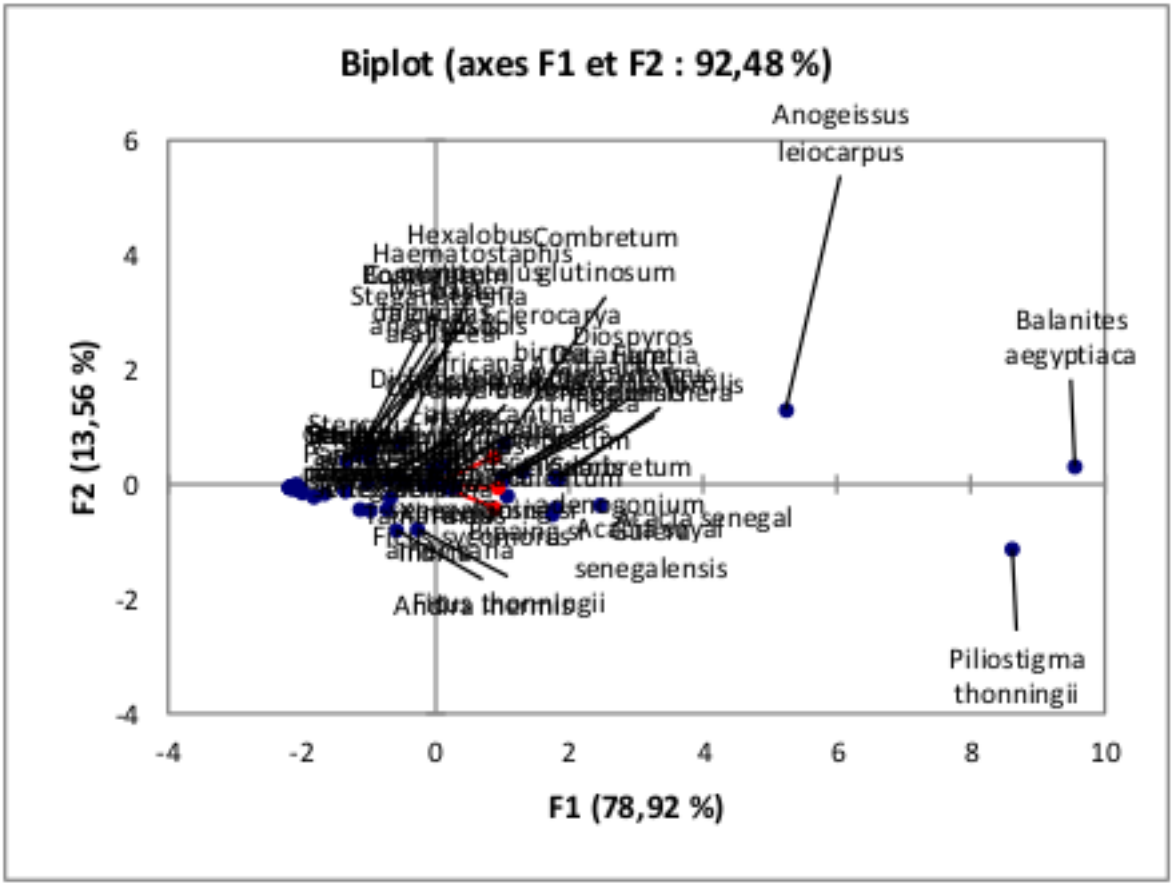

Figure 9. Distribution of inventoried species

Table 8
Proposition of a plan of durable management of reforested sites

Propositions	GoingI	GoingII	Kilguim	Moye/Ecart
Sensitization of the population on the importance of reforested sites.	57,14	61,43	68,57	68,57±14,55a
Identification and protection of reforested sites	17,14	34,29	20	20,00±4,24e
Maintenance and pruning of reforested sites	30	38,57	34,29	34,29±7,27d
Common technical follow up by the local population	28,57	18,57	25,71	25,71±5,45e
Follow up assisted by MINFOF, CTFC, and MINEP.	14,29	7,14	45,71	45,71±9,70c
Durable management of natural resources of reforested sites	31,43	31,43	22,86	22,86±4,85e
Creation of local employment and structuration of reforestation field.	21,43	11,43	15,71	15,71±3,33f
Implication of communities in reforestation	54,29	64,29	67,14	67,14±14,24a
Fight against the burning of reforested sites	67,14	64,29	27,14	27,14±5,76e
Help of supplimentary experts	28,57	10	20	20,00±4,24e
Professionalization of GIC for reforestation	20	20	17,14	17,14±3,64f
Execution of reforestation programs within date limits	25,71	27,14	35,71	35,71±7,58d
Maintenance of community forest by the council	30	20	32,86	32,81±6,97d
Planification and programmingreforestation activities	27,14	22,86	32,86	30,00±6,36d
Reorganize the system of control of reforested sites	12,86	17,14	14,29	14,29±3,03f
Sensitize the communityand the decentralized collectivity on the problems of reforestation	22,86	44,29	54,29	54,29±11,52b
Valorize existing technological and scientific technics, and develop new durable management tools for reforested sites	42,86	47,14	52,86	52,86±111,21b
Mean/Standard deviation	21,88± 10,80b	22,24± 15,48b	24,18± 12,76a	

term investment which occupies the earth for many years. That is the reason why we have to avoid or minimize onset errors because it at times become impossible to correct them after some years. We also note amongst others, the lack of experts in the management of reforested sites by the council after the transfer of competence opens a path way for discount results in the reforestation program and even at the reforestation operation scale. In perspective, it will be judicious: to extend the study site to all the reforested sites in the Extreme-North in order to be able to identify all the problems faced by reforestation; identify the major problems erode the success of reforestation operations in the sahelian zone of Cameroon: case of Extreme-North; to carry out a deep preliminary field study and adaptation of species to the milieu earmarked for reforestation programs; further research on better strategies (technics and methods) for a durable development of reforestation sites for the conservation of biodiversity.

