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Research Article

Morphology and Rehabilitation Roles of Chomo Grass (*Brachiaria humidicola*) in Gully and Fragile Degraded Lands in Mana Sibu District, Western Ethiopia

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Abstract

Degradation of fragile lands and gully formation are pressing challenges in Western Ethiopia, particularly in the Mana Sibu District. The integration of Chomo grass (*Brachiaria humidicola*), a stoloniferous perennial grass with strong adaptive and restorative properties, has shown promising potential for ecological restoration and soil conservation. This study aimed to characterize the morphological traits of Chomo grass across different age categories and assess its role in the sustainable rehabilitation of degraded landscapes. A randomized complete block design was employed to evaluate both above- and below-ground morphological traits, including plant height, stolon length, leaf sheath, root depth, and plant density. Results revealed statistically significant differences ($p<0.001$) in most traits across age groups, indicating rapid early development and increasing restoration capacity with plant age. The highest ground cover (98.67%) and root length (125 cm) were recorded in older stands, supporting its effectiveness in enhancing soil stability, vegetation recovery, and water retention. Field observations further confirmed Chomo grass's role in stabilizing gullies and fragile lands, reducing erosion, and supporting livelihoods through fodder production. The study recommends the expansion of Chomo grass as a viable biological soil and water conservation strategy in degraded areas.

Keywords

Chomo Grass, Morphological Traits, Degraded Land Restoration, Gully Rehabilitation, Mana Sibu District

1. Introduction

Chomo grass, as its popular name suggests, is a type of grass. Chomo grass (Koronivia grass) is a stoloniferous perennial grass with a leafy, procumbent, creeping appearance. Its creeping habit and stolons distinguish it from other Brachiaria species, including *Brachiaria dictyoneura*, which it is frequently confused with [2]. Koronivia grass grows in thickets. The culms stay prostrate, but the lower nodes can produce roots. The leaves are brilliant green, flat, lanceolate blades that are 4-20 cm long and 3-10 mm broad. The inflorescences include 2 to 4 racemes with hairy, brilliant green spikelets that are 3-4 mm long [5]. A perennial grass with a deep root system that is densely stoloniferous and rhizoma-

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tous. The vegetative culms are prostrate or arched in the bottom section, where they root from the lower nodes [1]. As discovered in the field, Brachiaria species could penetrate the soil to a depth of 90cm [6]. The root dispersion and soil profile of different species, on the other hand, varied. In comparison to *Brachiaria brizantha* and *Brachiaria decumbens*, *Braciaria dictyoneura* and *Brachiaria humidicola* exhibited a higher proportion of root lower in the soil [8].

Root morphology influences the growth and development of aboveground plant organs by altering mineral nutrition transfer from the root to the shoot [4]. Drought is severe abiotic stress that results in significant crop losses [22]. As a result, plant roots use morphological plasticity to adapt to and respond to soil moisture levels [11, 7]. Identifying root characteristics that boost the capability of soil foraging for water and maintaining productivity during periods of reduced water availability are case studies of research fields with practical value. Because specific root traits targeted for plant improvement under drought and nutrient limitation conditions have been the subject of several excellent papers [12], which briefly describe root traits that are of practical value for crop and forage production systems.

Rooting depth: Because crops with deeper roots have better access to stored water and nutrients like nitrogen, a soluble nutrient that tends to seep into the deeper layers of the soil, rooting depth is one of the most often studied features [13]. However, under some growing conditions, a moderately high rate of nitrate supply can be inhibiting [7]. Although the physical and chemical properties of the soil have a substantial influence on rooting depth [12], previous research has found additional parameters that influence rooting depth that might be used in crop breeding programs. Root tips with large diameters have better root penetration of hard, dry soils, in addition to the aforementioned functions [10].

