



Practices of assisted natural regeneration in agroforestry parklands among three major ethnic groups in western Burkina Faso

TYANO Abdoulaye¹, OUEDRAOGO Amidou¹, FANE SIRIKI², HIEN Mipro¹, YELEMOU Barthelemy^{3,1}

¹Université Nazi BONI, Laboratory of Bioresources, Agroecosystems and Environmental Health (LaBASE) 01 BP 1091 Bobo Dioulasso 01, Burkina Faso.

²Agroforestry Resource Center/Department of Rural Engineering and Water and Forestry of the Rural Polytechnic Institute for Training and Applied Research (IPR/IFRA) of Katibougo, P.O. Box 06, Koulikoro, Mali. Telephone: (+223) 66590905; Email: faneki08@gmail.com. University Center of Gaoua, Department of Applied Biological Sciences

³National Center for Scientific and Technological Research (CNRST), Institute of Environment and Agricultural Research (INERA), 03 BP 7047 Ouagadougou 03, Burkina Faso

*Corresponding Author: TYANO Abdoulaye, tabdoulayemagloire@gmail.com

Submitted 10/04/2026, Published online on 30/06/2026 in the <https://www.m.elewa.org/journals/journal-of-applied-biosciences-about-jab/> <https://doi.org/10.35759/JABs.221.3>

ABSTRACT

Objective: Burkina Faso's agroforestry parklands are losing woody species due to climate change and population growth. Farmers increasingly adopt Assisted Natural Regeneration (ANR), more documented in the country's arid north but under-researched in western regions. This study addresses that gap.

Methodology and results: The study was conducted in three rural communes of Burkina Faso's southern Sudanese region. In each commune, 42 farm managers per ethnic group were surveyed on ANR knowledge, his constraints, spared species, and ecosystem services. Despite lacking formal training, 97% of farmers protect woody species. Legal restrictions discourage 70% in the practice. Commonly spared species are *Parkia biglobosa* (African locust bean), *Vitellaria paradoxa* (shea tree) cited by all farmers, *Borassus akeassi* (African fan palm) (cited by 74%). These species provide food, medicine, timber, fuel, regulate ecosystems, and hold socio-cultural value.

Conclusion and application of results: This study suggests that policymakers review the legal status of woody plants from the Assisted Natural Regeneration (ANR). Indeed, the current protected status is perceived by producers as restrictive, as it limits certain traditional or commercial uses, which can reduce their motivation to maintain the regeneration of "protected" species in their fields. Encouraging awareness and supporting local initiatives would amplify the ecological, agricultural, and cultural benefits of this practice. This could contribute to strengthening the resilience of rural communities in the face of climate and environmental challenges

Keywords: Cultural importance index; Ecosystem services; protected trees.

INTRODUCTION

Sub-Saharan Africa remains one of the regions most exposed to threats of natural resource degradation and structural poverty due to both climatic and anthropogenic dynamics (Mouleye *et al.*, 2020a). This vulnerability stems from a combination of structural factors such as reliance on rainfed agriculture, rapid population growth, and weak resilience infrastructure (Gondard, 2023). The effects of climate change, particularly rainfall variability and the increasing frequency of extreme events, undermine livelihoods and exacerbate food insecurity and territorial inequalities (Dzanku, 2015). In this context, ecosystem degradation is not merely an ecological crisis but also a driver of deepening poverty. The significant decline in rainfall observed since the 1970s has led to increased mortality of woody species, while ongoing demographic growth places mounting pressure on food resources, fuelwood, and agricultural land (OCDE & FAO, 2016; Diallo *et al.*, 2022). This pressure manifests in the expansion of cultivated land and intensified wood harvesting, contributing to vegetation cover loss and ecosystem degradation (Reij & Garrity, 2016). Climate change, combined with extensive farming practices and resource overexploitation, has accelerated soil depletion and fragmentation of vegetation formations (Dzanku, 2015; Mouleye *et al.*, 2020). In response, several local and regional initiatives have emerged to curb environmental degradation. Among them, on-farm tree management adopted by a growing number of Sahelian farmers has proven to be a low-cost agroecological strategy for sustainably improving agricultural productivity and food security (Bil-Assanou *et al.*, 2020). Assisted Natural Regeneration (ANR) is a restoration and management technique aimed at promoting the natural recruitment of desired wood species (Oluwajuwon *et al.*, 2024). Agroforestry, particularly through ANR, offers multiple benefits in terms of climate resilience,

