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Sustainable Utilisation and Conservation of

Forest resources through different Land management Practices in Dzongu, Eastern Himalaya

The paper deals with the tree composition and structure in the Cardamom Based Agroforestry (CBA), Field-Based Agroforestry (FBA), Private forests (PF) and Sacred Groves (SG) of Dzongu, North Sikkim, Eastern Himalaya. Traditional practices and knowledge about the use of tree species were identified. The highest tree density was observed in PF and the highest basal area cover was reported in SG. The maximum population structure was exhibited by PF and SG with better regeneration capacity. The tree species were reported to be highest in SG (43%), followed by PF (23%), whereas CBA presented the least or poorest regeneration. The FBA and CBA were characterized by the composition of tree species with ecological and economic significance for the local community. Although agroforestry supports livelihoods, the exploitation of trees also exerts pressure on the ecological functioning of the wild. The indigenous community 'Lepchas' cultural practice of maintaining SG within the village surroundings not only helps to conserve local resources but also strengthens the human-nature bond.

Key words: Sustainability, Conservation, Agroforestry, Indigenous community, Sacred groves.

Forest resource management and land management practices of the Lepcha community could be a model for sustainable resource utilization and resource conservation.

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Introduction

Sikkim, which is part of the Eastern Himalaya, is a prominent biodiversity hotspot region in India. The region, enriched with rich biodiversity, is also the home of various ethnic communities exhibiting friendly interactions with nature. The Khangchendzonga Biosphere Reserve (KBR) situated in the state of Sikkim, presents a unique example of culture, heritage, tradition, belief system, and knowledge of the landscape that have been approved by indigenous communities residing in the region. The indigenous group 'Lepchas' is considered one of the autochthones of Sikkim. The Lepchas were originally hunters and gatherers who worshiped nature. Their cultural practices and belief system reflect a deep connection to and respect for their land and resources. The communities rely on forest resources for a variety of non-timber forest products (NTFPs) and practice agroforestry to meet their daily needs (Sharma and Sharma, 2017).

Building bridges between 'nature' and 'culture' particularly in situations where traditional societies live, has emerged as one of the priorities to address biodiversity conservation with sustainability concern (Ramakrishnan, 2006). The Convention on Biological Diversity (CBD) (2011-2020) and the Bio-logical Diversity Act, 2002 emphasize the value of traditional knowledge in problem solving through practices such as local conservation, sustainable use of plants and animals, and so on. Resource use sustainability can be achieved through better land-use strategies that increase productivity in the area under cultivation and best utilize available land and resources (Sundriyal *et al*., 1994). The importance of indigenous people and their TEK in biodiversity conservation has now been identified and much celebrated (Brook and McLachlan, 2008; Ramakrishnan, 2008). Among many indigenous

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cultural practices, the establishment of sacred groves in the forest patches in and around the village, is the most prominent from the perspective of forest conservation (Onyekwelu and Olusola, 2014; Onyekwelu *et al*., 2022), and the social taboos related to the groves often help to maintain its sanity (Parthasarathy and Babu, 2019; Onyekwelu, 2021). India has the highest number of culturally important forests as sacred groves, estimated at over 100,000 (Malhotra *et al*., 2007), which are gradually diminishing with modernization (Abayie Boateng, 1998; Chandrakanth *et al*., 2004; Ormsby and Bhagwat, 2010). Agroforestry practices by communities may be the best solution to Sikkim's challenges of biodiversity conservation, food security, and sustainable development (Sharma *et al*., 2016). Besides, agroforestry also contributes to community income through the marketing of agroforestry products; better nutrient cycling, and acting as a potential carbon sink (Rai and Sharma, 1998; Sharma and Sharma, 2017).

Till date, very few studies have been conducted to build the linkages between the culture and the ecological conservation of the tribal communities in the state. Our understanding of the traditional knowledge regarding plant resources and the practices that tend to promote sustainable use and conservation is still in its infancy. Under the current circumstances, the Lepcha tribe, with their rich cultural and traditional knowledge and status as an endangered tribe, receives the highest priority and importance for such endeavors.