Root hairs: Root hair proliferation is increased in P-limited settings, and root hairs can contribute 70% or more of the total root surface area and account for up to 90% of the P obtained [10, 15]. The water condition of young root tissue is protected by root hairs [21]. Root hairs help the roots penetrate the hard, dry soil [10]. Single cell projections develop from root epidermal cells to form root hairs. Because root hairs make up such a big percentage of the overall root surface area, it's no surprise that they account for nearly half of the plant's water absorption. When wild-type Arabidopsis plants were compared to a root hairless mutant, the relevance of root hairs for water uptake was demonstrated.

Roots branching: During P deficiency, the length and quantity of lateral roots (LR) initiate and emerge [17]. LR initiation and elongation are stimulated by external nitrate, whereas LR growth is inhibited by a high plant internal nitrate/N status. N capture from low-N soils is improved by reducing the frequency of LR branching and increasing the length of the LR [7, 23]. The total root biomass, total root length, and root surface area are all increased by lateral roots. As a result, higher lateral root density is thought to be linked to enhanced nutrient and water intake [20]. The desired lateral root density, like many other root features, is determined by the soil's nutrition and water availability. Recent research has investigated the link between root branching and the acquisition of soil resources in greater detail. In soils when nitrogen is scarce, maize lines with long and few lateral roots, for example, yield 30% more than those with many short lateral roots. In general, lateral roots are the most active element of the root system for water uptake, accounting for the majority of the length and surface area of root systems in many plant species [18]. Brachiaria can flourish in a variety of environments, from the lowlands to the mountains [1]. Brachiaria species are arguably the most extensively farmed fodder grass species in the tropics, according to [13]. Infertile and acidic soils are not a problem for Brachiaria varieties [19]. It can grow on a wide range of soil types, from very acid-infertile (pH 3.5) through heavy cracking clays to high pH coralline sands [1]. The moisture need varies from 600–2800 mm throughout the native area, but is less vigorous in situations with less than 1600 mm annual rainfall and more than 6 months dry season. Altitude and temperature [1] grows at heights up to 2400 meters above sea level in its native area in equatorial Africa, but can extend to 1000 meters.

2. Materials and Methods

2.1. Study Area

Manasibu District is one of the 180 woredas in the Oromia Region of Ethiopia. The location of Mana Sibu Woreda is lying between 9 °30'00"-10°00'00" North latitude and 34°50'00"- 35 °20'00"east longitudes (Figure 1). Population of Mana Sibu woreda of 126,083 and the 15911 households, 64,399 were men and 61,684 were women; 14,008 or 11.11% of its population was urban dwellers [3] whereas the major economic activity is Agriculture based on rain-fed. The study area has six land use/land covers which include arable lands (56%), grasslands (16%), settlement areas (14%), forest lands (6%), degraded lands (7%), and marshy areas (1%). The area is suitable for the cultivation of different annual and perennial crops. Hence, cereals (mainly maize, sorghum, barley, wheat, and teff), pulses (horse beans, field peas, and haricot beans), vegetables (tomato, cabbage, and onion), oil crops (Niger seed, and linseed), perennial fruits (mango, banana, avocado), root crops (potato, taro, yam, and sweet potato), and cash crops (coffee and spices) are the source of food and cash to the people. Perennial crops (coffee and fruits) accounted for 51% of the total area, followed by cereals (26%), oil crops (14%), pulses (5%), and vegetables and root crops (3.4%). The altitude of Mana Sibu District ranges between 1145-1989 meters above sea level. The annual average temperature is 20.38℃ whereas, the average low is 14.25℃ and the Average high is 26.5℃. The total annual precipitation in the District is 1652mm, and the average precipitation is 137.67mm in the District.

