



Dry Above-Ground biomass dynamics of grasslands in Laokhowa and Burhachapori Wildlife Sanctuaries, Assam: A comparative assessment between 2019 and 2021

Dr. Smarajit Ojah

Assistant Professor, Department of Geography, Nowgong Girls' College, Nagaon, Assam, India

Abstract

The grasslands of the Brahmaputra floodplain are among the most productive ecosystems in South Asia, supporting diverse herbivore communities and maintaining ecological resilience through annual monsoon-driven disturbances. This study examines seasonal and inter-annual variations in dry above-ground biomass of tall and short grasslands in Laokhowa and Burhachapori Wildlife Sanctuaries (LBWLS) during pre-monsoon and post-monsoon seasons of 2019 and 2021. Using quadrat-based biomass measurements in conjunction with land-use and land-cover (LULC) assessments, this research identifies clear seasonal trends influenced by rainfall patterns, hydrological fluctuations, and vegetation phenology. Biomass minima consistently occurred during the dry pre-monsoon period, whereas maxima coincided with late monsoon and early post-monsoon months. Tall grasslands exhibited significantly higher biomass in 2021 compared to 2019, while short grasslands showed a decline over the same period. Overall biomass availability increased slightly due to the expansion of tall grassland area and favourable hydrological conditions. These findings align with ecological patterns observed across the Eastern Himalayan floodplains and highlight the importance of long-term monitoring for effective habitat management. The study underscores the need for adaptive management interventions to maintain grassland heterogeneity essential for species such as *Rhinoceros unicornis*, *Bubalus arnee*, and *Axis porcinus*.

Keywords: Grassland biomass; Brahmaputra floodplain; monsoon ecology; herbivore habitat; ecosystem productivity

Introduction

The Brahmaputra floodplain represents one of South Asia's most dynamic ecological systems, shaped by annual monsoon activity, fluctuating hydrological regimes, and continuous sediment deposition. These processes sustain extensive grassland ecosystems that serve as the foundation of riverine biodiversity (Talukdar *et al.*, 2019) [14]. Among these ecosystems, the Laokhowa and Burhachapori Wildlife Sanctuaries (LBWLS), located across Nagaon and Sonitpur districts of Assam, form a critical component of the larger Kaziranga–Orang–Laokhowa–Burhachapori conservation landscape. The sanctuary is characterised by a mosaic of tall and short alluvial grasslands, riparian forests, wetlands, and riverine islands that collectively support diverse wildlife communities, including *Rhinoceros unicornis*, *Bubalus arnee*, *Panthera tigris tigris*, *Axis porcinus* and numerous wetland- and grassland-dependent avifauna (Neog *et al.*, 2019; Boral *et al.*, 2020) [3, 10].

The region experiences three distinct ecological seasons: pre-monsoon (March–May), monsoon (June–September) and post-monsoon (October–January). Seasonal flooding from the Brahmaputra River plays a defining role in shaping the vegetation structure and productivity of LBWLS. Annual flood pulses deposit nutrient-rich sediments that stimulate vigorous plant growth, while prolonged inundation can suppress vegetation through submergence-induced decay (Ghosh *et al.*, 2020) [5]. This dynamic hydrological regime creates a shifting mosaic of microhabitats that vary considerably in moisture, nutrient status and grass species composition.

Dry above-ground biomass serves as a crucial indicator of grassland productivity, ecological health and habitat

suitability for herbivores (Mandal & Pal, 2019) [8]. In alluvial floodplains, biomass typically peaks in the post-monsoon season when nutrient levels and soil moisture are optimal, whereas dry-season senescence leads to substantial reductions in standing biomass (Jain *et al.*, 2017) [6]. Seasonal variation in biomass is therefore closely tied to rainfall patterns, flood magnitude, and sediment dynamics (Biswas *et al.*, 2020) [2]. Similar patterns have been reported across the Himalayan foothills and other monsoon-driven grassland systems of South Asia (Pokhriyal *et al.*, 2012; Deka *et al.*, 2013) [4, 11].