landscape restoration, and livelihood diversification (Saley *et al.*, 2019; Kelly *et al.*, 2021). Since the 1980s, ANR has enabled farmers in southern Niger to significantly increase tree density in fields, notably through the protection of naturally regenerated seedlings (Reij & Garrity, 2016). In Mali's S nou plain, this approach has led to the creation of over 450,000 hectares of agroforestry parklands dominated by *Faidherbia albida* (Delile) A. Chev., with positive effects on crop yields (Kater *et al.*, 1992). In Burkina Faso, the Swiss organization "newTree" supported the implementation of ANR through fencing and the establishment of agroforestry buffer zones, enabling the regeneration of more than 200 sites between 2003 and 2012 (Kaguemb ga-M ller, 2012). However, although ANR is practiced and documented in the Sahelian zone of Burkina Faso, it remains poorly studied in the western region of the country. In addition, beyond technical and ecological considerations, the implementation of Assisted Natural Regeneration is strongly influenced by cultural perceptions and traditional uses of tree species. Practices related to the selection, protection, and utilization of trees vary among ethnic groups, reflecting local knowledge and distinct socio-economic rationales. In western Burkina Faso, three major ethnic groups shape agricultural and social dynamics. A comparative study of these groups provides insight into how culture influences the conception and practice of ANR, and helps identify appropriate levers to strengthen the ecological resilience and sustainability of agroecosystems. The objective of this study is to analyse the design and practices of Assisted Natural Regeneration (ANR) in western Burkina Faso, highlighting the influence of cultural representations and local knowledge specific to the three main ethnic groups in the area. The aim is to understand how perceptions, traditional practices, and socio-

economic logic shape the adoption and implementation of ANR, in order to identify appropriate levers for enhancing vegetation

cover, ecological resilience, and the sustainability of agroecosystems.

MATERIALS AND METHODS

Selection of Study areas: This study was conducted in western Burkina Faso, specifically in three rural communes: Pénì, Toussiana, and Douna (Figure 1). These locations were selected based on their accessibility and to include three major

indigenous ethnic groups: the Tiéfo in Pénì, the Tussian in Toussiana, and the Turka in Douna. The study area lies within the southern Sudanian phytogeographic zone (Fontès & Guinko, 1995).