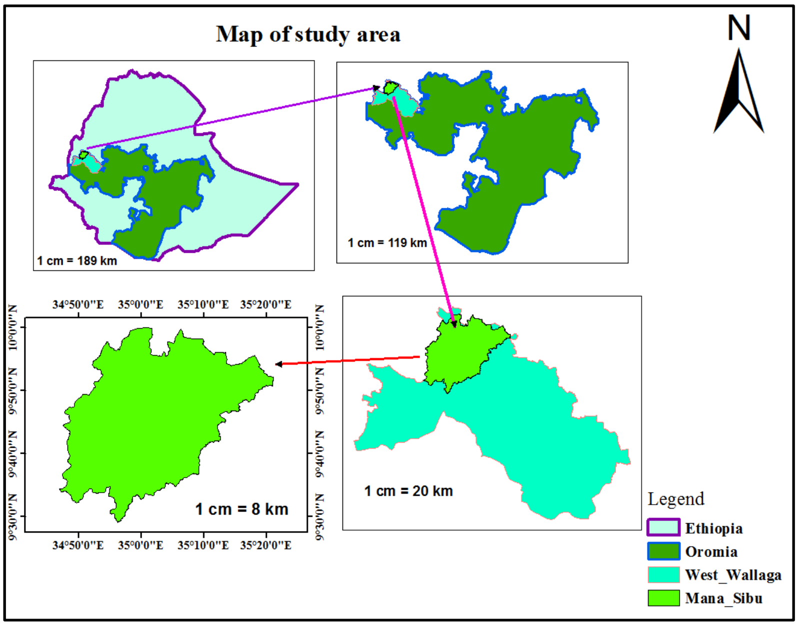

Figure 1. Map of Study Area.

2.2. Research Design and Methods

2.2.1. Chomo Grass (*Brachiaria humidicola*) Characterization Design

The morphological characterization of chomo grass for biological soil and water conservation practice was carried out following the randomized complete block design (RCBD). For chomo grass morphological characterization Gombo Kiltu Jale kebele was selected site from Manasibu district. Because of all age categories of chomo grass fulfill the aim of the study. Each age class had three replications, which were classified in blocks as young (0–10 years), middle (10–20 years), and old (20–30 years). Chomo grass morphological characteristics data collection was carried out from the twenty-seven (27) selected plants (three plant status x three age classes x three replications). The individual plants selected for data collection were determined to have high, medium, and low based on vegetative traits growth status for a more accurate representation of each age class in this study.

Table 1. Description of chomo grass vegetative traits growth.

SN	Plant status	Description of plant growth status
1	Low	A poorly growing plant condition in three different age categories at data collection season
2	Medium	A medium growing plant status in three different age categories at the data collection time
3	High	A well growing plant condition in three different age categories when data collection carried out.

2.2.2. Methods for Characterizing Chomo Grass (*Brachiaria humidicola*)

Nine plants investigated for morphological characters for each age were evaluated in chomo grass (three replications per age class). In this case, the following traits/characteristics were collected: plant height, plant spread length, leaf length, shoot length, and length of leaf sheath; plant density; ground cover; below ground trait root length (cm), and root density per plant. The plant height and shoot length were measured using a measuring tape (cm). Plant density in a 1m by 1m plot was counted and measured using square meters and root length (cm). Ground cover was measured by 1m by 1m cover of the soil surface with presence and absence of plants or litter and expressed as % of area. Root length was measured using measuring tape after carefully digging the trench without causing harm to the roots. In this study, three chomo grass growth status with high, medium, and low vegetative traits were randomly selected for morphological description (Figure 2).

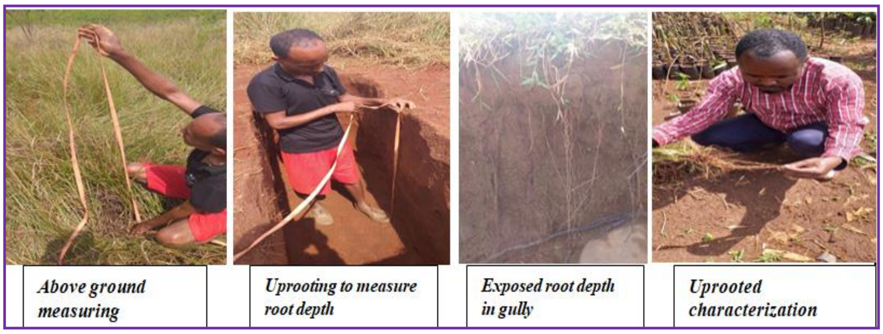

Figure 2. Chomo grass characterization in Mana sibu (source: Field survey, 2022).

