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Research Article

On-Farm Management of *Vitellaria paradoxa* C. F. Gaertn. in Amuria District, Eastern Uganda

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The population of shea butter tree (*Vitellaria paradoxa* C. F. Gaertn.)—a priority tree with enormous economic and cultural values to the parkland communities in Uganda, is rapidly declining due to rapid human population growth, increasing land fragmentation, and high demand for woodfuel especially charcoal. Reversing this trend will depend on the rural community involvement in the planting, facilitating natural regeneration, and tending of shea trees on farm. As such a survey was conducted in Amuria district, eastern Uganda, to assess local strategies and constraints to on-farm management of shea trees, and document socio-demographic factors influencing the on-farm conservation. About 93% of the households protected naturally regenerated *V. paradoxa* trees mainly on farms. *V. paradoxa* was mostly propagated through coppices and seedlings. Although insecure land tenure, insecurity, pests, disease, and shortage of planting materials were reported as major hindrances, farmsize, family size, and gender significantly ($P \leq 0.05$) influenced people's willingness to conserve *V. paradoxa*. Byelaws and policies on shea conservation need to be properly enforced, and further propagation research is required especially towards shortening the juvenile period of *V. paradoxa* so that more farmers can start propagating the tree other than relying on its natural regeneration.

1. Introduction

The shea butter tree (*Vitellaria paradoxa* C. F. Gaertn.) is one of the many economically valuable trees frequently seen in parkland landscapes in Sudano-Sahelian belt of Africa [1, 2]. It is a tree species of high priority for African genetic resources [3]. The fruit pulp can be eaten by both humans and animals, while the butter extracted from the seed kernel has remarkable importance in traditional food security, manufacturing of body care products, pharmaceutical, and confectionery industries [4]. The wood is used for charcoal, construction and furniture, while the latex may be used in glue making [5]. It also plays a role in amelioration of microclimate and soil fertility in savanna woodlands [6].

Protected for its edible fruit pulp and butter, income generation, cosmetics, medicines, wood, and soap production, *V. paradoxa* is one of the most abundant indigenous tree species in the Sudanian zone that forms the backbone of livelihoods over most of its 5000 km range [7, 8]. However, *V. paradoxa* faces a high degree of thinning, selection, and natural mortality leading to a noticeable reduction in density [5, 9, 10]. In Uganda, indiscriminate burning of bushes and cutting of trees coupled with population increase, insecurity, and expanding agricultural land clearing have led to woodland degradation [11]. Many shea trees are cut for building poles and charcoal because of their ability to resist termite attack and high marketability, respectively [12]. Additionally, natural regeneration has declined as coppicing and pollarding have limited ability to produce epicormic shoots that usually sustain the wild population [2].

The indigenous agroforestry system operating in eastern Uganda and Amuria district in particular is of widely spaced trees in the croplands of sorghum and millet in conjunction with livestock rearing [13]. This subsistence farming system is characterized by dispersed trees such as *V. paradoxa, Tamarindus indica, Borassus aethiopum*, and *Prosopis africana* [2] that are deliberately retained on cultivated or on fallowed land for their multiple products including fodder, wood, fruits, charcoal, timber, and medicine [14]. Yet, Okullo et al. [15] indicated places where farmers lack access to improved seeds of most tree species including knowledge on seed collection, species selection, and planting techniques, to be

facing low adoption rates for agroforestry. In order to sustain trees such as *V. paradoxa* in the agroforestry parklands, it is critical to understand traditional management strategies by the local people [16, 17]. In this paper, we examine local management strategies, type of shea propagation materials, and constraints and sociodemographic factors that influence on-farm management of *V. paradoxa* in Amuria district.

2. Study Area and Methods

The study was conducted in Acowa and Wera subcounties, in Amuria district in the eastern part of Uganda (Figure 1). Located between 33° to 34° E and 10° to 30° N, Amuria is largely flat within an altitudinal range of 900 and 1200 meters above sea level with a few hills. The soils are ferralsols, usually deep, representing almost the final stages of tropical weathering [18]. Amuria receives 850–1500 mm of rainfall per annum with the mean annual maximum temperature ranging between 32.5° to 35°C and the mean annual minimum temperature of 15°–17.5°C [19]. The district is covered with wooded savanna vegetation consisting of scattered shrubs 2–6 meters high in grassland to an open canopy of trees 6–12 meters high underlain by grass. According to the 2002 National Housing and Population Census, the population of the district was 183,817 people, increasing at an average annual growth rate of 2.8% [20]. Of these, over 90% are engaged in agricultural cultivation and livestock keeping [13].