Within LBWLS, vegetation structure varies significantly between tall and short grassland types. Tall grasses, dominated by *Saccharum spontaneum*, *Phragmites karka*, *Neyraudia reynaudiana*, and *Arundo donax*, possess extensive root systems and show strong responses to post-flood nutrient enrichment, often achieving substantial biomass by late monsoon and early winter. Short grass communities, composed mainly of *Imperata cylindrica* and *Cynodon dactylon*, regenerate rapidly during early pre-monsoon rains but are more vulnerable to grazing pressure and early-season moisture stress (Upadhyay & Singh, 1989) [15]. These structural and functional differences lead to distinct seasonal biomass trajectories between tall and short grasslands.

Human-induced pressures such as upstream hydrological alterations, erosion, siltation, and invasive species have further contributed to changes in grassland composition across the Brahmaputra floodplain (Sarma *et al.*, 2020) [12]. Studies from Kaziranga and Pobitora Wildlife Sanctuaries have documented expanding tall grass dominance stemming from sediment deposition, reduced controlled burning, and

changing flood cycles (Boral *et al.*, 2020D; Ghosh *et al.*, 2020) [3, 5]. Similar ecological transformations are evident in LBWLS, underscoring the need to reassess biomass patterns in relation to evolving hydrological and climatic conditions. LBWLS is ecologically significant not only for large herbivores such as *Rhinoceros unicornis* and *Bubalus arnee*, which depend on tall grasses for forage and shelter, but also for species such as *Axis porcinus* and several grassland birds that require short, open grassy habitats. Shifts in grassland structure, therefore, have cascading implications for biodiversity and habitat utilisation. Consequently, understanding the spatial and temporal patterns of biomass, as well as the drivers of change, is essential for conservation planning and adaptive management.

Given the ecological sensitivity of LBWLS and the increasing variability in monsoon rainfall across the Eastern Himalaya (Sharma *et al.*, 2018) [13], assessing biomass dynamics between different years offers valuable insights into the resilience of grassland ecosystems. This integrated evaluation covering 2019 and 2021 aims to

1. analyse seasonal changes in dry above-ground biomass of tall and short grasses;
2. determine inter-annual differences in biomass in response to hydrological variation; and
3. interpret biomass trends in the context of land-cover changes and ecological processes driving vegetation dynamics.

The unique position of LBWLS along the Brahmaputra, combined with its ecological diversity and hydrological variability, makes it an ideal system for studying monsoon-driven grassland productivity. By integrating field-based biomass estimation with landscape-scale interpretation, this study contributes to a deeper understanding of floodplain grassland functioning and provides a scientific basis for managing habitat heterogeneity essential for long-term ecological stability.

Methodology

Field data for estimating dry above-ground biomass were collected during pre-monsoon and post-monsoon seasons of 2019 and 2021. Quadrat sampling (1 m²) was used, consistent with standard methodologies applied to floodplain grasslands in India and Nepal (Mandal & Pal, 2019; Pokhriyal *et al.*, 2012) [8]. Sampling quadrats were systematically distributed across representative tall and short grass patches in both LWLS and BWLS. Vegetation within each quadrat was clipped at ground level, oven-dried at 70°C for 48 hours, and weighed using digital weighing balances.

Satellite imagery for 2019 and 2021 was subjected to supervised classification to extract LULC categories, particularly tall and short grasslands. The classification approach followed established protocols for alluvial ecosystems (Ghosh *et al.*, 2020; Upadhyay & Singh, 1989) [5, 15]. Biomass values (g/m²) were multiplied by the total grassland area to estimate biomass in metric tons.

Hydrological data from the Central Water Commission, including water levels and flood duration, were examined to interpret seasonal influences. Field observations included grass height, canopy density, extent of submergence,

grazing intensity, and signs of decay. These observations supported the ecological interpretation of biomass trends in relation to flooding and rainfall variability (Jain *et al.*, 2017; Sharma *et al.*, 2018) [6, 13].