3. Result and Discussion

3.1. Morphological Characterization of Chomo Grass (*Brachiaria humidicola*)

3.1.1. Chomo Grass (*Brachiaria humidicola*) Above Ground Characteristics

Based on direct field measurements and documented results, the morphological parameters of above-ground Chomo grasses (*Brachiaria humidicola*) are shown in Table 1. The findings demonstrated that, with the exception of the plant's base diameter and shoot length, which were non-significant at p<0.05, the majority of plant features were statistically highly significant at p < 0.001. The middle and old ages, which were accounted as 75 cm and 111 cm, and 205 cm and 315, respectively, showed the largest mean difference of vertical height and plant spread (stolon) length For the plant`s leave sheath length and population density, the highest mean difference were also recorded in the middle and old ages. In contrast to the aforementioned characteristics, the greatest mean variation in ground cover and stem number were observed between young and middle age accounted as 7 and 11cm, and 89.7% and 96.33 %), respectively. However, the Chomo grass may vary depending on pre-conserved soil fertility and grazing conditions. This high proportion of Chomo grass ground cover potential exceeds the findings of [9], who have explained the relationship between vegetation cover and relative erosion loss is exponential, while 60% vegetation cover can reduce erosion by 90%. Based on this previous study, the highest mean ground cover (98.67%) of old age Chomo grass could dramatically minimize soil erosion. But compared to other vegetative conservation strategies, its benefits for soil conservation are less well established.

Table 2. Above ground Chomo grass (Brachiaria humidicola) traits.

Age classes	PH (cm)	SL (cm)	NS(no)	PDB (cm)	ShL (cm)	LLSh (cm)	PD(m^2)	GC (%)
Young (0-10)	56	103	7	0.15	6	3	26	89.7
Middle (10-20)	75	205	11	0.20	7	5	30	96.33
Old (20-30)	111	315	13	0.25	9	8	57	98.67
p.value	0.000^{***}	0.000^{***}	0.017^{*}	0.422^{ns}	0.252^{ns}	0.013^{*}	0.000^{***}	0.009^{***}
R	0.96	0.994	0.862	0.5	0.596	0.87	0.874	0.852
R^2	0.91	0.987	0.744	0.25	0.355	0.758	0.764	0.725

***highly significant at *p<0.001*, **significant *at p<0.01*, * significant at *p<0.05 and* ^{ns} *non-significant*
Note: PH = Plant height, PSL = Plant Stolon length, NS =Number of stems, PDB = Plant diameter at base, ShL = Shoot length, LLSh = length of leaf sheath, PD = Plant density, GC = Ground coverage

