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Characterisation of the woody flora in sites developed on the plateau and slope of the Satara land reclamation site for sylvo-pastoral purposes (Simiri/Niger commune)

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Abstract

In western Niger in general, and in the Tillabéri region in particular, major efforts have been made in terms of land restoration. The aim of this study is to assess the woody flora at the top and on the slope of the rehabilitated Satara plateau (western Niger). The study therefore selected a sub-site on the plateau and a sub-site on the slope of the same plateau. In each sub-site, structures were selected on transects, in which the various observations were made. The floristic composition was determined on the basis of an inventory. The survival of the woody species planted was assessed by calculating the survival rate. The dendrometric parameters measured were the height and diameters of the trunk and crown. The estimation of sequestered carbon was based on allometric equations. The results revealed a rich floristic diversity of nine (9) woody species divided into six (6) families, dominated by the Mimosaceae family. The spontaneous species are dominated by *Guiera senegalensis*, which has a specific contribution of 80% on the slope. The average density of woody species is 170.5 ± 30 feet/ha and $1,301 \pm 350.57$ feet/ha on the plateau and slope respectively. The survival rate was 59.12% and 69.75% respectively in the site developed on the plateau and the slope. The values of the dendrometric parameters are higher on the plateau than on the slope. The diameter of the trunk is 10.71 cm and 1.99 cm respectively on the plateau and the slope. The total carbon stock on the plateau and slope is 11,439.23 kg and 5,888.5 kg respectively. The study is helping to consolidate knowledge of plateau development.

Keywords: Developed site, woody plants, plateau, slope, Simiri.

1. Introduction

Niger is a Sahelian country that has been experiencing a decline in its plant and wildlife resources for decades, as a result of land degradation (Larwanou, 2005) ^[1]. This degradation has been spectacular since the 1970s, following the disappearance of the plant cover that protected the soil (Zoubeirou and Karim, 1997) ^[3]. Cultivated land, grazing land and forests are among the resources most affected (Moussa *et al.*, 2024) ^[3].

The Tillabéri region (western Niger) is one of the areas that has suffered most from land degradation. In the past, this region had enormous forest resources, including tiger bush. The biodiversity of the latter has been significantly reduced by the droughts of the 1970s and 1980s and by human activities (Moussa *et al.*, 2022; Vieri *et al.*, 2014) ^[4, 5]. The consequences include the degradation of vegetation cover, the appearance of glaciais, the silting up of watercourses and a fall in agricultural yields, in a context of demographic growth (Vieri *et al.*, 2014; FAD, 2008) ^[5, 6]. It should be emphasised that these consequences further weaken people's resilience to shocks, including food insecurity.

In view of the growing vulnerability of populations, a number of techniques have been developed for reclaiming agro-sylvo-pastoral land. Commonly known as Water and Soil Conservation/Soil Defence and Restoration (CES/DRS)

techniques, these promote, among other things, the regeneration of plant cover, water infiltration and improved soil fertility (Laminou *et al.*, 2020; Moussa *et al.*, 2025) ^[7, 8]. The results of these CES/DRS techniques are highly variable in space (Douma *et al.*, 2011; Amani *et al.*, 2021) ^[9, 10]. It is in this context that the present work was carried out with a view to studying woody vegetation in two different components of a landscape unit. The aim was to assess the woody flora at the top and on the slope of the Satara plateau in western Niger.

2. Materials and Methods

2.1. Study area and sites

The rural commune of Simiri is the study area (Fig 1). The main town of the commune is located 78 km from Niamey (the capital of Niger). The area is characterised by the landscape units (plateaux, sandy skirts, glaciais and lowlands) that characterise western Niger (Ambouta *et al.*, 1996) ^[11]. On the plateaux, regosol and lithosol soils formed on clayey sandstone from the Continental Terminal are found (Ambouta, 1997) ^[12]. The soils of the sandy skirt and glaciais are of the tropical ferruginous type with little leaching. Alluvial soils are found in the lowlands (Moussa *et al.*, 2013) ^[13]. The climate is Sahelian, with annual rainfall ranging from 200 to 400 mm (Laminou *et al.*, 2020) ^[7].

