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Ecological and Socio-Economic Impacts of *Chromolaena odorata* and *Mesosphaerum suaveolens*, Two Invasive Alien Species in Central and Southern Benin, West Africa

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Abstract

Chromolaena odorata and *Mesosphaerum suaveolens*, two invasive plants originating from tropical America, exert significant pressure on forest ecosystems in West Africa, particularly by disrupting natural regeneration processes. Their expansion in the Lama Classified Forest in southern Benin has raised increasing ecological and socio-economic concerns. This study investigated how *C. odorata* affects natural regeneration dynamics and examined local perceptions related to both species. Vegetation surveys were conducted in plots situated in invaded and non-invaded zones to assess species composition and seedling density. Complementary interviews with local communities were carried out to document the socio-economic impacts attributed to these invasive plants. Results show a marked decline in seedling abundance and species richness in invaded areas compared to non-invaded zones, indicating strong ecological pressure linked to the presence of the species. Community perceptions consistently highlight the predominantly harmful effects of *C. odorata* and *M. suaveolens* on agriculture, forest regeneration, and livelihoods. The study highlights the significant ecological and socio-economic threats posed by these invasive species and emphasizes the need for targeted management to protect ecosystem integrity in affected areas.

Keywords: *Chromolaena odorata*; Lama Classified Forest; Invasive Plant; *M suaveolens*; Natural Regeneration

Introduction

Biological invasions are a major challenge for biodiversity conservation, ecosystem stability, and food security, particularly in tropical developing regions [1]. These species, often introduced accidentally but sometimes deliberately, can rapidly establish and dominate local plant communities, causing profound changes in ecological dynamics and ecosystem functions [2]. In West Africa, invasive species such as *Chromolaena odorata* (L.) King RM, et al. [3] and *Mesosphaerum suaveolens* (L.) Kuntze are raising concerns due to their impact on both agricultural systems and natural habitats.

C. odorata, native to tropical America, is among the most problematic invasive plants in Africa, colonizing fallow land, field margins, secondary forests, and even protected areas [4]. It is characterized by rapid growth, high biomass production, and allelopathic effects that inhibit the germination and growth of native plants, leading to notable losses in local

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plant diversity [5]. *M suaveolens*, also native to tropical America, is emerging as a weed of concern in wetlands and food crops such as cassava and maize, where it competes with cultivated plants and reduces productivity [6]. Beyond ecological impacts, plant invasions impose socio-economic burdens, particularly for rural communities dependent on natural and agricultural resources [7]. Reduced yields, higher management costs, and the need to adapt cultural practices can exacerbate farmers' vulnerability, especially where access to resources and technologies is limited [8]. Despite this, integrated studies combining ecological and socio-economic assessments of *C. odorata* and *M. suaveolens* remain scarce in West Africa [9].

This study aims to assess both the ecological and socio-economic impacts of *C. odorata* and *M. suaveolens* in rural areas of Benin. By combining surveys of local communities, analyses of management costs, and measurements of natural regeneration of woody species, the research provides evidence to guide sustainable management strategies for these invasive plants.

Materials and Methods

Study Area

This study was conducted in the Lama Classified Forest in southern Benin, as well as in surrounding municipalities affected by the spread of the two species (Figure 1). This forest constitutes one of the last vestiges of semi-deciduous forests in the Sudano-Guinean zone of the country and represents an ecosystem of major importance. It's located between 6°55-7°00N and 02°04- 02°12 E, in southern Benin. This forest is the largest natural forest in southern Benin and one of the last relict forests in the Dahomey Gap.