Methodology

Study area

The study was carried out in the villages of Lingdem- Lingthem Gram Panchayat Unit (GPU) of Dzongu, North Sikkim India. The study area falls in the buffer zone of KBR within 900 m asl to 1600 m asl. Dzongu, located in 27°39' N – 27°22' N lat. and 88°21' E–88°35' E long., is a Lepcha community reserve in North Sikkim, under Article 371 (F) of Indian Constitution for preserving the Lepcha culture and the associated Traditional Knowledge of the community. Phytosociological analysis of four different land use practices *viz.*, the Private Forests (PF) which are the forest adjacent to villages having private ownership, Cardamom Based Agroforests (CBA) the privately owned land used for cardamom cultivation mixed with tree species, Field Based Agroforests (FBA) the private area within the village actively used for agricultural practices having tree species mixed or planted in boundaries and farm woodlot, and the culturally identified Sacred Groves (SG) the land within or outside forest area traditionally conserved for cultural significance, were conducted during the investigation.

Phytosociological analysis

Phytosociological analysis was conducted through Quadrat study of the vegetation (Misra, 1968) in the selected sites. The plots of .25 ha (50 m x 50 m) with ten quadrats of 10 m x 10 m were laid randomly for sampling the adult woody species. Each 10m x 10m, designed with two quadrats of 5 m x 5 m were studied for tree saplings. Further, 10 quadrats of 1m x 1m were laid down for sampling the tree seedling following Cottom and Curtis (1956). The tree species in each quadrat were identified in the field using local standard flora. Tree girth were measured at breast height (1.37 m) were later converted to diameter. The individuals of woody species with a Girth at breast height (GBH) greater than or equal to 30 cm were considered as an adult, 10- 30 cm as sapling and below 10 cm as a seedling. Further the population structure of the species was analyzed across six diameter classes *i.e.* 10-30 cm, 30-50 cm, 50- 70 cm, 70- 90 cm, 90- 110 cm and >110 cm.

The status of regeneration of species was determined based on population size of seedlings, saplings and adults as (modified from Khan *et al.,* 1987; Shankar, 2001; Khumbongmayum *et al*., 2006): (a) “good”, if seedlings > or < saplings > adults; (b) fair, if seedlings > or ≤ saplings ≤ adults; (c) “poor”, if a species survives only in sapling stage, but no seedlings (though saplings may be <, > or = adults); (d) “none”, if it is absent both in sapling and seedlings stages, but found only in adults and (e) “new”, if a species has no adults, but only saplings and/or seedlings. The community quantitative parameters such as frequency, density, basal area (BA) and Importance Value Index (IVI) were calculated according to Mishra (1968). The Shannon - Wiener index (H′) (Shannon and Wiener, 1963), and Pielou's evenness index (Pielou, 1966), Sorensen's Similarity index (Sorensen, 1948) were also evaluated. Species nomenclature used in this study follows worldfloraonline.org

Socio- ecological survey

Socio-ecological surveys were conducted in interaction with the local communities based on a semi-structured questionnaire. Altogether, 42 respondents, including both genders, were surveyed. Data about the use of tree species for timber, NTFPs and the source of collection were collected. The identification of the sacred groves, the taboos and cultural practices related to them, was done through Focused Group Discussion (FGD) with the elderly people residing in the village. Relative Frequency of Citation or quotation index (RFC) is calculated by the formula-

$$RFC = FC/N$$

Where FC is the number of informants who mentioned the plant species and N is the total number of the informants (Tardio and Pardo-de Santayana, 2008). RCF value varies from 0 to 1. The higher the value of RFC the greater is that species known for the mentioned purpose of use.

Result and Discussion

Tree species composition and diversity

A total of 88 tree species belonging to 60 genera and 37 families were recorded from all the sites. The

common families encountered are Lauraceae, Moraceae, Anacardiaceae, Rutaceae. Dominant species based on IVI and most dominant families based on number of species representation in each families in each sites are recorded (Table 1).

Species richness is seen highest in PF followed by SG, CBA and FBA. The Shannon-Weiner Diversity Index was highest in FBA and lowest in PF. Similar pattern was seen for Evenness Index (Table 2).

The species composition among different sites varied to some degree. Sorensen's Similarity index showed that PF and CBA had 50% of the species similar while PF and FBA showed highest dissimilarity (Table 3).

Tree population structure

Tree density showed a general decline with an increase in diameter. PF has the highest density in the smallest diameter classes, while SG has the highest density in the largest diameter classes. The total density of trees is highest in PF (540 individual ha^{-1}), followed by SG (470 individual ha^{-1}), CBA (255 individual ha^{-1}), and FBA (240 individual ha^{-1}), whereas the density is highest in PF. In case of the basal area the results obtained in decreasing order as SG (91 m^2ha^{-1}) followed by PF (76 m^2ha^{-1}), CBA (66 m^2ha^{-1}) and FBA (43 m^2ha^{-1}) (Fig. 1).