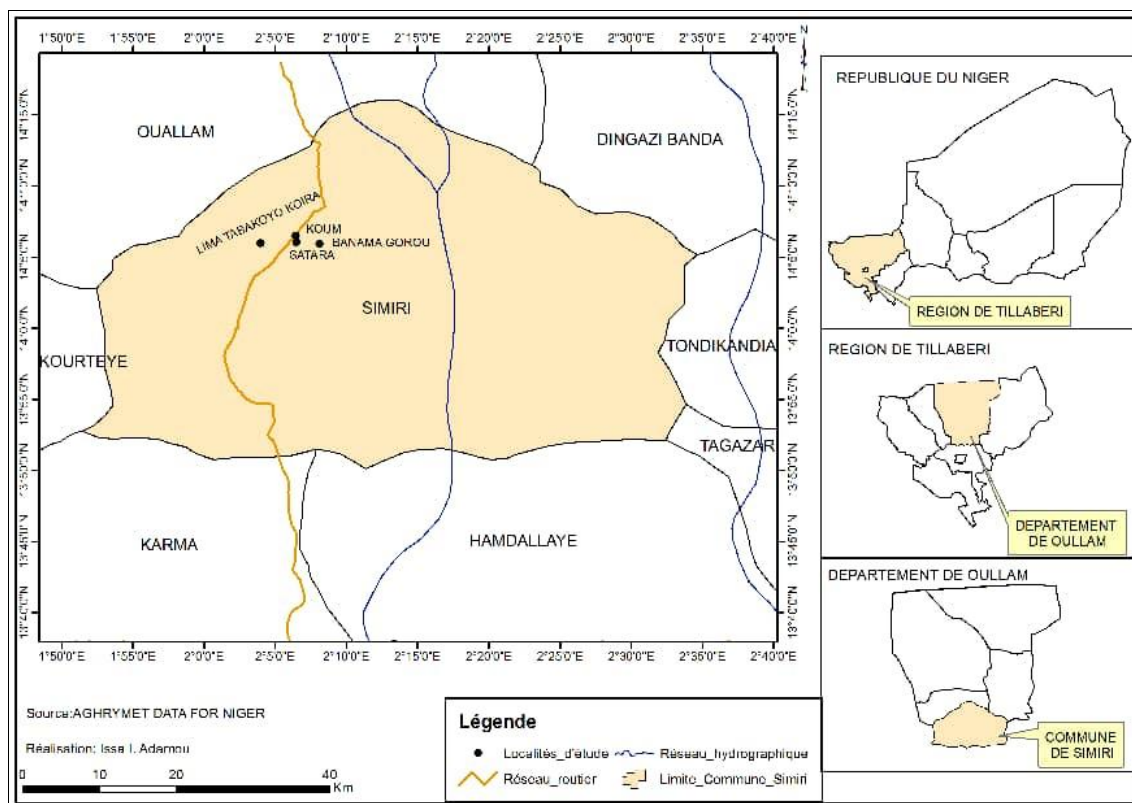


Fig 1: Location of the study zone

The study site is the restored Satara plateau. The plateau is characterised by lateritic, armoured and bare soil. There were a few copses in places, made up of Combrétacées and a discontinuous herbaceous carpet under the ligneous plants. The study covered two (2) sub-sites:

- A restored sub-site on the plateau (summit) where the

enhancement techniques are sylvo-pastoral benches and half-moons (Fig 2);

- A restored sub-site on the slope of the same plateau (Fig 3) where sylvo-pastoral trenches have been made.