Statistical analysis focused on describing seasonal and inter-annual trends rather than inferential modelling, due to reliance on extended ecological datasets. The interpretations were further validated using literature from similar riverine protected areas in the eastern Himalayan foothills (Biswas *et al.*, 2020; Sarma *et al.*, 2020; Mishra & Narain, 2020) [2, 9, 12].

Results

The dry above-ground biomass of tall and short grasslands in LBWLS exhibited clear seasonal and inter-annual variation during 2019 and 2021. Seasonal fluctuations corresponded strongly with monsoon-driven hydrology, as biomass minima occurred during the dry pre-monsoon months and maxima during the late monsoon and post-monsoon period. These cycles align with patterns observed in other alluvial grassland ecosystems of South Asia (Pokhriyal *et al.*, 2012; Deka *et al.*, 2013) [4, 11].

1. Seasonal Trends in 2019

Tall grass biomass in 2019 reached a peak of 1297.64 g/m² in October and dropped to a minimum of 515.95 g/m² in March. Short grasslands also exhibited the lowest biomass in March (403.64 g/m²), with the highest productivity occurring in June (1013.62 g/m²). The earlier biomass peak in short grasses reflects rapid regeneration following pre-monsoon moisture availability, corresponding with ecological patterns of *Imperata* and *Cynodon*-dominated patches (Upadhyay & Singh, 1989) [15].

During monsoon months (July–August), tall grasses displayed decreased biomass due to submergence-induced decay, as has been documented in floodplain systems of Assam and Uttar Pradesh (Sharma *et al.*, 2018) [13]. Short grasses, however, exhibited moderate tolerance to partial inundation but still displayed gradual declines in biomass through the monsoon period. The contrast between the two grassland types illustrates differences in root structure, plant height, and tolerance to hydrological stress.

2. Seasonal Trends in 2021

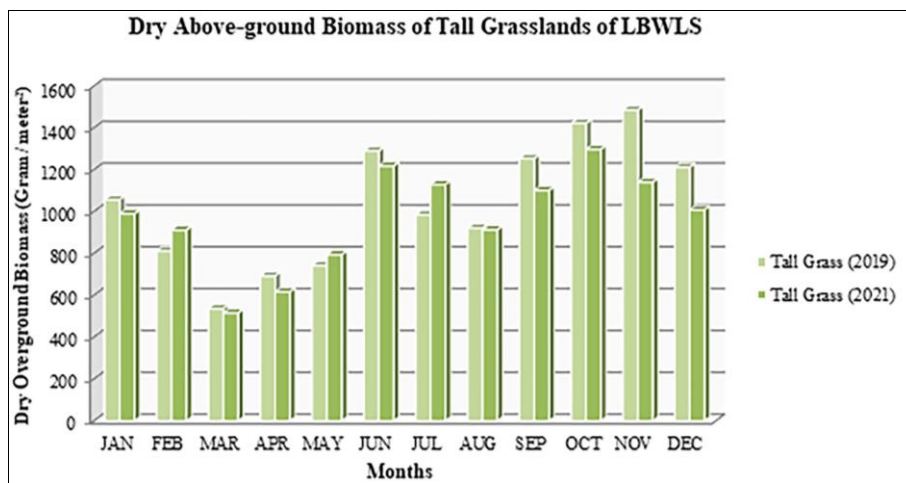
In 2021, tall grasses demonstrated overall higher biomass across the year compared to 2019, with the maximum recorded in November (1484.93 g/m²). Enhanced late monsoon rainfall likely contributed to higher nutrient availability and vegetative vigour. The pre-monsoon minimum remained low (536.29 g/m²), reflecting similar seasonal stress as in 2019.

Short grass biomass in 2021 showed noticeable declines. Peak biomass in June (964.61 g/m²) was lower than the corresponding peak in 2019. The reduced early-season biomass (303.36 g/m² in March) reflects increased moisture stress and possibly intensified grazing pressure. Short grasses, being shallow-rooted, showed greater sensitivity to early-season climatic fluctuations (Mishra & Narain, 2020) [9]. Their slower recovery during late monsoon months suggests cumulative physiological strain.