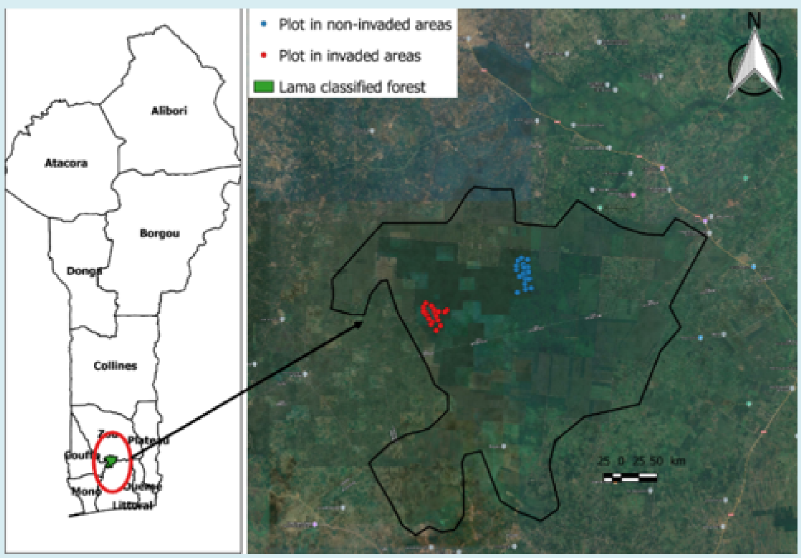

Figure 1: Study area location.

Socio-Economic Survey

To assess how *C. odorata* and *M. suaveolens* affect local socio-economic conditions, we conducted a structured survey among rural communities in six municipalities: Zè, Bohicon, Zogbodomè, Dassa-Zoumè, Savè, and Glazoué. The survey aimed to assess local perceptions of the species influencing agricultural productivity, livestock rearing, access to natural resources, and household income.

The number of respondents was determined using the Dagnelie [10] formula:

$$n = \frac{U^2 * ((1-p) * p)}{d^2}$$

where n defines the survey population size, U represents the standardized confidence interval coefficient (1.96 corresponding to 95% certainty), p reflects the anticipated proportion of respondents demonstrating species familiarity, and d constitutes the acceptable sampling error margin, established at 7% precision [11]. Respondents were selected using a stratified random sampling approach to ensure representativeness across different villages and socio-economic groups.

Field Design and Data Collection Methods

A total of 40 quadrats measuring 10 m × 10 m were established, equally distributed between invaded and uninvaded areas. Quadrats were positioned to capture a representative range of local conditions while minimizing

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topographical and anthropogenic biases. Within each quadrat, all woody regeneration, including seedlings and saplings, was recorded [12]. Plant specimens were collected for identification at the National Herbarium.

Measured Ecological Variables

From the collected data, parameters such as species richness in regeneration and regeneration density were calculated. Shannon's diversity index (H′), which considers both species richness and relative abundance, and Pielou's evenness index (J′), which measures the balanced distribution of individuals between species, were also measured [13-15].

Statistical Analyses

Statistical analyses were performed using R software (version 4.3.2, R Core Team, 2023). Data normality was assessed using the Shapiro-Wilk test, and variance homogeneity was evaluated with Levene's test. For variables meeting both assumptions, one-way ANOVA was applied. When these assumptions were not met, the Wilcoxon rank-sum test was used as a non-parametric alternative. The significance level was set at $\alpha = 0.05$ for all tests. Floristic composition between invaded and uninvaded areas was compared using the Jaccard similarity index. Non-metric multidimensional scaling (NMDS) was employed to visualize floristic structure, and PERMANOVA was used to evaluate the effect of invasion on floristic composition using the vegan package [16].

Results

The survey included 196 participants, representing several socio-professional groups. Farmers were the most represented with 95 respondents (48.5%), followed by livestock breeders (26.5%), agricultural product dealers (14.8%), traditional healers (7.1%), and forest rangers (3.1%) (Figure 2).