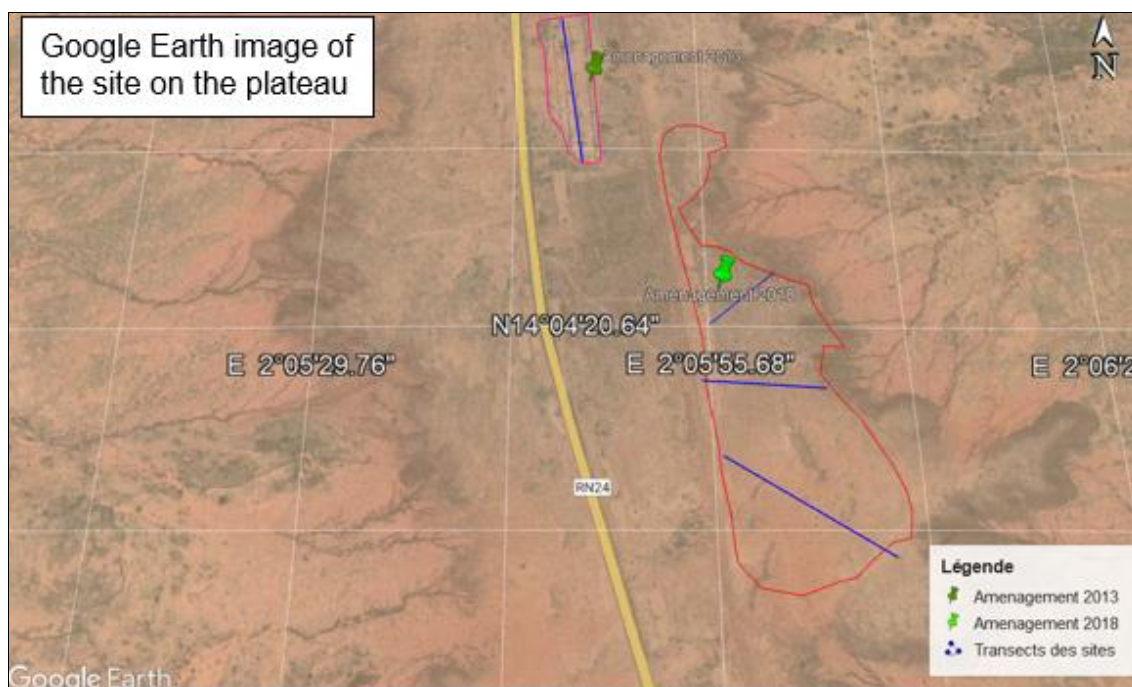


Fig 2: Location of the sub-site on the plateau

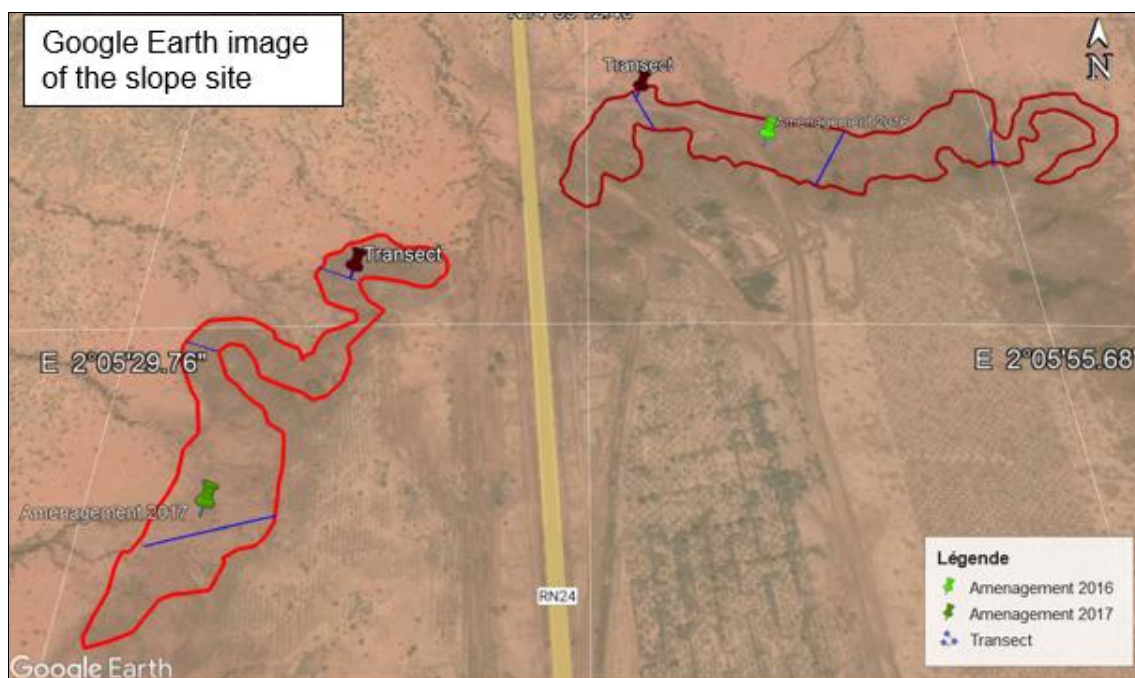


Fig 3: Location of the sub-site on the slope

2.2. Study of ligneous vegetation

The inventory was systematic and covered planted and spontaneous woody species in land reclamation techniques crossed by transects. The dendrometric parameters measured were height, trunk diameter at 20 cm and 1.30 m and crown diameter (Fig 4). All woody species with a

diameter of less than 1.3 m were considered to be young regenerations. One (1) control site was identified in each geomorphological unit, in which a 50 m x 40 m plot was set up for the various observations. Four (4) to three (3) 100 m x 100 m plots were set up in each layout to assess the survival rate of planted woody plants.