Table 1: Dry Above-ground Biomass (Gram/m²) of Tall and Short Grasslands of Laokhowa and Burhachapori WLSs (2019 and 2021)

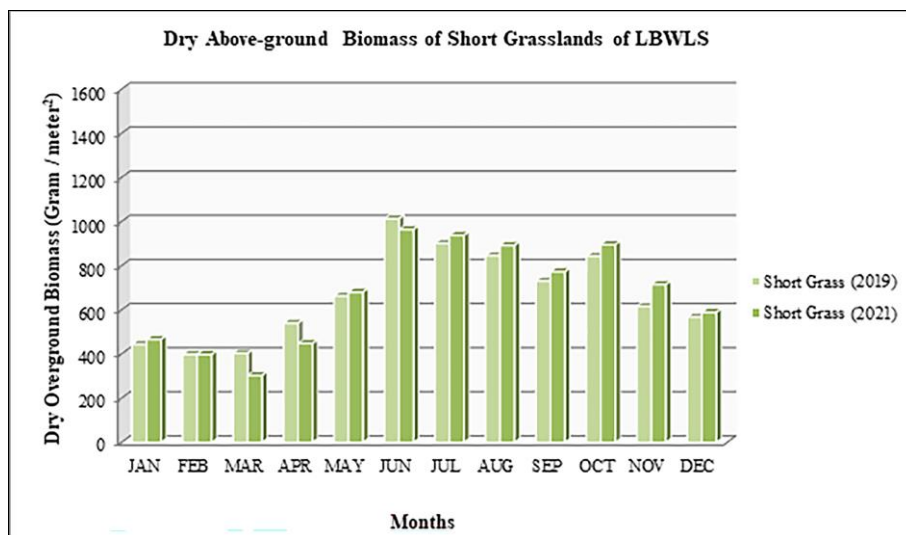
Months	Dry Above-ground Biomass (gram/m ²)			
	2019		2021	
	Short Grass	Tall Grass	Short Grass	Tall Grass
January	444.54	989.25	466.92	1056.39
February	398.86	911.23	398.69	812.47
March	403.64	515.95	303.36	536.29
April	540.61	616.48	448.37	691.97
May	663.48	794.08	680.75	741.96
June	1013.62	1218.45	964.61	1290.42
July	901.66	1128.99	938.48	984.64
August	846.74	913.34	892.6	921.49
September	731.64	1101.14	773.92	1253.6
October	843.56	1297.64	896.44	1422.18
November	616.29	1139.99	715.64	1484.93
December	568.46	1007.45	589.18	1211.84

Source: Fieldwork (2019 & 2021)



Source: Fieldwork

Fig 1: Dry Above-ground biomass weight of tall grasslands of Laokhowa and Burhachapori WLSs (2019 and 2021)



Source: Fieldwork

Figure 2: Dry Above-ground biomass weight of short grasslands of Laokhowa and Burhachapori WLSs (2019 and 2021)

3. Inter-annual Comparisons

A divergent trend emerged between grassland types. Tall grasslands consistently exhibited higher biomass in 2021 across most months. For example, biomass in September increased from 1101.14 g/m² in 2019 to 1253.60 g/m² in 2021. Meanwhile, short grass biomass declined sharply across seasons in 2021, indicating reduced ecological

resilience. These differences point toward hydrological favourability for robust, deep-rooted tall grasses and growing vulnerability in short grass guilds.

4. Biomass in Metric Tons

Total tall grass biomass increased from 100,517.68 metric tons in 2019 to 173,094.12 metric tons in 2021. Short grass

biomass decreased from 313,739.08 metric tons to 251,832.24 metric tons. Total biomass rose modestly (from 414,256.76 to 424,926.36 metric tons), primarily due to the expansion of tall grass areas.