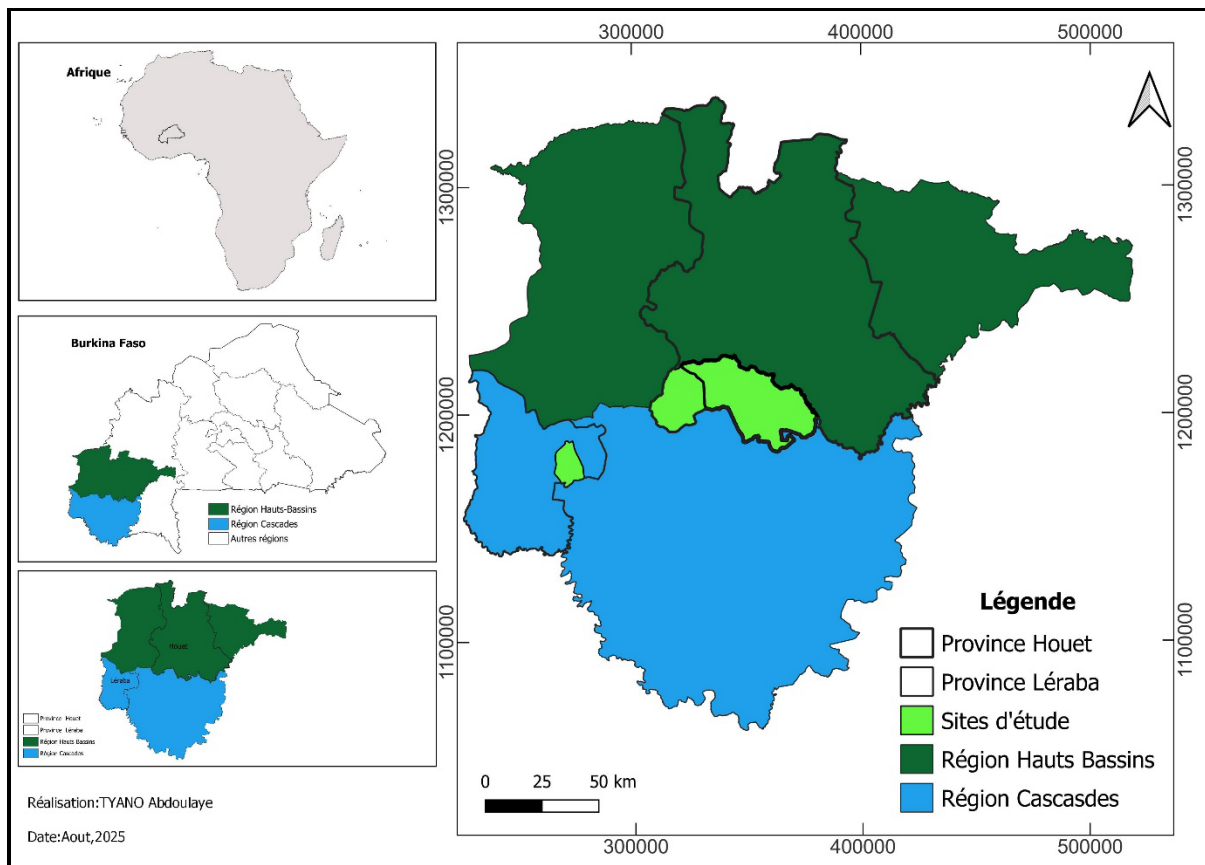


Figure 1: Location of the study area

Description of the Study Area: The study area is located in the southern Sudanian phytogeographic zone, situated south of the 11°30' N parallel (Fontès & Guinko, 1995). The climate in this zone is characterized by two main seasons: a wet season lasting 6 to 7 months, from April to October, with an average annual rainfall ranging from 900 to 1100 mm. This region represents the most densely

wooded area of the country. Its vegetation is primarily composed of dense shrub savannas, tree savannas, wooded savannas, and open forests interspersed with gallery forests (Béné *et al.*, 2022).

Sampling and Data Collection: The survey was conducted among agroforestry parkland farmers using a structured questionnaire. A sample of forty-two (42) farm household heads

was interviewed within each ethnic group. The questions focused primarily on Assisted Natural Regeneration (ANR) practices, the challenges associated with these practices, the selection of spared woody species, the reasons behind these choices, and the ecosystem services provided by woody plants in agroforestry parklands.

Data Analysis: The survey data were analysed using key indicators to assess the factors influencing farmers' decisions to adopt Assisted Natural Regeneration (ANR) practices.

Service Citation Frequency: It is used to measure the relative importance of services as perceived by informants. It is calculated using the following formula:

$$SCF = \frac{N_{cs}}{N} \times 100$$

N_{cs} is the number of informants who cited or acknowledged benefiting from the service

N : is the total number of informants interviewed (Houéhanou *et al.*, 2016).

RESULTS

Practice of Assisted Natural Regeneration (ANR): All respondents reported that they spare certain plants during field clearing. Regarding the maintenance of these plants, 90.47% stated that they actively protect them against bushfires, overharvesting, and animal damage (Figure 2). However, 70% of respondents indicated that harvesting products from trees maintained in the fields is

Species Use Frequency (SUF): the SUF was used to identify the species preferred by different ethnic groups in their ANR practices. It was calculated using the formula:

$$SCF = \frac{N_{Ce}}{N} \times 100$$

Cultural Importance Index (CI): the CI was used to assess the variability of knowledge related to agroforestry species, based on the formula:

$$IC = \sum_{s=Si}^{SNu} X \sum_{i=1}^{i=n} \frac{SRsi}{N}$$

Nu is the total number of service categories, SR is the number of services reported, Si is the number of services mentioned by the informant I and N is the total number of informants interviewed (Tardío & Pardo-de-Santayana, 2008).

challenging due to their protected status. Overall, 70% acknowledged having conflicts with environmental officers when attempting to exploit products from spared plants. Among the 126 respondents, 114 individuals (90.47%) reported having received no training in agroforestry plant management or in best practices related to ANR.