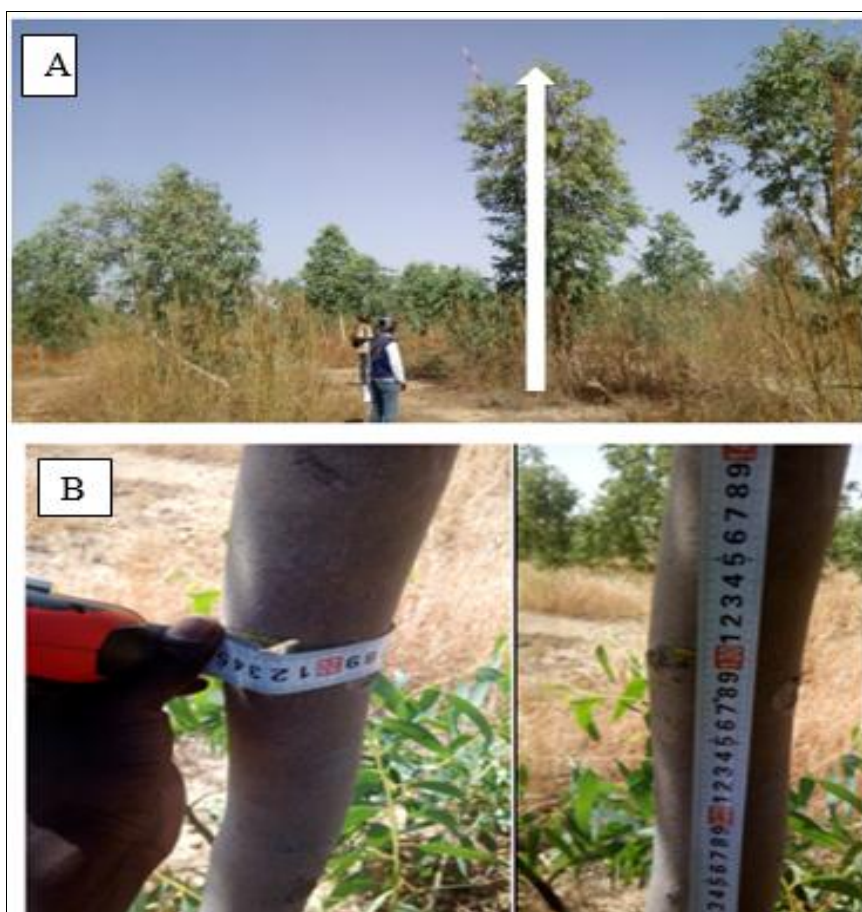


Fig 4: Measurement of the height (A) and trunk diameters of woody plants (B)

The dendrometry parameters were used to determine:

- Specific frequency (Fs): Fs of a species; this is the number of times the species was encountered on all the transects;
- Woody cover (R): $R = (Si/St) \times 100$ where Si = sum of the areas covered by the crowns of the woody species and St = total area of all the recovery techniques used on all the transects on the site;
- Basal cover or basal area (Rb): $Rb = \pi.d^2/4$ where d = trunk diameter at 20 cm or 1.3 m from the ground;
- Density (D): $D = (Ni/St) \times 100$ where Ni = number of woody plants inventoried in the land recovery techniques on all the transects and St = total surface area of the land recovery techniques on the transects;
- Specific contribution (CS): $CS = (FS/Ft) \times 100$ where FS = Specific frequency of a species, Ft = total frequency of all species in the land recovery techniques.

Estimation of carbon stock

The determination of the amount of carbon present in the different tree components was done based on the allometric equations of FAO (1997) [14] and adapted according to the

carbon stock models for the different tree components by Boulamane *et al.* (2013) [15]. The carbon stock models for the different tree components are:

- Trunk SCTr = $191 \times (D2H)$;
- Branch SCBr = $46 \times (D2H)$;
- Leaf SCF = $5,4 \times (D2H)$;

D: diameter at 1.30 m; H: tree height; D and H in metres; SCTr: carbon stock in the trunk; SCBr: carbon stock in the branches and SCF: carbon stock in the leaves.

3. Results

3.1. Floristic composition of ligneous plants

The inventory of woody vegetation revealed 9 species in six (6) families (Table 1). On the developed sites, the dominant families in terms of number of species and specific contribution were Mimosaceae, Caesalpiniaceae and Combretaceae. The species *Acacia senegal* and *Guiera senegalensis* are present in all the managed sites. The species present in all the control sites (reference site) is *Guiera senegalensis*.

Table 1: Floristic composition of ligneous plants

Species	Slope site		Plateau site		Families	CS/F (%)	NE/F
	A	T	A	T			
<i>Acacia senegal</i> *	X		X		Mimosaceae	22.22	2
<i>Prosopis juliflora</i> *	X						
<i>Bauhinia rufescens</i> *	X				Caesalpiniaceae	22.22	2
<i>Piliostigma reticulatum</i>			X				
<i>Combretum micranthum</i>	X				Combretaceae	22.22	2
<i>Guiera senegalensis</i>	X	X	X				
<i>Ziziphus mauritiana</i> *	X		X		Rhamnaceae	11.11	1
<i>Boscia senegalensis</i>	X		X		Capparaceae	11.11	1
<i>Eucalyptus camaldulensis</i> *			X		Myrtaceae	11.11	1
Total	7	1	6	0	6	100	9

A: Recovered site, T: Control site, CSF: Specific contribution per family, NE/F: Number of species per family, X: Species present, *: Species planted.