In order to capture socioeconomic data and information on on-farm management, structured questionnaires were administered purposively to 80 respondents, 20 from each of the 4 sampled parishes in the subcounties with high *V. paradoxa* densities following Agea et al. [21]. Statistical Package for Social Scientists (SPSS) program [22] was used to analyze the questionnaire responses. Logistic regression analysis [23] and cross-tabulation [24] was used to test the relationship between sociodemographic factors and willingness to manage shea trees.

3. Results

3.1. Socioeconomic Characteristics of Respondents. The study group consisted of 55% males and 45% females (Table 1). More than 72% of them were below 49 years of age, and 28% were 50 years and above. A half of the respondents had hardly settled in Amuria district for 21 years, 73% were married, 68% had 5–9 people in their households, and about 80% of them owned less than 10 hectares of land. Whereas 39% of the respondents had studied up to primary level, 28% had never attained any formal education. The major occupation was peasantry (70%).

3.2. Local Management Strategies for Vitellaria paradoxa Trees. A majority of the farm families in Amuria district raise *V. paradoxa* deliberately on farm, allow natural regeneration, discourage other people from cutting down, and weed around shea trees alongside other crops during cultivation (Table 2).

Table 1: Socioeconomic characteristics of the respondents (N = 80).

Factor	Sex		Total	Percentage
	Male	Female		
Age (years)				
<30	10	12	22	27.50
30–49	19	17	36	45.00
50–69	10	4	14	17.50
>70	5	3	8	10.00
Period of stay (years)				
<21	16	24	40	50.00
21–35	12	5	17	21.25
>35	16	7	23	28.75
Marital status				
Single	6	8	14	17.50
Married	35	23	58	72.50
Widowed	3	5	8	10.00
Family size (number of persons)				
1–4	8	3	11	13.75
5–9	26	28	54	67.50
>9	10	5	15	20.75
Gender				
Male			44	55.00
Female			36	45.00
Education background				
None	10	12	22	27.50
Primary	20	11	31	38.75
Secondary	10	9	19	23.75
Tertiary	4	4	8	10.00
Current occupation				
Peasant	31	25	56	70.00
Student	1	4	5	06.25
Civil servant	8	4	12	15.00
Self-employed	4	3	7	08.75
Plot/land size (hectare)				
<10	32	31	63	79.75
10–29	10	5	15	18.75
>30	2		2	02.50

Table 2: Local management strategies for shea trees by farming households in Amuria district, eastern Uganda.

Local management strategies for shea trees	% response
Raised them deliberately on farm	97.50
Allowed natural regeneration on farm	92.50
Discouraging other people from cutting down	90.00
Ploughing around and weeding	88.75
Protected from pests and diseases	50.00
Staking young trees from destruction by livestock	30.00
Planted on farm boundaries	18.75