5. DECLARATION OF INTEREST STATEMENT

The authors declare that they have no conflict of interest with regards to the manuscript.

ACKNOWLEDGMENTS

We also address our recognition to all the people who, by their availability, took part for the realization of this work.

ORCID

Kodji Paul	0000-0001-5752-8349
Tchobsala	0009-0007-5317-8995
Beyang Ware Guidakre	0009-0003-0724-0875
Haiwa Gilbert	0009-0006-0861-886X
Dieudonne Djackba Danra	0009-0001-5737-6637
Souare Konksala	0009-0007-0678-6592

REFERENCES

ABIOGeT., 2016. Youth Green Jobs Project: "05 million trees"., . ABIOGeT 2016-2020 forestry action plan (PAFA 2016-2020). Canada.

Anonymous., 1987. The development of arid territories and the fight against desertification: Integrated strategy. UNDP, USSR Commission, Moscow.

Boubacar, H., 2010. Biophysical characterization of woody resources in degraded and revegetated areas in the Sahel. Diploma of Advanced Studies in Applied Biology, Faculty of Sciences /UAM, Abdou Moumouni University, Niamey –Niger.

CTFC., 2011. Appuyer les collectivités locales et leurs communautés sur les activités de plantation forestière, In : Rapport de l'atelier international de réflexion et d'échange tenu au CTFC. Cameroun, Yaoundé, pp. 59-61.

Haiwa., 2013. Impact of deforestation on vegetation dynamics in the department of Mayo-Kani (canton of Lara). 92p..

Mbolo., 2005. Typology and cartography of the Vegetation of the Dja Biosphere Reserve. State thesis. 131p.

MINFOF., 2003. Cellule de suivi de la Régénération du Reboisement. Programme national de reboisement. Pp. 27-33.

Poissonnet, J., César, J., 1972. Specific structure of the herbaceous stratum in the palm savannah of Lambo (Ivory Coast). Ann. United. Abidjan, E. 5(1), 557–601.

RIDDAC., 2016. . RIDDAC - Portal of Forests, Environment and Sustainable Development in Central Africa, the reforestation campaign in Cameroon intensifies.

Ruralter., 2010. VSF-CICDA –Agronomists and Veterinaries sans frontiers, Lyon -France, 2010An innovative community reforestation experience in Haiti, method, results and analysis. Florian Delerue, Haïti.

Saleh, A., Djingui, T., Okenye, M., 2014. Evaluation of large-scale reforestation in the Far North Region.

Tchobsala., 2011. Impact of logging on the natural vegetation of the peri-urban area of Ngaoundéré (Adamaoua). . 204p.