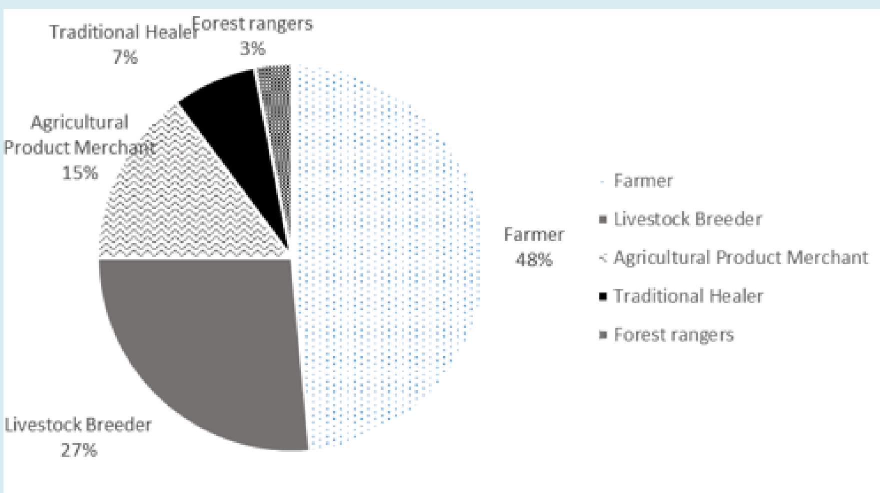

Figure 2: Distribution of respondents by socio-professional category

Socio-Economic Impacts Of *C. odorata* and *M. suaveolens*

Most respondents (78.6%) consider these species harmful to their activities due to increased land management costs, reduced pastoral resources, biodiversity loss, and lower yields. Farmers reported *that C. odorata* rapidly invades fallow land and perennial crops, leading to a marked increase in weeding efforts (Table 1). Producers affected by this species estimate the average annual management cost at 45,200 ± 8,700 FCFA/ha, with higher expenses during the rainy season, when growth is most intense. For *M. suaveolens*, the average cost is estimated at 31,800 ± 6,400 FCFA/ha/year, and its impact is considered particularly severe in humid and lowland areas, where it limits the cultivation of cassava (*Manihot esculenta*) and maize (*Zea mays*). Regarding productivity, 64.8% of farmers indicated that *C. odorata* reduces crop yields by more than 25%, compared with 47.3% for *M. suaveolens*. These losses are commonly linked to reductions in cultivated areas and adjustments to cropping calendars aimed at limiting species expansion. Although *C. odorata* is largely perceived negatively, 15% of producers associate its presence with improved soil fertility, noting its frequent occurrence on fallow or previously cultivated land and the contribution of its litter to surface organic matter. Some secondary uses were reported, mainly for medicinal purposes, plot demarcation, or mulching. However, these benefits are considered insufficient to offset economic losses and increased labor demands. Consequently, most respondents (83.7%) expressed a desire to eradicate or

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substantially reduce these species.

Aspect evaluated	Chromolaena odorata	Mesosphaerum suaveolens
Perception of the species	Mainly considered harmful (costs, biodiversity loss, yield reduction)	Mainly considered harmful, especially in humid lowland areas
Annual management cost (mean ± SD)	45,200 ± 8,700 FCFA/ha	31,800 ± 6,400 FCFA/ha
Period of highest cost	Rainy season (vigorous growth)	Rainy season (humid areas)
Impact on crops	Rapidly colonizes fallows and perennial crops; increased weeding workload	Particularly problematic for cassava and maize in lowlands
Yield loss (> 25%)	Reported by 64.8% of respondents	Reported by 47.3% of respondents
Farmers' strategies	Reduced cultivated area, adjusted crop calendar	Reduced cultivated area, adjusted crop calendar

Table 1: Reported impacts of *C. odorata* and *M. suaveolens.*

Ecological Impact of the Species in the Lama Classified Forest

The analysis of floristic inventories and vegetation structure surveys reveals clear differences between invaded areas by *C. odorata* and non-invaded areas. This fast-growing, heliophilous species develops dense stands that strongly affect the composition and dynamics of plant communities. In invaded plots, high leaf cover restricts light availability at ground level, thereby limiting the establishment of local herbaceous and woody species. Moreover, substantial biomass and litter accumulation, together with the production of allelochemical compounds, alters soil-related conditions and constrains woody regeneration. The data provide evidence of significant impacts of the invasion on species diversity and regeneration density.

Specific Richness and Regeneration Density

Species richness was calculated to evaluate the effect of invasion by *C. odorata* on floristic diversity. Differences between invaded and uninvaded areas were assessed using the non-parametric Wilcoxon rank-sum test. A highly significant difference was detected between the two conditions ($W \approx 32$, $p \approx 4.9 \times 10^{-6}$). Invaded areas exhibited substantially lower species richness (median ≈ 2.5 species) compared to uninvaded areas (median ≈ 6.5 species) (Figure 3).