Seedling density was highest in PF (910 individual ha^{-1}), followed by SG (820 individual ha^{-1}), CBA (130 individual ha^{-1}), and FBA (125 individual ha^{-1}). Only PF and SG showed good population structure with decreasing density of seedling sapling and adult tree species, while in FBA and CBA sapling was highest followed by adult and seedling (Fig. 2).

Regeneration Status of Tree Species

The tree species shows the highest regeneration (43%) in SG, followed by PF (23%), FBA (18%), and CBA (11%). Most of the species had poor (47%) or no (34%) regeneration in the CBA. New species are found more in FBA (29%), followed by PF (16%). Many adult tress species such as *Aporosa octandra*, *Artocarpus lakoocha*, *Cornus capitata*, *Ehretia acuminata*, *Walsura* sp., etc are found without its saplings or seedlings in PF and CBA (Fig. 3).

Forest Resources Use

Different study sites contribute to the daily needs of the local people in different ways. Fodder is extracted mainly from PFs, followed by those from agroforests. Of the total fodder requirement in the study area, a large proportion is contributed by FBA (61%), followed by PF and CBA. People refrain from collecting fodder from the sacred grove. PF contributes the most (49%) of the locals' fuelwood needs, followed by CBA, FBA, and SG. While people usually do not collect any resources from SG, dead and fallen tree branches are sometimes brought for fuelwood purposes. Similarly, FBA accounts

Table 1 : Woody species composition

Treatment sites	Dominant families	IVI based dominant species
PF	Lauraceae, Moraceae, Anacardiaceae	*Schima wallichii, Gynocordia odorata, Macaranga peltata*
FBA	Lauraceae, Moraceae, Rutaceae	*Cryptomeria japonica, Brassaiopsis mitis, Machilus edulis*
CBA	Lauracea, Anacardiaceae, Euphorbiaceae	*Alnus nepalensis, Machilus edulis, Macaranga denticulata*
SG	Moraceae, Euphorbiaceae, Lauraceae	*Ficus benghalensis, Toona ciliata, Choerospondias axillaris*

Table 2 : Plant diversity and other community characteristics of *PF, FBA, CBA and SG

Parameter	PF	FBA	CBA	SG
Number of families	33	18	22	22
Number of genera	50	22	29	29
Number of species	62	34	38	39
Shannon diversity index	3.21	2.09	2.47	2.55
Evenness index	0.82	0.72	0.78	0.80

Table 3 : Per cent Similarity of tree among different sites

Sites	Sites			
	PF	FBA	CBA	SG
PF	100	20.83	50	41.58
FBA		100	38.89	24.66
CBA			100	49.35
SG				100