3.1.2. Below Ground Characteristics of Chomo Grass (*Brachiaria humidicola*)

This study revealed that the rooting characteristics of the studied chomo grass were statistically highly significant at *p < 0.001*, where root diameter at the base and lateral root length were significant at *p < 0.05* and *p < 0.01*, respectively (Table 3). Nevertheless, in all age groups, neither the quantity of primary lateral roots nor the density of primary roots per plant were significant at the $p < 0.05$ level. According to the research's below-ground morphological viewpoint, the mean length of chomo grassroots in the young, middle, and elderly age groups is 28 cm, 112.2 cm, and 125 cm, respectively. This suggests that the greatest mean significance difference was observed between young and middle age rather than between middle and old age, indicating that it developed during the early growing period and entered the ground, anchoring the soil and aggregates. However, the result variation may be attributed to the inherent soil preconditions of the managed plot. Furthermore, rather than between middle and old age, the greatest mean difference in primary root density per plant was seen between young and middle age. This result is in line with the finding of [14], who found that the diameters of Vetiver plants ranged from 0.3 mm to 1.4 mm. While the greatest mean difference in the number of primary lateral roots was found between young and middle age, the greatest mean difference in lateral root length was found between middle and old age. According to the regression analysis, the number and length of roots decreased from the oldest to the lowest age category (AC) ($R^2 = 0.981$ and $R^2 = 0.519$), respectively. This finding is consistent with the finding of [14], who discovered that the number of roots in a regression analysis decreased linearly with the distance ($R^2 = 0.97$ and $R^2 = 0.86$) between the culm and the total number of roots. This characterization of Chomo grass' deep root type is also in agreement with the finding of [8], who reported that *Brachiaria humidicola* had a more extensive root system at a lower soil level. The fact that the Brachiaria genus produces a lot of roots to aid in aeration, soil aggregation, and water collection is another advantage of using the species in integrated systems [16]. This study also agrees with [6], who reported that field observations indicated that Brachiaria species might reach a depth of 90 cm in the soil.

Table 3. *Below ground chomo grass (brachiaria humidicola) morphology.*

Age Classes	RL (cm)	RDB (cm)	PRDP (no)	NPLR (no)	LRL(cm)
Young (0-10)	28.00	0.12	13.00	17.00	10.00
Middle (10-20)	112.20	0.19	17.00	21.00	13.80
Old (20-30)	125.00	0.23	19.00	23.00	19.50
p. Value	$.000^{***}$	$.032^{*}$	$.111^{ns}$	$.137^{ns}$	$.008^{**}$
R	*0.990*	*0.827*	*0.714*	*0.696*	*0.893*
R^2	0.981	0.684	0.519	0.484	0.797

Note: RL= root length/depth, RDB= root diameter at base, PRDP= primary root density per plants, NPLR = number of primary lateral roots, LRS= lateral root length

3.2. Rehabilitation of Large Gully and Fragile Degraded Lands Role of Chomo Grass

3.2.1. Fragile Degraded Land Restoration Role of Chomo Grass

Soil conservation is defined broadly to include both erosion control and fertility maintenance through the growth of chomo grass in degraded open land and cultivable land. Farmers in the Mana Sibu district use this as an indigenous practice. The results of the study show that Chomo grass seeding, when combined with suitable management practices, is a better viable option for stabilising gully heads, reducing inclined land erosion via the beneficial effects of soil aggregates, and quickly increasing vegetative cover on open retired pastures (Figure 3). Its roots are crucial in strengthening the topsoil's resistance to erosion from concentrated flows. By imposing vegetation barriers as a result of improved infiltration rates of the study area's nitosoils and alisoils, the method significantly reduces soil erosion and runoff and increases water usage efficiency. This result is consistent with the study by [24], who reported that the gullies treated with vegetation could have the potential to reduce sediment loads emanating from gullies. For soil resource management, the Chomo grass technique necessitates a somewhat less initial investment After three years of development, the profits from Chomo grass goods are also gathered. This characteristic of the Chomo grass is shorter than the returns from bamboo culms, which are also accrued after a gestation period of 7 years when used for gully rehabilitation [25].

The field observation and survey conducted for this study revealed that the planting of native chomo grass on degraded and retired land, together with the subsequent growth stages, is a practise that is increasingly being employed for the restoration of retired land and the conservation of soil and water in the study area. Studies have been conducted on the advantages and efficacy of establishing Chomo grass (Brachiaria humidicola) for the restoration of extremely vulnerable and totally degraded soils and repairing soil fertility and repairing severely degraded areas by the use of Chomo grass seems to be a successful strategy. The regeneration of vegetation, soil fertility, water retention ability, and silt trapping have all enhanced as a result of the Chomo grass planting techniques and functions. Chomo grass not only improves restoration, but the local population has also utilised the grass by using a cut-and-carry method to provide livestock feed. In order to improve the restoration of delicately degraded areas and maybe return the land to its previous, better status for crop production and other uses, it appears that integrating with environmentally adaptable Chomo grass planting is beneficial.