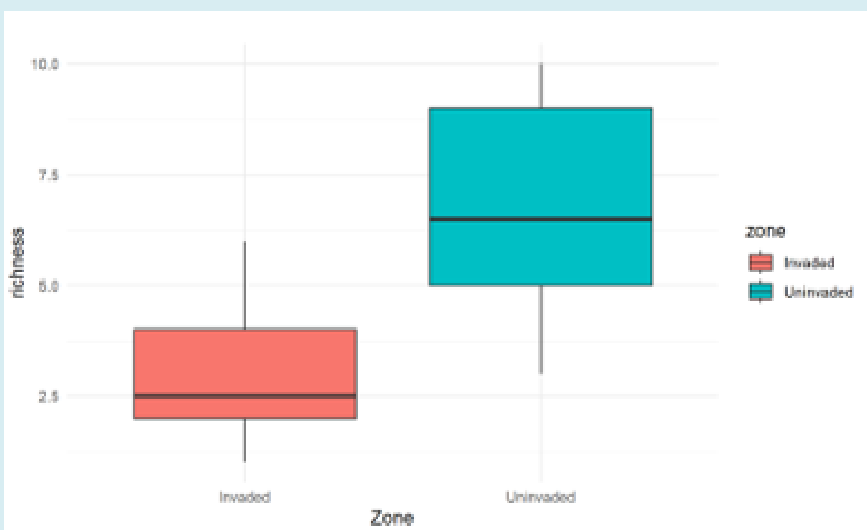

Figure 3: Comparison of species richness between invaded and non-invaded areas.

Individual density was assessed to evaluate the effect of *C. odorata* invasion on natural regeneration abundance. Differences between invaded and uninvaded areas were tested using one-way ANOVA. A highly significant difference was detected between the two conditions ($F_{1,38} = 186.4$, $p = 3.13 \times 10^{-16}$). Invaded areas exhibited substantially lower mean density (mean ≈ 11 individuals) compared to uninvaded areas (mean ≈ 31 individuals) (Figure 4).

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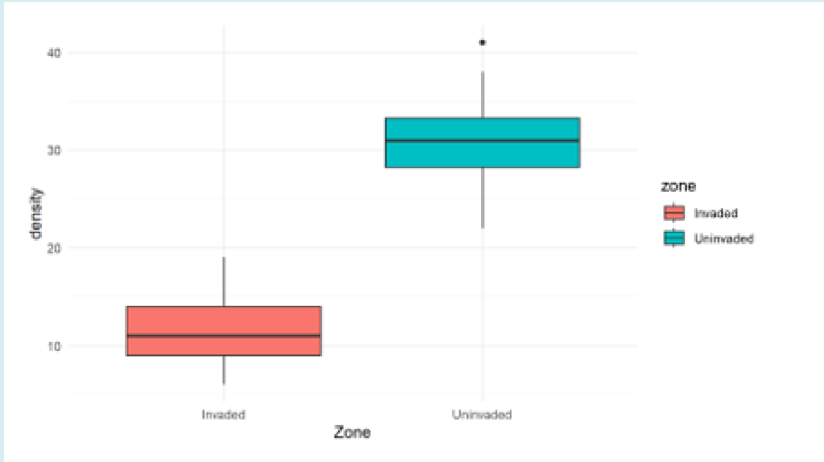

Figure 4: Individual density across invaded and non-invaded areas.

Impact of *C. odorata* Invasion on the Specific Diversity of Natural Regeneration

The Shannon diversity index was calculated to evaluate the effect of *C. odorata* invasion on the diversity of natural regeneration. Differences between invaded and uninvaded areas were tested using a one-way analysis of variance. The ANOVA revealed a highly significant difference between the two conditions ($F_{1,38} = 32.92$, $p = 1.3 \times 10^{-6}$). Invaded areas exhibited substantially lower mean Shannon index values (mean ≈ 0.75) compared to uninvaded areas (mean ≈ 1.7) (Figure 5). These results align with the reduced species richness observed in invaded areas.