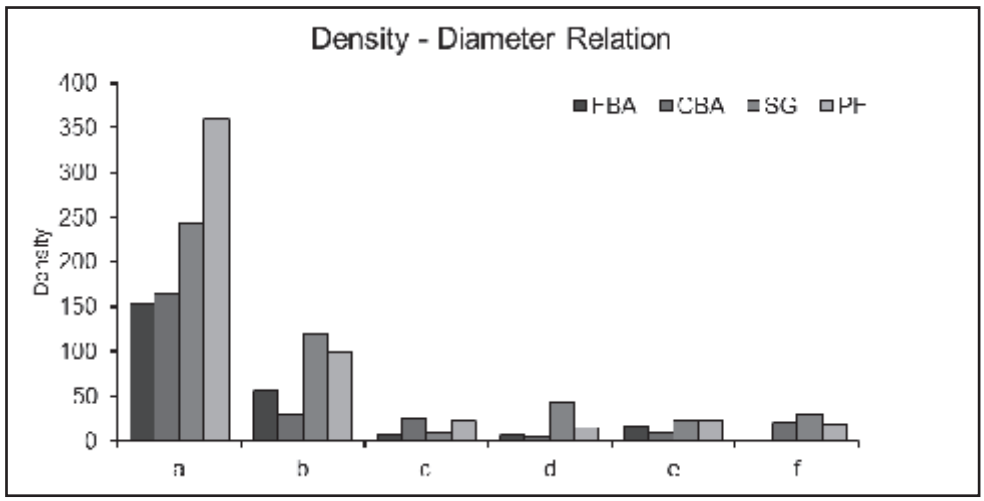

Fig. 1 : Density of tree species across different diameter class

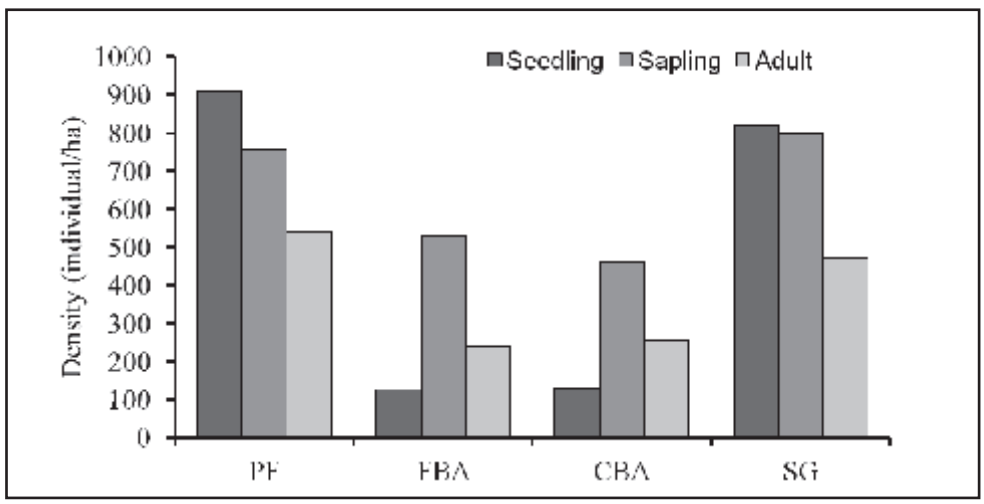

Fig. 2 : Population structure of trees in different sites

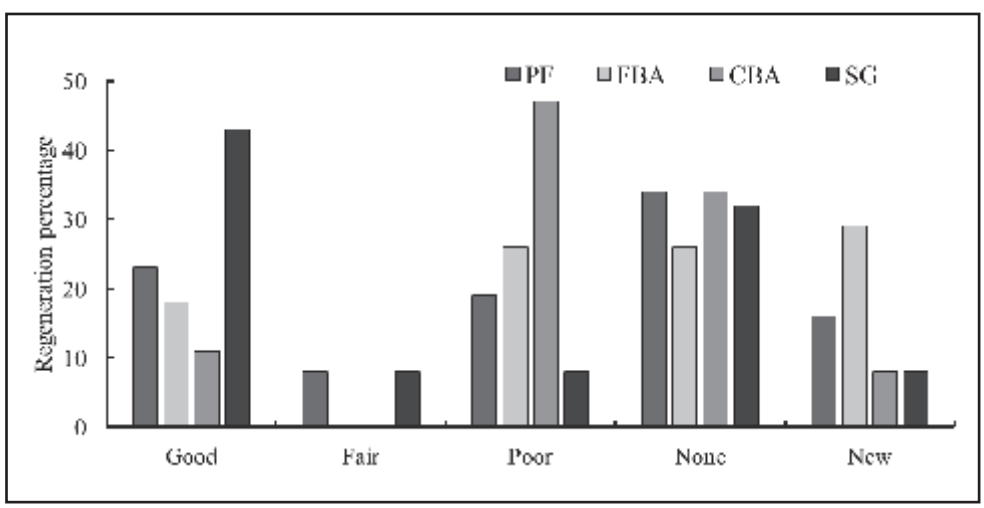

Fig. 3 : Regeneration pattern of tree species in different sites

for the majority of fruit extraction (77%), followed by PF (21%), and CBA (2%). Timber is extracted largely from PF (72%) followed by CBA (24%) and FBA (4%) (Fig. 4).

Based on Relative Frequency of Citation (RFC) various species under different categories of use have been listed. Species in the table are given in decreasing order of RFC value. It is clear from the field studies that most of the tree species in FBA are sources of fuelwood, fodder, or fruit, whereas timber-yielding species were reported to be most abundant in PF, followed by CBA (Table 4).