3.2. Frequency and specific contribution of woody plants

Planted species are the most common. They represent an average specific contribution of 71.08%. This specific

contribution is 48.25% for *Acacia senegal* and 20.02% for *Eucalyptus camaldulensis* (Table 2).

Table 2: Frequency and specific contribution of woody species

Species	Plateau site				Slope site				CSM	
	A		T		A		T			
	FS	CS (%)	FS	CS (%)	FS	CS (%)	FS	CS (%)	A	T
<i>Acacia senegal</i> *	27	32.7	0	0	110	64	0	0	48.25±33.34	0
<i>Prosopis juliflora</i> *	0	0	0	0	1	1.25	0	0	0.62±0.5	0
<i>Bauhinia rufescens</i> *	0	0	0	0	2	2.72	0	0	1.36±1	0
<i>Piliostigma reticulatum</i>	5	9.14	0	0	0	0	0	0	4.57±6.74	0
<i>Combretum micranthum</i>	0	0	0	0	1	1.25	0	0	0.31±0.5	0
<i>Guiera senegalensis</i>	7	11.1	0	0	50	80	2	100	21.25±19.4	100
<i>Ziziphus mauritiana</i> *	1	4.76	0	0	2	2.5	0	0	1.82±1.8	0
<i>Boscia senegalensis</i>	2	9.52	0	0	1	1.25	0	0	2.69±43.4	0
<i>Eucalyptus camaldulensis</i> *	29	40	0	0	0	0	0	0	20.02±20	0
Total	71	100	0	0	167	100	2	100	100	0

A: Recovered site, T: Control site, *: Species planted, FS: Specific frequency, CS: Specific contribution, CSM: Average specific contribution

3.3. Wood density

The density of woody plants varies from one site to another and from one species to another (Table 3). With a density of 1,301 plants per ha, the site on the slope has the densest

vegetation. This high density is the result of the strong presence of the species *Guiera senegalensis*, which has a density of 872 plants/ha.

Table 3: Average density of woody plants per hectare by species

Species	Number of trees per hectare					
	Plateau site	Slope site	Total sites recovered	Control plateau site	Control slope site	Total control sites
<i>*Acacia senegal</i>	64.5	381.5	223	0	0	0
<i>*Bauhinia rufescens</i>	0	26	13	0	0	0
<i>Boscia senegalensis</i>	2.50	0	1.25	0	0	0
<i>Guiera senegalensis</i>	14	872	443	0	1.5	1.5
<i>Piliostigma reticulatum</i>	15	0	7.5	0	0	0
<i>Prosopis juliflora</i>	0	11	5.5	0	0	0
<i>Combretum micranthum</i>	0	10.5	5.25	0	0	0
<i>*Eucalyptus camaldulensis</i>	73	0	36.5	0	0	0
<i>*Ziziphus mauritiana</i>	1.5	0	0.75	0	0	0
Total	170.5±30	1,301±350.57	736±481	0	1.5±0.49	1.5±1

3.4. Survival rate and woody cover

The survival rate of the woody species planted, the average cover and the auger area vary from one site to another. The survival rate of species planted on the plateau is lower than

that of species planted on the slope (Table 4). On the other hand, the average cover and basal cover are greater in the site planted on the plateau.

Table 4: Survival rate, basal cover and average cover of woody plants

Site	Plateau site	Slope site	Average
Survival rate (%)	59.12	69.75	64.43
Average coverage (%)	8.64±6.72	5.48±2.06	7.06±4.39
Basal coverage (cm ²)	414.61±337	58.88±38.03	296.03±236.74

3.5. Height and diameter of woody plants

The average height, average trunk diameter and average crown diameter of woody plants on the plateau site are the highest (Table 5). The average height and trunk diameters at

20 cm of the woody plants on the slope were the lowest. However, one of the sub-sites on the slope has ligneous plants whose height makes it possible to measure the various trunk diameters.