Figure 2: Photograph of an overview of an agroforestry parkland under Assisted Natural Regeneration

Ecosystem Services Associated with ANR:

The study revealed a wide range of ecosystem services linked to Assisted Natural Regeneration (ANR), grouped into four main categories: provisioning services, regulating services, cultural services, and supporting services (Table 1). Provisioning services were

the most frequently cited, including food (100%) and energy (78.33%). These were followed by regulating services, such as crop protection (81.67%), cultural services like field boundary marking (68.33%), and supporting services such as soil fertilization (67.5%).

Table 1: List of Ecosystem Services Provided by Agroforestry Parklands

Ecosystem services		Service Citation Frequency (%)
	Food	100
	Energy	78.33
Provisioning services	Medicinal	66.67
	Timber	40
	Fodder	48.33
Regulating services	Protection	81.67
Cultural services	Rituals	43.33
	Field demarcation	68.33
	Soil	67.5
Supporting services	Shade	12.5

Species Spared by the Three Ethnic Groups:

Species such as *Vitellaria paradoxa* and *Parkia biglobosa* are systematically spared in cultivated fields by producers from all three ethnic groups (Table 2). *Borassus akeassi* is spared in agroforestry parklands across all groups, but it is more frequently cited among the Turka (95%) than among the Tussian (73.8%) and the Tiéfo (54.76%). *Eucalyptus*

camaldulensis was cited exclusively by the Tiéfo (45.23%), while *Vitex doniana* was spared only by the Turka (76.19%). *Khaya senegalensis* was mentioned by both the Tiéfo and the Tussian, with citation frequencies of 50% and 45.23%, respectively. Principal Component Analysis (PCA) reveals cultural diversity in agroforestry practices, with species spared differently across ethnic groups (Figure

3). Group 1 includes species such as *Vitellaria paradoxa*, *Parkia biglobosa*, and *Bombax costatum*, which are conserved in fields by all ethnic groups. The Turka show a preference for species such as *Saba senegalensis*, *Vitex doniana*, *Faidherbia albida*, and *Gmelina arborea* (Group 2). Group 3 corresponds to the

Tiéfo ethnic group, who, in addition to common species, spare *Trichilia africana*, *Eucalyptus camaldulensis*, *Prosopis africana*, among others. Group 4 represents the Tussian, who spare species such as *Lannea microcarpa*, *Annona senegalensis*, *Moringa oleifera*, and species from the *Piliostigma* genus.

Table 2: Main Woody Species Retained in Agroforestry Parklands

Species	Species Use Frequency (%)		
	Tiéfo	Tussian	Turka
<i>Vitellaria paradoxa</i> c. F. Gaertn.	100.00	100.00	100.00
<i>Parkia biglobosa</i> (Jacq.) R. Br. ex G. Don	100.00	100.00	100.00
<i>Borassus akeassii</i> Bayton. Ouedraogo & Guinko	54.76	73.00	95.23
<i>Faidherbia albida</i> (Delile) A. Chev	50.00	47.61	85.71
<i>Khaya senegalensis</i> (Desr.) A. Juss.	50.00	45.00	00.00
<i>Eucalyptus camaldulensis</i> Dehnh.	45.23	00.00	00.00
<i>Detarium microcarpum</i> Guill. et Perr.	00.00	45.23	00.00
<i>Vitex doniana</i> Sweet	00.00	00.00	76.19
<i>Khaya senegalensis</i> (Desr.) A. Juss.	0.00	00.00	50.00