The modification of the natural forest land can be observed in all the four sites- PF, CBA, FBA and SG. The timber felling in these private lands are done only with the permission from the forest department. Other activities like NTFP extraction are done freely by the community in their respective lands. Agro-forests in Cardamom fields and agriculture fields, an important land use practice of Lepchas are maintained by the community to meet their daily requirement of fuel-wood and fodder. However, the separation of the portion of land within the village as a sacred grove, is not related to the economic benefit rather can be associated with the traditional mode of conservation of the floral and faunal resources of the region. Sacred groves with some sacred trees identified by the Lepchashaman *'Bungthing'* or '*Mum*', as the place where the forest deities reside. They believe that the older, larger trees or those with broader canopy cover are resided by the forest deities and thus are protected as a sacred tree, because of which the SGs has trees with greater basal area. Many taboos prevail amongst the villagers about the sacred groves like making loud noises, making the area around the sacred tree dirty, sound of cutting or felling of tress, burning wastes around the area will disturb the deities residing in the sacred tree. Cattle-grazing is prohibited in the two studied SGs. Only the dead and fallen branches are taken as fuel-wood. Thus the total tree density in SG is higher than that of CBA and FBA. This represents the

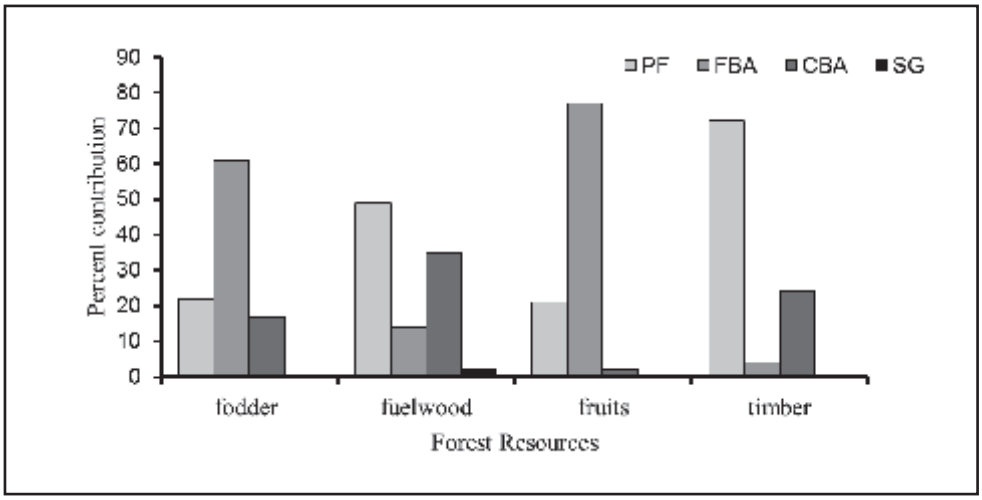

Fig. 4 : Tree species with different use values in the four treatment sites

Table 4 : Survey based preferred fodder, fuel-wood and timber species

Forest resources	Most preferred tree species (RFC)	Extracted from
Fodder	*Ficus auriculata* (0.95), *Ficus semicordata* (0.86), *Brassaiopsis hainla* (0.81), *Ficus. Neriifolia* (0.71), *Litsea monopetala* (0.71), *Bauhinia purpurea* (0.71), *Celtis tetrandra* (0.67), *Sloanea dasycarpa (0.67), Grewia optiva* (0.62), *Morus macroura* (0.50)	FBA, CBA, PF
Fuel wood	*Alnus nepalensis* (0.79), *Schima wallichii* (0.76), *Engelhardtia spicata* (0.71), *Castanopsis indica* (0.64), *Choerospondias axillaris* (0.52), *Cryptomeria japonica* (0.48), *Gynocardia odorata* (0.48), *Macaranga denticulate* (0.36), *Toona ciliate* (0.29), *Betula alnoides* (0.17)	FBA, PF, CBA
Fruits	*Juglans regia* (0.83), *Castanopsis indica* (0.76), *Choerospondias axillaris* (0.71), *Machilus edulis* (0.64), *Rhus chinensis* (0.57), *Mangifera sylvatica* (0.48), *Docynia indica* (0.48), *Evodia fraxinifolia* (0.36), *Zanthoxylum armatum* (0.29), *Beilschmiedia roxburghiana* (0.24)	FBA, PF, CBA
Timber	*Terminaliamy riocarpa* (0.71), *Juglans regia* (0.62), *Castanopsis indica* (0.60), *Toona ciliate* (0.57), *Magnolia lanuginose* (0.48), *Betula alnoides* (0.45), *Cryptomeria japonica* (0.43), *Duabanga grandiflora* (0.43),*Choerospondias axillaris* (0.31), *Alnus nepalensis* (0.24)	FBA, PF, CBA

expression of their keen sense of conserving the forests and its resources. The impurities signify not only the dirt or the pollutants but also the impurities of thoughts and acts. In this way the community, pave the way for conservation and survival of even a sensitive species in this pristine patch of land. The higher sapling and seedling density of tree species in SG can emphasize the role of SGs as plant species repository.