A key factor in the restoration of these degraded areas was the introduction of Chomo grass. Three up to five years after sowing, the Chomo grass had very high grass cover of above ten years (Figure 3). Some authors considered that *Undisturbed Ecosystems* mean unmanaged ecosystems that naturally provide ecological services to humanity, and *Agro ecosystems* represent managed ecosystems providing essential goods for human development [26]. Because of the innate functional capacities that soils possess, which are determined by their formation and origin, capacity is modeled over time to ascertain the extent to which a soil can continue to function after a given stress and the extent to which a soil can resume its functions once the stress has been alleviated [27]. The environment in which lands develop plays a fundamental role in defining land behavior and its potential functionality. The latter is relevant since, in one way or another, the functions of lands contribute to the provision of ecosystem services. Coordination with the surrounding environment will determine the ability to offer such services. There is a fragility threshold for lands that is established by two border conditions: There are two types of land fragility: (i) land fragility where resilience is impossible and any human intervention results in a significant decline in one or more land functions, such as sealing, creating a "point of no return" and making the system unstable, and (ii) land fragility where resilience is possible to any anthropic intervention e.g. intensive compaction, and its return to the productive potential reached will be progressively lower and the system will stabilize once soil functions are balanced.

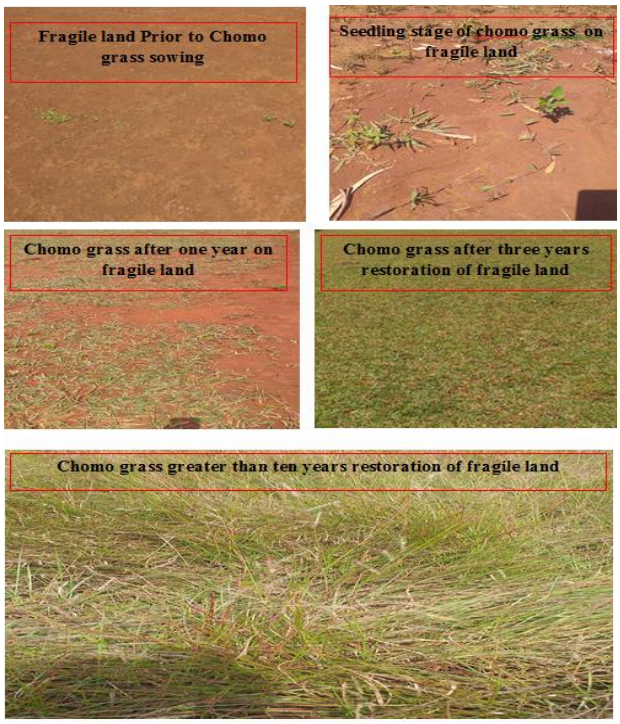

Figure 3. *Stages of fragile degraded land restoration process.*

3.2.2. Chomo Grass for Sustainable Restoration of Gully

As confirmed by the stakeholders of the study area residents, prior to the establishment of the sustainable rehabilitation of gully by Chomo grass, the study sites were severely exposed to high water erosion and degradation seen for long period because of termite infestation and unwise use of cultivated lands. The soils are characterized with moderate depth and exposed hardpan layer on the surface. Remaining woody riverine plants are found around rivers and streams. But after planting Chomo grass at the head and side of the gully and implementing sustainable rehabilitation practises, the intervention improved the gully bed and resulted in noticeable vegetation recovery as a permanent regeneration of orthodox species. Figure 4 illustrates how homo grass covers the soil and keeps the gully from being scouring. Additionally, it lowers flow velocity by raising the channel section's hydraulic resistance, which significantly lowers runoff and washing.