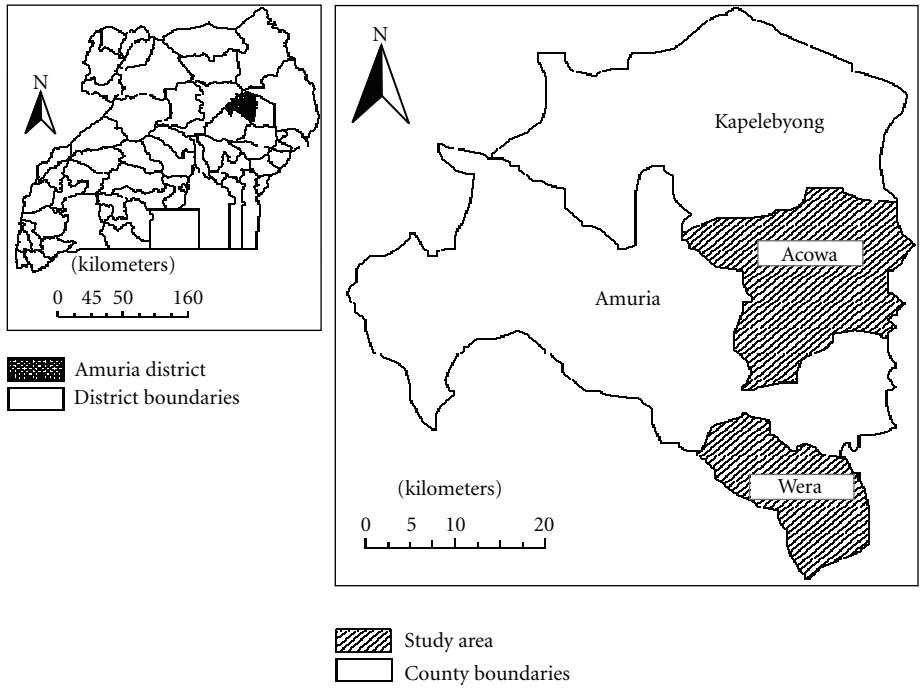

Figure 1: Location of the study area in Uganda.

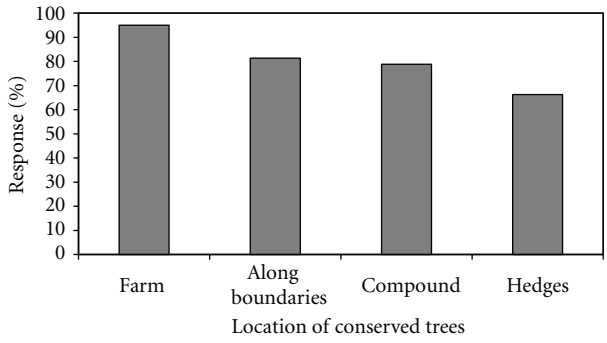

Figure 2: Management niches of shea trees by farm households in Amuria district, eastern Uganda.

3.3. Management Niches of Shea Trees by Farm Households. Shea trees are managed on cultivated lands, along boundaries, home compounds, and hedges (Figure 2).

3.4. Local Propagation Methods and Constraints to Management of Shea Trees. The main methods of shea tree propagation used by farming households are coppices (98%) and seedlings (45%). Two households (3%) reported using cuttings. Land shortage and insecure tree tenure, pest and disease incidences, shortage of planting materials, weak law enforcement in the area, civil unrest, and bush fires greatly constrained the management of shea trees in Amuria district (Table 3).

3.5. Willingness to Manage Shea Trees by Farming Households. Logistic regression analysis (Table 4) shows that respondents' willingness to manage shea trees is significantly ($P \leq 0.05$) influenced by gender, family size, and farm size. Considering gender, male household heads were more willing (51%) to manage shea trees than their female counterparts (Table 5). The marginal effect of 7.814 implies that there is a 781% greater chance of liking shea tree management activities if the household head is male. The marginal change on the attitudes towards shea management activities as a result of gender is 4.116, implying that if the household is male headed, the probability of managing shea trees increases by 412%.

Table 3: Constraints to on-farm management of shea trees ($N = 80$).

Constraints in the management of *V. paradoxa*	% response
Land shortage and insecure tree tenure	45.0
Pests and disease incidences	38.8
Shortage of planting materials	30.0
Weak law enforcement in the area	20.0
Inadequate skills/advisory services for shea management	15.0
Frequent displacement due to insecurity	10.0
Bush fire occurrences	07.5
High poverty levels	06.3
Long juvenile period before fruiting	06.3
High demand for shea charcoal	05.1
Destruction by grazing animals	02.5

Table 4: Logistic regression of sociodemographic characteristics that influence people's willingness to manage the shea trees (N = 80).

Variable	R	Odd ratio	P value	Significance at 5%
Gender	4.116	7.814	0.042	*
Age	1.248	1.504	0.264	ns
Period of stay	1.099	1.216	0.295	ns
Marital status	0.120	1.350	0.729	ns
Family size	5.082	0.191	0.024	*
Education	0.912	1.599	0.340	ns
Occupation	1.286	0.839	0.257	ns
Land size	6.124	3.457	0.013	*

* = Significant; ns = not significant at $P \leq 0.05$.

Table 5: Cross-tabulation of gender, family size, and size of the land owned against respondents' willingness to manage shea trees (N = 80).