The tree composition in CBA and FBA are maintained by the owners of the land, depending on its social use values. FBA is mainly composed of fruit trees and fodder tree species. The owners can easily extract their daily basic requirement of fuel-wood and fodder from their own fields. Most of the timber-yielding species are rather found in PF followed by CBA. Fuel-wood collection and timber extraction is done maximum from PF. The population structure is devoid of stable composition of seedling and saplings with the adults in case of CBA and FBA and regeneration structure also shows more new species in FBA, since the resources are used and planted according to the livelihood needs. CBA and FBA, though actively used, have shown some regeneration, since the socio-culturally preferable species are allowed to establish further supplemented by plantation in some cases. Most of the NTFPs requirements of the villages are meet by the agroforestry and private forest resources, aiding to the sustainability of resources. Moreover, the conservation of most of the species is also done via culturally identified sacred groves.

Conclusion

There is a continuous challenge to balance the conservation and sustainable use of the land and natural resources without suppressing the needs of the traditional communities dependent on it. Legal ban on hunting, green felling of timber, grazing, are among the best solution of conservation of the resources. In addition to these protectionist strategies, the practices of the indigenous communities of Sikkim that have directly or indirectly supported sustainable use as well as the conservation of the forest and the local resources, needs to be identified and empowered. The traditional agroforestry practices have helped the locals to achieve resource use sustainability in the study area and help decrease the extraction pressure in the wild. The importance of the traditional system of forest conservation through Sacred groves should also be identified. Steps to recognize and maintain the sacredness and importance of this virgin forest area should be taken so that the wave of development and urbanization may not surmount the identity and the virtue of these places. Adoption of this practise not only boosts the tangible and intangible values of the forests for the dependent indigenous communities can also involve local people in the global theme of forest conservation and sustainable use of the resources.

पूर्वी हिमालय के जोंगू में विभिन्न भूमि प्रबंधन प्रथाओं के माध्यम से वन संसाधनों का सतत् उपयोग और संरक्षण

शीला सिन्हा, अनिल कुमार बिष्ट, कैलाश सिंह गैरा और प्रकाश छेत्री

सारांश

यह पेपर इलायची आधारित कृषिवन (CBA), फील्ड-बेस्ड एग्रोफोरेस्ट्री (FBA), निजी वनों (PF) और जोंगू, उत्तरी सिक्किम, पूर्वी हिमालय के पवित्र उपवनों (SG) में पेड़ की आकृति और संरचना से संबंधित है। वृक्ष प्रजातियों के उपयोग के बारे में पारंपरिक प्रथाओं और ज्ञान की पहचान की गई। पीएफ में उच्चतम वृक्ष घनत्व देखा गया और एसजी में उच्चतम बेसल एरिया कवर की सूचना दी गई। बेहतर उत्थान क्षमता के साथ पीएफ और एसजी द्वारा अधिकतम जनसंख्या संरचना का प्रदर्शन किया गया। पेड़ों की प्रजातियों को एसजी (43%) में सबसे अधिक बताया गया, इसके बाद पीएफ में (23%), जबकि सीबीए ने सबसे कम या सबसे खराब पुनर्जनन प्रस्तुत किया। FBA और CBA को स्थानीय समुदाय के लिए पारिस्थितिक और आर्थिक महत्व वाले वृक्ष प्रजातियों की संरचना द्वारा चित्रित किया गया। हालांकि कृषि वानिकी आजीविका का समर्थन करती है, लेकिन पेड़ों का शोषण जंगल के पारिस्थितिक कामकाज पर भी दबाव डालता है। स्वदेशी समुदाय 'लेपचाओं' की गांव के परिवेश में एसजी बनाए रखने की सांस्कृतिक प्रथा न केवल स्थानीय संसाधनों के संरक्षण में मदद करती है बल्कि मानव-प्रकृति के बंधन को भी मजबूत करती है।

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