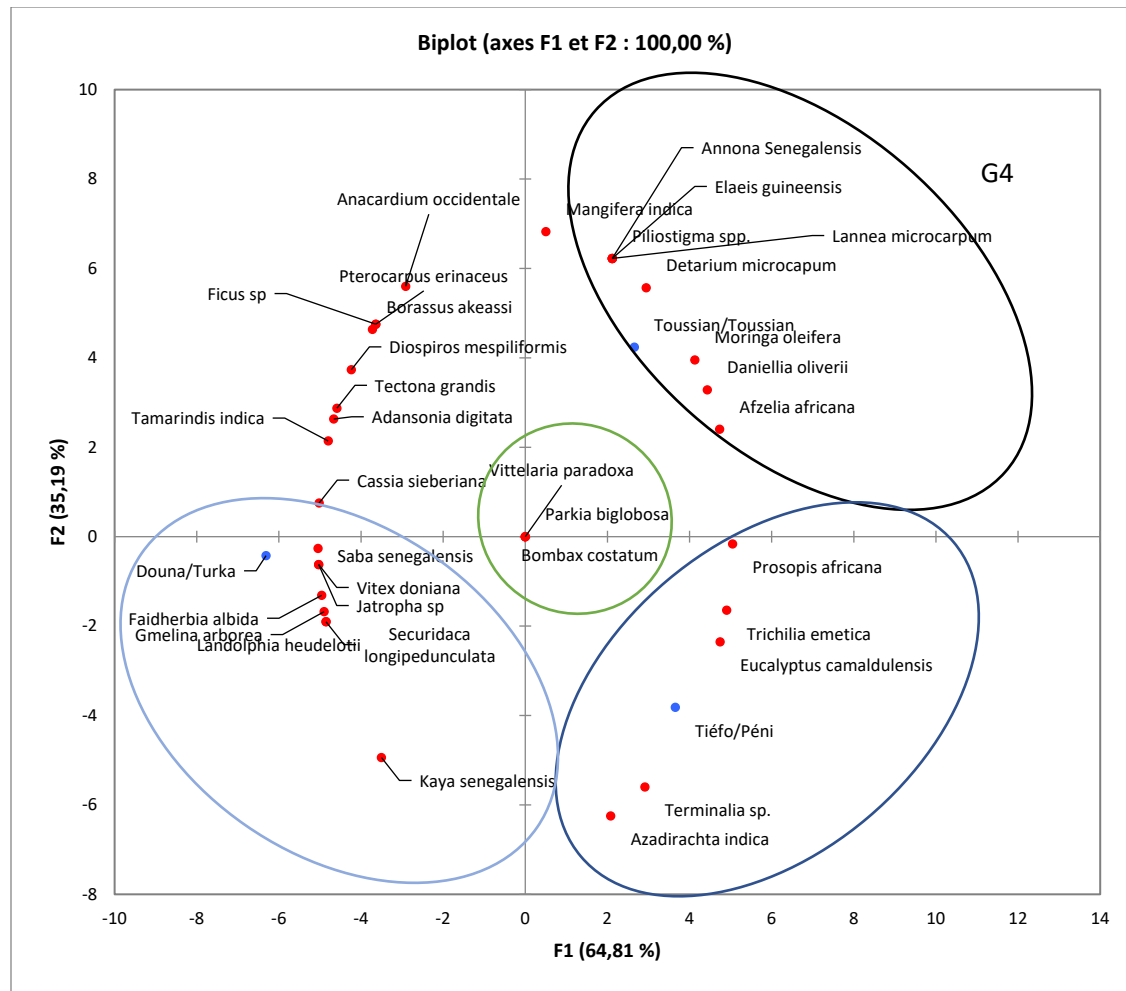


Figure 3: Principal Component Analysis of Retained Agroforestry Species According to Ethnic Groups

Cultural Importance of Species: The total Cultural Importance Indices (CI_t) of *Vitellaria paradoxa* and *Parkia biglobosa* are highest among the Tiéfo and Tussian ethnic groups (Table 3). *V. paradoxa* has a CI_t of 5.95 and 5.48 for the Tiéfo and Tussian respectively, while its CI_t among the Turka is 3.78. Regarding *P. biglobosa*, its CI_t reaches 5.88

among the Tiéfo, compared to 5.33 and 3.68 for the Tussian and Turka respectively. The species with the highest CI_t among the Turka is *Borassus akeassi*, with a value of 4.20. Another characteristic species for the Turka is *Faidherbia albida*, which has a CI_t of 1.78, compared to 0.95 among both the Tiéfo and the Tussian.