Socioeconomic variables	Percentage willingness to manage shea trees		
	Willing	Not willing	Total
Gender of respondent			
Male	50.50 (40)	04.5 (04)	55.00 (44)
Female	45.00 (36)	—	45.00 (36)
Family size (number of persons)			
<5	13.75 (11)	—	13.75 (11)
5–9	66.25 (53)	01.25 (01)	67.50 (54)
10–14	13.75 (11)	01.25 (01)	15.00 (12)
>14	03.75 (03)	—	03.75 (03)
Plot/land size (hectare)			
<5 ha	31.25 (25)	—	31.25 (25)
5–9	13.75 (11)	01.25 (01)	15.00 (12)
>9 ha	53.75 (43)	—	53.75 (43)

Note: Bracketed is frequency.

Family size positively influenced attitudes towards shea management (P = 0.24, R = 5.082) (Table 4). A cross-tabulation (Table 5) shows households with 6–9 members to be with the highest interest (66%) in the management of shea trees. The marginal effect of 0.191 implies that there is a 19% greater chance of liking shea tree management activities if the family had 6–9 members. The marginal change on the attitudes towards shea management activities as a result of family is 5.082, implying that if the household has 6–9 members, the probability of managing shea trees increases by 508%.

Households with over 9 hectares of land were more willing to manage the species (54%). The marginal change on the attitude towards shea tree management as a result of land size was 3.46 indicating that the level of shea management increases by 346% if the household had over 9 hectares of land.

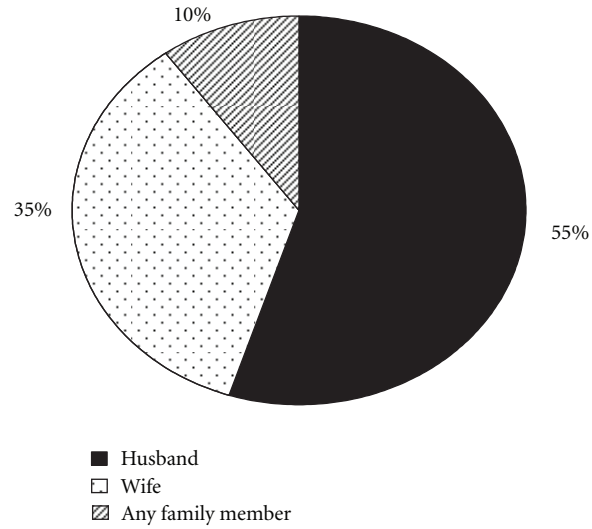

Figure 3: Who makes the decision to conserve shea trees within the faming households in Amuria district, eastern Uganda?

3.6. Who Makes the Decision to Conserve Shea Trees within the Farming Households? The key decision makers in shea tree management in the households in Amuria are husbands and wives by 55% and 35%, respectively. Other family members such as children, relatives, and grandparents account for 10% in the shea management decision making process (Figure 3).

4. Discussion

4.1. Local Management Strategies for Vitellaria paradoxa. Special shea management strategies reported by 98% of the respondents included facilitating natural regeneration through weeding, thinning, pruning, pollarding, and spraying coppices and seedlings against pests and diseases (Table 2). This is consistent with Mujabi-Mujuzi et al. [25], who noted that weeding of woody perennials is always carried out alongside agricultural crops while pollarding, pruning, and thinning of trees and shrubs are done by men to reduce the effect of shading, stimulate flowering, increase fruiting, and facilitate harvesting. There is therefore a great opportunity to conserve shea trees if these skills are promoted as local practices which are usually critical in the success of biodiversity conservation [16, 17].

Although shea trees are conserved on farms, along boundaries, compounds, and hedges, this practice is not confined to Amuria district only. A report by Schreckenberg [26] shows that many people in Guinea do plant and protect trees directly around their houses, and the products of these always belong to the planter. As products from naturally regenerated indigenous species can be harvested freely unless they are in a farmer's field, a majority of species yielding important NTFPs sustaining local people's livelihoods are always located in the crop fields and fallows [26]. This coupled with increased transition of land into permanent cropping systems means that protection, planting, and

management of trees on farms are becoming progressively more intensive [15].