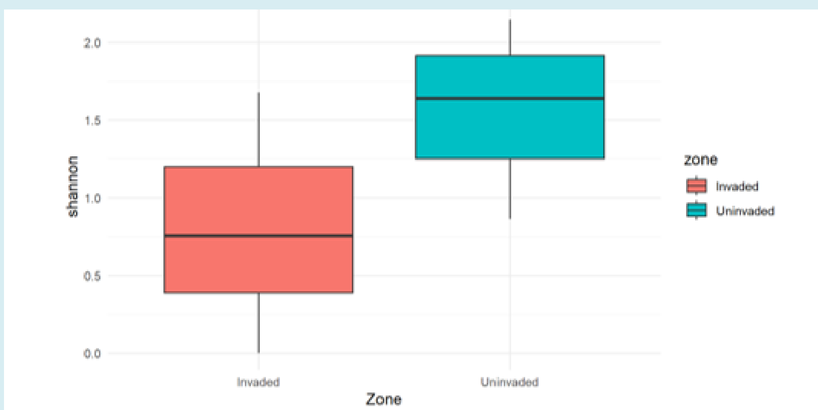

Figure 5: Shannon diversity between invaded and uninvaded areas.

Analysis of Floristic Similarity Between Invaded and Non-Invaded Areas

Floristic similarity between invaded and non-invaded areas was assessed using the Jaccard and Sorensen indices. The Jaccard index ranged from 0.50 to 1.00 (median: 0.90), while the Sorensen index ranged from 0.33 to 1.00 (median: 0.82). High index values indicate that some sites maintain a relatively similar species composition. Lower minimum values, particularly for the Sorensen index, indicate that other sites exhibit notable differences in floristic composition. Invaded areas show greater homogeneity, reflecting local losses of characteristic species.

Differences in Floristic Composition (PERMANOVA) and Ordinal Representation of Plant Communities (NMDS)

To assess the effect of *C. odorata* on natural regeneration, floristic composition was compared between invaded and uninvaded areas using PERMANOVA. The analysis indicated a significant difference between the two groups ($F = 1.931$, $R^2 = 0.048$, $p = 0.014$), suggesting that the species composition of invaded plots differs from that of uninvaded plots. This

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finding supports further analyses of community structure using NMDS and similarity indices. NMDS analysis revealed a separation between invaded and non-invaded plots. Invaded plots showed greater dispersion, indicating greater variability in floristic composition, while non-invaded plots were more clustered, indicating more homogeneous communities (Figure 6).

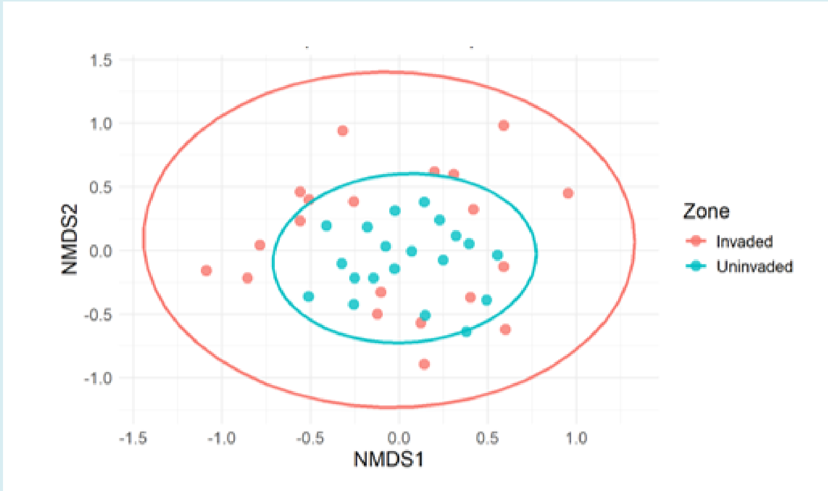

Figure 6: NMDS analysis of floristic composition.

The results show that invaded areas differ markedly from uninvaded areas in terms of floristic composition and regeneration. Invaded areas exhibited lower species richness, lower diversity (Shannon index), and altered community structure compared to uninvaded areas.

Discussion

Socio-Economic Impacts

This study shows that *C. odorata* and *M. suaveolens* impose substantial socio-economic pressures on local farming communities. Most respondents perceived these species as pests that contribute to the growing scarcity of pastoral resources, prompting the movement of large herds and exacerbating farmer-herder conflicts, which in some cases have resulted in fatal incidents [17]. These invasive species reduce local biodiversity and greatly increase the occurrence and intensity of vegetation fires in protected areas [18].