Table 3: Cultural Importance Indices of Key Woody Species in Agroforestry Parks

species	Ethnic groups	Food	Med.	Timber	Energy	MP	CPS	F	SFS	C	MC	D	ICt
<i>V. paradoxa</i>	<i>Tiéfo</i>	1.00	0.70	0.35	0.78	1.00	0.80	0.20	0.68	0.08	0.38	0.00	5.95
	<i>Tussian</i>	1.00	0.75	0.30	0.80	1.00	0.85	0.10	0.53	0.03	0.13	0.00	5.48
	<i>Turka</i>	1.00	0.20	0.05	0.75	0.93	0.75	0.03	0.03	0.00	0.00	0.00	3.78
<i>P. biglobosa</i>	<i>Tiéfo</i>	1.00	0.75	0.35	0.78	1.00	0.75	0.23	0.63	0.08	0.33	0.00	5.88
	<i>Tussian</i>	1.00	0.65	0.13	0.83	1.00	0.85	0.20	0.50	0.05	0.13	0.00	5.33
	<i>Turka</i>	1.00	0.10	0.05	0.70	0.98	0.80	0.00	0.05	0.00	0.00	0.00	3.68
<i>B. akeassii</i>	<i>Tiéfo</i>	0.35	0.08	0.08	0.00	0.30	0.15	0.00	0.10	0.05	0.00	0.35	1.45
	<i>Tussian</i>	0.83	0.20	0.43	0.05	0.65	0.28	0.03	0.18	0.4	0.00	0.78	3.80
	<i>Turka</i>	0.90	0.03	0.43	0.05	0.93	0.15	0.00	0.00	0.83	0.00	0.90	4.20
<i>F. albida</i>	<i>Tiéfo</i>	0.00	0.08	0.00	0.00	0.03	0.08	0.33	0.43	0.03	0.00	0.00	0.95
	<i>Tussian</i>	0.00	0.10	0.03	0.00	0.00	0.10	0.3	0.4	0.03	0.00	0.00	0.95
	<i>Turka</i>	0.00	0.03	0.05	0.00	0.05	0.00	0.83	0.83	0.00	0.00	0.00	1.78
<i>K. senegalensis</i>	<i>Tiéfo</i>	0.00	0.08	0.13	0.00	0.00	0.05	0.33	0.08	0.03	0.03	0.10	0.80
	<i>Tussian</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	<i>Turka</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Legend: Med. = medicinal, MP = Products Marketed by farmers, CPS= Crop Protection Services, F= Fooder, SFS: Soils Fertilization Service, FDS: Field Demarcation Service, CI: Cultural Index total.

DISCUSSION

All farm managers interviewed acknowledged sparing certain woody species during field clearing. A large majority (90.47%) also reported protecting these species after harvest. These practices align with the principles of ANR, particularly the selection and maintenance of useful plants, as defined by Rinaudo *et al.* (2020). The main reasons cited for conserving specific species were linked to provisioning services, especially food and energy. Similar findings were reported by Cissé *et al.* (2019) in the Boura watershed and by Ouédraogo *et al.* (2020) in protected areas of eastern Burkina Faso. The Cultural Importance Index (CI) of the assessed species revealed particularly high values for *Vitellaria paradoxa*, *Parkia biglobosa*, and *Borassus akeassii*. These three species are the most commonly spared by the ethnic groups studied, due to their high nutritional and commercial value. Farmers actively promote their natural regeneration, recognizing their nutritional and economic benefits, as reported by Hien (2023). According to this author, products derived from these plants provide a significant share of essential minerals and vitamins, despite the small quantities consumed. The CI of *Borassus akeassii* varies across ethnic groups, increasing from the Tiéfo to the Turka, with the Tussian in between. Both the Turka and the Tussian attribute a supporting service to this species: its presence in or around fields helps resolve land disputes, according to their testimonies. According to Béné *et al.* (2022), this species was introduced into the western part of the country by the Karaboro and the Turka, who