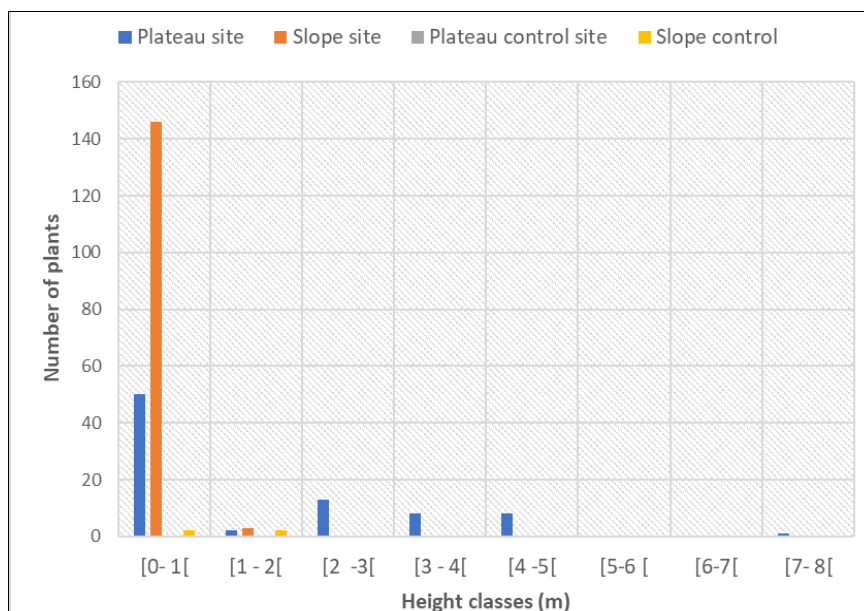
Table 5: Wood dendrometric parameters

Sites	Average height (metres)		Tree crown diameter (m)	Basal coverage (cm ²)	Trunk diameter at 20 cm (m)
	Recovered	Control (reference)			
Plateau site	1.75	0	2.99	414.93	10.71
Slope site	0.3	1	0.75	22.12	1.99

3.6. Distribution of woody individuals in height classes

The height class of less than 1 m dominates on all the sites (Fig 5). Height classes greater than 1 m are represented by one class in the control sites and by five (5) classes in the

managed sites. The *Eucalyptus camaldulensis* species grows faster (1.1 m/year) than the other species in the height classes above 2 m.

**Fig 5:** Distribution of woody individuals in height classes in the recovery and control sites

3.7. Distribution of woody individuals in crown diameter classes

Acacia senegal and *Eucalyptus camaldulensis* have the largest crown diameters (Fig 6). The site on the plateau has

trees with large crown diameters. However, the majority of woody trees have a crown diameter of between one (1) and three (3) metres.

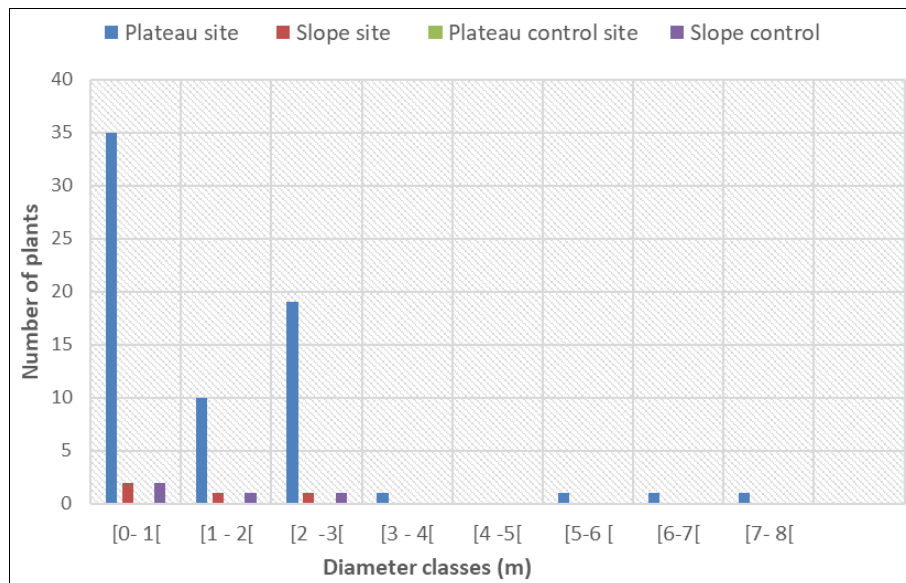


Fig 6: Distribution of woody individuals in crown diameter classes

3.8. Carbon stock in woody plants

It was found that a tree stored an average of 7.65 kg of carbon in its aerial part in the site developed on the plateau (Table 6). This is the site that stored the most carbon because of the volume of woody individuals and its large surface area.