4.2. Shea Propagation Materials Used in Amuria District. Coppices are the main materials used for propagating shea trees in Amuria district (Figure 1). This is consistent with Sekatuba et al. [27], who noted that few farmers usually carry out deliberate propagation and management of indigenous trees. Naturalized fruit species are commonly propagated by seeds and seedlings. In other countries like Ghana, natural regeneration is the single most important and commonly used procedure by the research stations to achieve a density of 400 shea trees per hectare [28]. Additionally, natural regeneration is cost effective as farmers usually do not have to buy seeds for propagation, and it also allows farmers to process edible oil from the kernels [7]. However, a study by Sheail et al. [29] revealed that leaving nature alone defeats the purpose of nature conservation. This makes advocacy for the management of indigenous fruit trees on-farm necessary.

Seedlings and cuttings are also used for raising shea trees to a smaller extent. This could be because edible oil is processed from the kernels [7]. In addition, a report by Okafor [30] indicated indigenous fruits to be contributing significantly to diets of rural households as they have high nutritional value and are rich in vitamins and minerals.

4.3. Constraints to On-Farm Management of V. paradoxa. Land shortage and insecure tree ownership are the main challenges to *V. paradoxa* management in Amur1a district (Table 3). The findings agree with Okullo et al. [15], who noted that land and tree ownership can pose negating effects for the management of shea trees. The continued fragmentation of land resulting from high population growth in Amuria district has led to a decrease in land size per household. Consequently, during cultivation of crops farmers tend to clear all the trees. This coupled with sharing of inherited land from the parents over generations makes people to be reluctant to plant trees [15]. This implies that secure tenure and tree usage can significantly motivate farmers to plant and care for trees.

Pests and diseases have been reported as the most important challenge in the management of *V. paradoxa* in Amuria district. Caterpillars of *Cirina butyrospermii* were noted to be adversely defoliating shea butter trees from seedlings to mature trees, especially on the onset of new leaves. The larvae of *Mussidia nigrioella* and *Certitis silvestrii* also feed on the pulp of mature shea trees. Unfortunately, a few of the pests that affect either crops or trees in agroforestry systems have received attention in recent years [31]. Nevertheless, control measures such as pruning can also be used to minimize the effect of parasite plants like *Tapinanthus sp.* [28].

Just like in many other countries, conservation efforts in Uganda have mainly focused on the tropical rain forests [32]. By contrast, the savanna environment has received less attention. This could be due to the fact that conservation of savanna lands is considered less of a priority by governments and donors than that of tropical rain forests [26]. Even then, law enforcement, collaborative management, and sensitization of local communities are very important factors for the success of any conservation programme [33, 34].

The respondents reported shortage of planting materials and inadequate advisory services on shea management. The shortage of farm tools was attributed to continuous displacement by rebels and Karimojongs cattle rustlers and poverty. A report by Barrow [33] indicates that extension services and awareness creation make local people especially women, local institutions, and state departments work jointly in the management of woodlands. Since extension services under the Uganda National Agricultural Advisory Services (NAADS) in Uganda guide farmers to develop environmentally sound farming, on-farm tree planting, and maintaining field types that best satisfy their socioeconomic needs [35], it should be encouraged and expanded in Amuria district.

The people of Amuria district have for the past twenty two years suffered internal displacement, famine, and cattle rustling [13]. Farmers reported that confinement in internally displaced persons' (IDPs) camps makes it impossible to carry out shea tending activities such as weeding, pruning, thinning and pollarding. Even if it has been reported that successful tree planting can occur in areas where human survival is often marginal with little of anything in cash, labour, or risk-taking confidence to spare [36], it is crucial to restore lasting peace in the area because it is a recipe for any development to take place [37].

Whereas most farmers prefer fast growing tree species that take a short period of time to give benefits, *V. paradoxa* is slow growing and only begins to produce fruit at 20 years [1]. According to Chevalier [38], *Vitellaria paradoxa* is exceedingly slow growing, and it is thought that large tree specimens (0.8–1.0 m dbh) are hundreds of years old. This makes most farmers undermine its conservation. Efforts should therefore be made to shorten the juvenile phase of shea trees so that farmers can start propagating them other than relying on natural regeneration.

Uncontrolled bush fires were reported to be a hindrance to shea management. A report by Agea et al. [21] indicates that fire is one of the challenges in the management of rangelands since they are dominated by grasses that are usually set on fire in the dry season to induce the growth of new pastures and during hunting of wild animals or to clear land for cultivation. Fire can interfere with the flowering and regeneration of *V. paradoxa* which always coincide with the dry season [1].