Average annual management costs associated with *C. odorata* exceed those reported for some areas in West Africa [19], likely reflecting its vigorous growth under the influence of the local rainfall regime. *M. suaveolens* remains particularly problematic in humid zones, where its high density significantly hampers the cultivation of cassava and maize [20]. The yield reductions reported are consistent with ranges observed in other studies, where productivity losses typically vary between 20% and 50% [21]. Adjustments made by farmers, including reducing cultivated areas and modifying cropping calendars, indicate that managing these species requires substantial additional resources [1]. While some benefits are acknowledged, their economic significance remains marginal and does not compensate for cumulative losses in production and labor [22]. Indeed, a minority of producers recognize *C. odorata* as an indicator of soil fertility, presenting a potential leverage point for integrated management strategies [23].

Ecological Impacts

The results reveal a substantial influence of *C. odorata* on local plant communities. The high leaf cover of this invasive plant in invaded areas corresponds to descriptions by Nuñez [24], who highlight the ability of this heliophilous species to form monospecific stands, thereby reducing light availability for regeneration of herbaceous and woody species. This is reflected in reduced density of young woody plants in affected areas [25]. The significant contribution of *C. odorata* litter, combined with allelochemical effects, modifies soil physicochemical properties and hinders germination and growth of local species [26]. These mechanisms partly explain the low species diversity observed in invaded areas, with comparable effects reported for West African forest ecosystems [27].

In the Lama classified forest, *C. odorata* represents a major disturbance, profoundly modifying forest structure and functioning [27]. Its rapid expansion is explained by effective biological traits for colonizing disturbed environments: rapid growth, abundant production of light wind-dispersed seeds,

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and regeneration capacity from stem or root fragments [28]. The superficial but extensive root system efficiently captures water and nutrients, depriving local plants of essential elements and increasing seedling mortality [29]. Allelopathic effects through inhibitory compounds released by decomposing leaves further reduce seed germination and seedling growth [30].

The abundant litter produced decomposes quickly, temporarily enriching soil with organic matter but accelerating nutrient cycles, making them less available to other species in the medium term [30]. The simplification of plant structure reduces habitats for many animal species [31], with specialized pollinators losing host plants and frugivorous species struggling to find traditional food [32]. The dominant presence of *C. odorata* modifies trophic networks, favoring generalist species and contributing to homogenization of forest fauna [33]. During the dry season, accumulated dry biomass exhibits high flammability, elevating fire risk. Such fires occur more frequently in invaded areas, hindering native species regeneration while promoting *C. odorata* persistence [34].

Implications and Recommendations

Management of *C. odorata* requires an integrated approach combining mechanical control methods with biological strategies and active restoration through planting competitive local species. Manual weeding effectiveness can be enhanced when combined with careful herbicide application during the wet season, prioritizing farmer training on safe use. Promoting innovative agricultural practices can limit spread. Continuous cultivation should be encouraged to reduce fallow lands favorable for invasion. Introduction of cover crops or legumes may strengthen cropping system resistance while improving soil fertility. Promoting local uses of these species for medicinal, agroecological, or artisanal applications could mitigate economic losses. These strategies require further research on long-term ecological impacts, socio-economic feasibility, and safety. Building technical capacity and raising awareness among local communities are essential for early detection, safe herbicide use, and participatory management. Establishing community monitoring committees could enable effective surveillance and rapid intervention. Finally, creating a regular monitoring system would allow evaluation of management outcomes, adaptation of interventions, and prediction of new invasion events.

Conclusion

The present study highlights the socio-economic and ecological impacts of *C. odorata* and *M. suaveolens*. Socio-economically, these species increase land management costs and alter cultivation practices, directly affecting local livelihoods. Ecologically, these species impair woody species regeneration through light competition and soil alteration, posing a threat to biodiversity and forest sustainability. These findings underline the need for integrated management strategies combining targeted control, adapted agricultural practices, and the rational use of local resources to support both conservation and rural well-being. Strengthening awareness and technical capacity among local stakeholders remains key to the long-term effectiveness of such interventions.

Conflict of Interests

The authors report no conflicts of interest.

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