Table 6: Estimated carbon stock per tree at the various sites

Site	SCTr (Kg/tree)	SCBr (Kg/tree)	SCF (Kg/tree)	Total (Kg/tree)	Site (Kg)
Plateau	6.03±2.15	1.45±0.3	0.17±0.27	7.65	11,439.23
Slope	0.3±0.21	0.073±0.05	0.008±0.006	0.4	5,888.5
Total	6.6±1.18	1.52±0.17	0.17±0.25	8.05	12,027.73

SCTr: Carbon stock in trunks, SCBr: Carbon stock in branches and SCF: Carbon stock in leaves

4. Discussion

The inventory of woody species revealed a rich flora of nine (9) species divided between six (6) families, dominated by the Mimosaceae family. Planted and volunteer species numbered five (5) and four (4) respectively. The species *Acacia senegal* was planted in all the sites recovered. It is complemented by *Eucalyptus camaldulensis* on the plateau and *Bauhinia rufescens*, *Prosopis juliflora* and *Ziziphus mauritiana* on the slope. *Acacia senegal* and *Guiera senegalensis* are present in all the restored sites. The specific contribution of *Guiera senegalensis* was 100% in the control site on the slope. The presence of this species in this untreated area proves that *Guiera senegalensis* is a resilient species. These results are similar to those of Gagara (2009) [16], who found 14 species belonging to eight (8) families dominated by Mimosaceae on the sylvo-pastoral half-moons (in Niger). This dominance of Mimosaceae has been confirmed by other studies carried out in the Sahelian zone, in particular by Ganaba (2005) [17], on the impact of water and soil conservation schemes on the regeneration of

woody resources in the Sahelian region of Burkina Faso, Salifou (2018) [18] in the Chadakori zone (Maradi/Niger) and Mohamed (2008) [19] in the Sudano-Sahelian zone of Senegal. The indigenous species *Guiera senegalensis* has a specific contribution of 80% (on the embankment), clearly higher than that of *Acacia senegal*, *Prosopis juliflora* and *Ziziphus mauritiana*, which are planted species. The spontaneous species *Guiera senegalensis*, which regenerates on the slope, would be favoured by the development work (trench) and the texture of the soil. *Piliostigma reticulatum* and *Boscia senegalensis* are found on the plateau and *Combretum micranthum* on the slope.

The success rate (survival rate) of the woody species planted in the trenches (site developed on the slope) corresponds to 69.75%. These results differ from those found by GIZ (2012) [20], which obtained a survival rate of 60% in the trenches. The success rate obtained on the plateau is 59.12%. This result is comparable to that found by Salifou (2018) [18]. The 59.12% survival rate on the plateau (*Eucalyptus camaldulensis* species in benches) is similar to that obtained by Noma (2018) [21] on the same plateau, but lower than that found by Laminou *et al.* (2020) [7], which is 64.44% in the Simiri zone. In terms of density, the site developed on the plateau recorded a low value, which can be explained by the frequency with which wood is periodically cut on this site. *Acacia senegal* and *Eucalyptus camaldulensis* are the most densely planted species, with densities of 223 and 36.5 trees/ha respectively. With the exception of the *Guiera senegalensis* species on the slope, all the planted species have a higher density than the spontaneous species. The average density (170.5 plants/ha on the plateau) is lower than those obtained by Blamah (2004) [22] and Ganaba and Kiema (2000) [23], who obtained 209 plants/ha and 230 plants/ha respectively in the Sahelian region of Burkina Faso.

As regards dendrometric parameters, in general, the heights

of the species present in the managed sites are greater than those in the control sites. For the height class below 1 m, *Acacia senegal* and *Boscia senegalensis* dominate, and are respectively spontaneous and planted species. In the same height class, *Guiera senegalensis* is more important at all sites.

The carbon stock stored by woody vegetation on the plateau site was estimated at 11,439.23 kg. This quantity is greater than that of the slope, which is 5,888.5 kg. The quantity of carbon sequestered is practically negligible in the control sites.

5. Conclusion

At the end of this study, it emerged that the development had had positive effects on the return of woody flora. This was reflected in an improvement in the richness of the flora, plant cover, spontaneous regeneration, particularly on the slope, and ecosystem services such as wood production and carbon storage. Dominated by the species *Guiera senegalensis*, spontaneous regeneration is much more important on the slope than on the plateau. In terms of carbon stock, the site developed on the plateau recorded the highest stock due to the greater volume of woody individuals and surface area than the site on the slope. The better survival rate obtained on the slope is due to the texture of the soil and the type of structure. The development of the plateau (summit and slope) makes it possible to regenerate ecosystem services, which will be progressive if the site is well maintained and used.