gradually passed it on to the Tussian and then to the Tiéfo. Its cultural importance is particularly high among the Turka (CI = 0.83), due to its role in ritual practices and its sacred status, which have contributed to its conservation. *Faidherbia albida* is recognized for its fodder value, its role in soil fertilization, and its ecological protection (Fané *et al.*, 2026), through nitrogen-fixing, receiving special attention since colonial times (Reij & Garrity, 2016a). *Khaya senegalensis* is also valued for its fodder services and its use in traditional veterinary medicine (Traoré *et al.*, 2025). *Vitex doniana* is more frequently cited by the Turka, with a high CI linked to its food use. According to respondents, its fruits are used to prepare a traditional beverage. Most farm managers reported having experienced conflicts with forestry agents regarding the exploitation of plant products from trees conserved in their fields. These finding echoes that of Cissé *et al.* (2019), who shown that legislation on protected species restricts farmers' rights of use, even when those species have been voluntarily conserved. This situation may lead to a reduction in floristic diversity, as farmers may choose to conserve only the least protected species. Furthermore, 90.47% of respondents stated that they had received no training in plant management within agroecosystems or in best practices related to ANR. This lack of training represents a barrier to the dissemination of sustainable practices and may compromise the resilience of agroecosystems.

CONCLUSION AND APPLICATION OF RESULTS

The study highlights that Assisted Natural Regeneration (ANR) in the agroforestry parklands of Péni, Toussiana, and Douna has been spontaneously adopted. Despite the lack of formal training for 90.47% of farmers, they actively preserve certain woody species, demonstrating ecological management rooted

in local knowledge. The most commonly conserved species are *Vitellaria paradoxa*, *Parkia biglobosa*, and *Borassus akeassii*, valued for their food, medicinal, and energy uses, as well as for their cultural and ecological functions. Cultural Importance Indices confirm their central role in agricultural

systems and rural social representations. However, tensions with forestry agents and the lack of training hinder the sustainability of ANR. Integrating this practice into agricultural and environmental public policies could support the restoration of degraded landscapes, strengthen the resilience of agroecosystems, and reconcile conservation, production, and territorial equity.

ACKNOWLEDGEMENTS

We warmly thank the agroforestry producers from the villages of Douna, Péni, and Toussiana who agreed to participate in this study. The authors would like to thank the Sustain Sahel project, funded by the European Union

REFERENCES

- Béné A, Devineau J-L, Fournier A, 2022. Distribution et traits caractéristiques des populations du palmier rônier *Borassus akeassii* dans le sud-ouest du Burkina Faso. *Bois et Forêts des Tropiques* 353: 17–29. <https://doi.org/10.19182/bft2022.353.a36993>
- Bil-Assanou IH, Boukari D, Sitou L, 2020. Scaling up assisted natural regeneration to intensify agroecologically agrosystems productivity. *Universal Journal of Agricultural Research* 8: 11–17. <https://doi.org/10.13189/ujar.2020.080102>
- Cissé M, Bationo BA, Traoré S, Boussim IJ, 2019. Perception d'espèces agroforestières et de leurs services écosystémiques par trois groupes ethniques du bassin versant de Boura, zone soudanienne du Burkina Faso. *Bois et Forêts des Tropiques* 338: 29–42.
- Diallo S, Faye M, Nacro HB, 2022. La variabilité pluviométrique et ses impacts sur les rendements et les surfaces cultivées dans le bassin arachidier de la région de Thiès (Sénégal). *Vertigo – La revue électronique en sciences de l'environnement*. <https://doi.org/10.4000/vertigo.34710>
- Dzanku FM, 2015. Household welfare effects of agricultural productivity: A multidimensional perspective from Ghana. *Journal of Development Studies* 51: 1139–1154. <https://doi.org/10.1080/00220388.2015.1010153>
- Fontès J, Guinko S, 1995. Carte de la végétation et de l'occupation du sol du Burkina Faso.
- Gondard C, 2023. Contribution à l'analyse des dynamiques de pauvreté et des politiques sociales en Afrique subsaharienne. Université de Bordeaux.