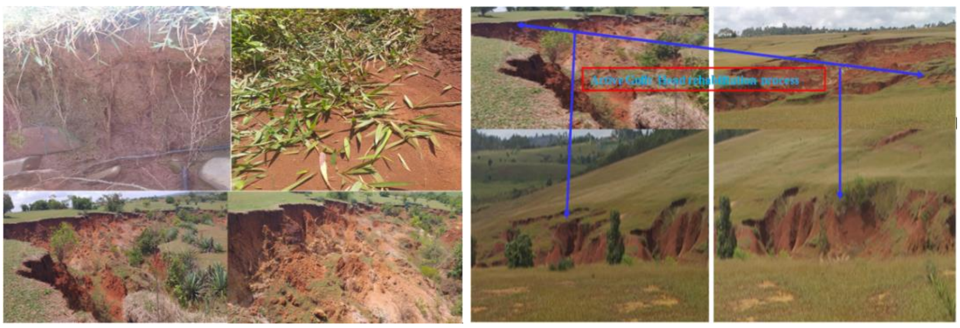

Figure 4. *Gully Rehabilitation Process by Chomo Grass in Mana Sibu (Field survey, 2022).*

The study area elders' participants explained that the Chomo grass planted in gully head areas by the local community, Agriculture office and NGO enhanced rehabilitation of many gully areas of degraded lands. According to the development agents and farmers who acted as key informants, encouraging sustainable gully restoration and oversowing Chomo grass contributed to the quick rehabilitation of small and medium-sized gullies. Nevertheless, the large gully treatment takes several years to stabilise and restore, as shown in Figure 2 above. The community thus realised the value of gully rehabilitation techniques and that oversowing Chomo grass was the best way to improve environmental and gully restoration. Thus, in order to initiate the restoration process, farmers adopted and have been putting into practise organic gully rehabilitation techniques including growing Chomo grass. The greater advantages of Chomo grass were also documented by [1]. These advantages include the grass's easier adaptation to acid soils, establishment on damaged land, and multiplication through seed and vegetative propagation. The documented facts presented that the project raise of Chomo grass has been widely accepted and practiced by farmers to restore the private and communal degraded lands. [28] Also reported that up to their field survey, about 2550 ha of private degraded lands were enclosed from free human and animal interventions and also planted with Chomo grass by individual farmers for forage production to the livestock. Gully rehabilitation practice and enrichment plantation (Chomo grass over sowing) widely adopted so as to restore severely degraded lands and gully rehabilitation in the area and beyond as the practices have been disseminating in neighboring districts and zones/provinces as a diffusion of technology for land resource management.

4. Conclusion

The morphological characterization and practical assessment of Chomo grass (Brachiaria humidicola) in the Mana Sibu District have clearly demonstrated its effectiveness in rehabilitating fragile degraded lands and gullies. The species' dense canopy, extensive root system, and high vegetative vigor, especially in older stands, contribute significantly to reducing erosion, enhancing soil fertility, and promoting vegetation regeneration. Its adaptability to degraded and nutrient-poor soils, combined with the socio-economic benefits of forage production, makes Chomo grass a strategic tool for sustainable land management. However, while small and medium gullies respond well within a few years of establishment, the rehabilitation of large gullies requires more time and integrated efforts. The results affirm the need for wider scaling-up of Chomo grass sowing practices as a biological conservation measure, particularly in areas where conventional approaches have failed. Further research is encouraged to quantify its long-term ecological and economic benefits and optimize management practices under varied environmental conditions.

Abbreviations

LR	Lateral Roots
RL	Root Length
RDB	Root Diameter at Base
PRDP	Primary Root Density per Plants
NPLR	Number of Primary Lateral Roots
LRS	Lateral Root Length

Author Contributions

Tola Geleta Jawi and Wakjira Takala Dibaba are the authors. The authors read and approved the final manuscript.

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Data Availability Statement

The data that has been used is confidential.

Conflicts of Interest

The authors declare no conflicts of interest.

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