6. References

1. Vegetation dynamics in the Sahelian domain of western Niger along an aridity gradient: roles of ecological, social and economic factors [PhD thesis]. Niamey (Niger): Abdou Moumouni University; 2005. p. 229.
2. Zoubairou T, Karim L. Analysis of soil conservation techniques in Niger. 1997. p. 55.
3. Moussa AO, Rabiou H, Soumana I, Dan Guimbo I. Study of land use dynamics in the Tondikiwindi commune in western Niger. *Afrimed AJ - Al Awamia*. 2024;(145):49-59.
4. Moussa AO, Dan Lamso N, Dan Guimbo I, Saidou S, Gama Dadi H. Study of the factors influencing landscape dynamics in the Ouallam department (Niger). *Int J Innov Appl Stud*. 2022;37(4):735-51.
5. Vieri MB, Abdourhaman D, Adamou A. Climate risk and adaptation in the Tillabéri region, Niger: building capacity for analysis and assessment. 2014. 281 p. ISBN: 978-2336-3084-93-0.
6. FAD. Water mobilisation project in the Tahoua department: Project completion report. 2008. 47 p.
7. Laminou MO, Amani A, Dan Guimbo I, Rachidi AH, Mahamane A. Impacts of benches in the recovery of degraded land in Niger. *J Appl Biosci*. 2020;(151):15510-29.
8. Moussa AO, Dan Guimbo I, Oumarou INA. Physicochemical characterisation of the soil in silvopastoral sites developed on plateaux in western Niger. *Afr Sci*. 2025;26(2):12-24.
9. Douma S, Idrissa S, Ali M, Saadou M, Ambouta K, Ichau A, *et al*. Restoration of bare beaches in a spotted bush in Niger. *Afr Sci*. 2011;7(1):77-92.
10. Amani A, Adam I, Barmo S, Abdourahaman EM, Mahamane A. Impacts of forest benches and half-moons on soil physico-chemical characteristics and spontaneous plant diversity in western Niger. *Int J Innov Appl Stud*. 2021;34(3):583-600.
11. Ambouta JMK, Valentin C, Laverdière MR. Fallow land and erosion crusts in the Sahel. *Sécheresse*. 1996;7:269-75.
12. Ambouta JKM. Definition and characterisation of contrasting vegetation structures in the Sahel: the case of the tiger bush in western Niger. In: d'Herbès JM, Ambouta JKM, Peltier R, editors. *Functioning and management of contrasting Sahelian forest ecosystems*. Paris: Libby Eurotext; 1997. p. 41-57.
13. Moussa MB, Maman MI, Ambouta JMK, Ali M, Aagaard AJ, Yahou H, *et al*. Characterisation of woody vegetation and surface pellicular organisations of agroecosystems at different stages of degradation in the rural commune of Simiri (Niger). *Int J Biol Chem Sci*. 2013;7(5):1963-75.
14. FAO. Guide to the interpretation of soil analyses. Working document 13. AG: DP/SEN/87/Q07. 1992. 86 p.
15. Boulamane M, Regina IS, Khia A, Oubrahim H. Estimation of the carbon stock in the iliaies of the Moroccan High Atlas. *Ann Rech For Maroc*. 2013;20(2):275-86.
16. Gagara LM. Impact of half-moons on the regeneration of natural resources in the PADL-DIFFA intervention zone [final dissertation]. Niamey (Niger): ITA/EF/FA/UAM; 2009. p. 45.
17. Ganaba S. Impact of water and soil conservation measures on the regeneration of woody resources in the Sahelian and northern Sudanian zones of Burkina Faso. 2005. p. 68.
18. Salifou MK. Effect of half-moons on the ecological restoration of degraded land in the village of Dargué (Chadakori) [Master's thesis]. Niamey (Niger): Faculty of Agronomy, UAM; 2018. p. 66.
19. Mohamed MC. Characteristics of the flora and woody vegetation of community forests in the Sudano-Sahelian zone of Senegal [Doctoral thesis]. Ziguinchor (Senegal): University of Ziguinchor; 2008. p. 85.
20. GIZ. Good practices of the CES/DRS: Contributing to climate change adaptation and producer resilience. 2012. p. 26.
21. Noma AS. Evaluation of the behaviour of *Eucalyptus camaldulensis* in the half-moons and forest benches of the Sataira plateau (rural commune of Simiri, Tillabéry region, south-western Niger) [Master's thesis]. Niamey (Niger): Faculty of Science and Technology, Abdou Moumouni University; 2017. p. 27.
22. Blamah J. Impact of anti-erosion management on fodder production and nutrient recycling in the Sahel [Engineer thesis]. Bobo-Dioulasso (Burkina Faso): Polytechnic University of Bobo-Dioulasso; 2004. p. 127.
23. Ganaba S, Kiéma A. Impact of erosion control measures on biodiversity in the Sahelian region of Burkina Faso. 2000. p. 54.