Amuria is one of the districts in the cattle corridor [39], and livestock rearing is practiced by a majority of the households. However, livestock grazing contributes to changes in vegetation through alteration of plant growth, architecture, and density. With the increasing number of cattle per household, overgrazing is common and may result in defoliation of trees, destruction of seedlings, and, most importantly, soil compaction [21]. According to Bourliere [40], soil compaction by grazing animals can greatly interfere with natural regeneration of many tree species. While postharvest grazing on communal basis also makes it very difficult for farmers to establish new trees on croplands

[41]. Since farmers lacked measure for overgrazing, if not combated, this could greatly hinder shea management.

The increasing demand for shea charcoal concurs with a report by Eilu et al. [35], which indicated that local communities living in the rural areas of developing countries usually depend on plant resources in the agricultural landscapes. However, management of *V. paradoxa* tree densities responds rapidly to changes in the demand and relative prices of its products. When *Vitellaria* nuts or butter sell for higher prices, regeneration is promoted, and if fuelwood prices outstrip those of other tree products, trees tend to be felled and sold on the fuelwood market [42]. Alternative sources of income such as bee keeping, if provided, would reduce charcoal burning which is greatly reducing the population of *V. paradoxa* and other trees in the district. Beekeeping is a profitable agroforestry practice through which a farmer can generate income while still using the land for food crops or tree production [31].

4.4. Sociodemographic Factors Influencing Management of V. paradoxa. Despite the above constraints, majority (99%) of the respondents are willing to manage shea butter trees. A logistic regression analysis (Table 4) shows that their willingness to conserve shea trees is significantly ($P \leq 0.05$) influenced by farm size, family size, and gender.

Cross-tabulation (Table 5) showed that larger farm holders are more willing to conserve shea trees. This could be because they do not mind retaining some trees while clearing land for agriculture; they could also be maintaining longer fallow periods and may have great resilience to risks of crop failure [21].

Farmers with moderate (5–9 people) family sizes (Table 4) could also be more willing to plant and protect more *V. paradoxa* trees because of the roles of shea trees in providing food resources during the lean seasons of farm cultivation [43]. According to Andersen [44], the size of the household determines the ability to satisfy basic needs.

Decisions on whether to grow or plant shea trees were mainly made by male respondents (55%, Figure 3). According to Okullo et al. [15], this is so because men are the most influential in families; they are regarded as owners of land the family occupies and in most cases have the discretion to plant or cut down trees while women are considered to be usurping men's power by planting trees. In Sierra Leone, for example, women were found to comply with men's decisions to clear NTFP species, as they viewed the income from the cash crops as more important than that from the tree products [45]. It is therefore important to recognize the decision-making role of men during the promotion of shea management in the area.

5. Conclusion and Recommendations

A majority of the farm families in Amuria district manage *V. paradoxa* deliberately on farm, by allowing natural regeneration and discouraging other people from cutting down trees. There is therefore an opportunity to sensitize the communities on the best farming practices if conservation of shea and other trees is to be sustained.

Since shea trees are managed on cultivated lands, along boundaries, home compounds, and hedges, there is need to strengthen the capacity of the Iteso Cultural Union, Elders Councils, Local Councils, District Forestry Services, and byelaw enforcement in the area to promote conservation.

It is important to undertake further research especially on propagation such that the juvenile phase of the *V. paradoxa* can be reduced in order to curtail the reliance on natural regeneration. This may encourage more farmers to start planting shea trees instead of waiting for coppices.

Training local communities on how to construct and use energy saving stoves such as Lorena would greatly reduce the cutting down of shea trees for charcoal and firewood which is usually associated with the traditional cooking methods [46].

On-farm carbon valuation and compensation of shea farmers could also be one of the incentives for shea management in Amuria and other districts in Uganda. This can be premised on the fact that shea trees have been reported to be reliable carbon sinks that can last over a hundred years.

This study shows men to be key decision makers in shea tree conservation followed by women. There is therefore an opportunity to sensitize both women and men on the values and technical requirements in the conservation of shea trees. However, indigenous knowledge should be documented and used as a basis for training on conservation of trees.

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