Ethical approval statement: The individuals surveyed were informed of the research objectives and the intended use of the data, and they gave their free and informed consent. The data were collected in strict compliance with the legislation in force in Burkina Faso, particularly regarding the protection of individuals.

through Grant Agreement No. 861974 under its Horizon 2020 research and innovation program

Funding: This work was funded by the Sustain Sahel project, which is funded by the European Union through Grant Agreement No. 861974 under its Horizon 2020 research and innovation program

- Hien T, 2023. Contributions à une approche interdisciplinaire d'évaluation du capital naturel et des services écosystémiques rendus par les sols. Université de Lorraine.
- Houéhanou DT, Assogbadjo AE, Chadare FJ, Zanzo S, Sinsin B, 2016. Approches méthodologiques synthétisées des études d'ethnobotanique quantitative en milieu tropical. *Annales des Sciences Agronomiques* 20: 187–205.
- Kaguembèga-Müller F, 2012. Régénération naturelle assistée de bosquets familiaux, activités génératrices de revenus à travers les produits non ligneux, foyer trois pierres amélioré en banco. NewTree et Tiipaalga, Ouagadougou, Burkina Faso.
- Kelly BA, Sanogo S, Sidibé SI, Castillo-Lorenzo E, Ceci P, Ulian T, 2021. Restoring vegetation and degraded lands by using assisted natural regeneration approach (ANRA): Case study at Bankass in the centre of Mali, West Africa. *Environment, Development and Sustainability* 23: 14123–14139. <https://doi.org/10.1007/s10668-021-01223-4>
- Mouleye IS, Diaw A, Hamadou Daouda Y, 2020. Effets du changement climatique sur la pauvreté et les inégalités en Afrique subsaharienne. *Revue d'économie du développement* 27: 5–32. <https://doi.org/10.3917/edd.333.0005>
- OCDE, Organisation des Nations Unies pour l'alimentation et l'agriculture, 2016. Perspectives agricoles de l'OCDE et de la FAO 2016-2025. OECD, Paris. https://doi.org/10.1787/agr_outlook-2016-fr
- Oluwajuwon TV, Chazdon RL, Ota L, Gregorio N, Herbohn J, 2024. Bibliometric and literature synthesis on assisted natural regeneration: An evidence base for forest and landscape restoration in the tropics. *Frontiers in Forests and Global Change* 7: 1412075. <https://doi.org/10.3389/ffgc.2024.1412075>
- Ouédraogo I, Sambaré O, Savadogo S, Thiombiano A, 2020. Perceptions locales des services écosystémiques des aires protégées à l'Est du Burkina Faso. *Ethnobiology Research and Applications* 20. <https://doi.org/10.32859/era.20.13.1-18>
- Reij C, Garrity D, 2016. Scaling up farmer-managed natural regeneration in Africa to restore degraded landscapes. *Biotropica* 48: 834–843. <https://doi.org/10.1111/btp.12390>
- Rinaudo, T., Muller, A., Morris, M., 2020. Manuel la Régénération Naturelle Assistée (RNA). Une Ressource pour les Gestionnaires de Projets, les Utilisateurs et Tous Ceux qui ont un Intérêt à Mieux Comprendre et Soutenir le Mouvement pour la RNA; FMNR Hub. *World Vision Australia: Melbourne, Australia*, 248p
- Saley IA, Salack S, Sanda IS, Moussa MS, Bonkaney AL, Ly M, Fodé M, 2019. The possible role of the Sahel greenbelt on the occurrence of climate extremes over the West African Sahel. *Atmospheric Science Letters* 20: e927. <https://doi.org/10.1002/asl.927>
- Tardío J, Pardo-de-Santayana M, 2008. Cultural importance indices: A comparative analysis based on the useful wild plants of southern Cantabria (Northern Spain). *Economic Botany* 62: 24–39. <https://doi.org/10.1007/s12231-007-9004-5>