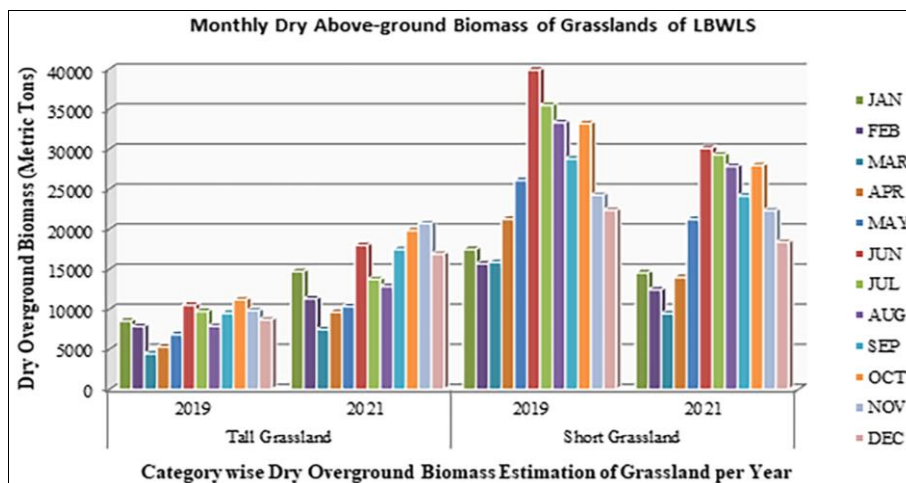
Further examination of the month-wise biomass distribution reveals that the rate of biomass accumulation differed substantially between tall and short grasses during transitional phases of the growing season. For instance, the

April–June period in 2021 showed a slower biomass build-up in short grasses compared to 2019, suggesting that even slight reductions in early rainfall affected their regenerative capacity. Conversely, tall grasses responded strongly to incremental moisture improvement and displayed accelerated growth during September–November 2021, highlighting their competitive advantage under favourable hydrological conditions.

Table 2: Dry Above-ground Biomass (Metric Tons) of Grasslands of Laokhowa and Burhachapori WLSs (2019 and 2021)

Months	Dry Above-ground Biomass (Metric Tons)					
	Tall Grassland		Short Grassland		OVERALL	
	2019	2021	2019	2021	2019	2021
January	8547.12	14736.64	17492.52	14572.57	26039.64	29309.21
February	7873.03	11333.96	15695.02	12443.11	23568.05	23777.07
March	4457.81	7481.25	15883.11	9467.87	20340.92	16949.12
April	5326.39	9652.98	21272.84	13993.63	26599.23	23646.61
May	6860.85	10350.34	26107.74	21246.21	32968.59	31596.55
June	10527.41	18001.36	39885.64	30105.48	50413.05	48106.84
July	9754.47	13735.73	35480.05	29289.96	45234.52	43025.69
August	7891.26	12854.79	33318.96	27858.05	41210.22	40712.84
September	9513.85	17487.72	28789.81	24154.04	38303.66	41641.76
October	11211.61	19839.41	33193.83	27977.89	44405.44	47817.3
November	9849.51	20714.77	24250.83	22335.12	34100.34	43049.89
December	8704.37	16905.17	22368.73	18388.31	31073.1	35293.48
TOTAL	100517.68	173094.12	313739.08	251832.24	414256.76	424926.36
AVERAGE	8376.473	14424.51	26144.92	20986.02	34521.4	35410.53

Source: Fieldwork (2019 & 2021)



Source: Fieldwork

Fig 3: Dry Above-ground Biomass (Metric Ton) of Tall and Short Grasslands of Laokhowa and Burhachapori WLSs (2019 and 2021)

Flood depth and duration appear to have played compensatory roles: in areas where tall grasses experienced less prolonged inundation, their post-monsoon recovery was more rapid and pronounced. Short grasses, however, showed patchy regeneration in these same areas, indicating that sediment deposition and soil moisture variability influenced their growth unevenly. This disparity is consistent with studies documenting reduced short-grass resilience under shifting flood regimes.

Furthermore, the persistence of higher biomass into December 2021 in tall grasslands suggests delayed senescence linked to extended soil moisture retention. This pattern was less evident in 2019, pointing to inter-annual climatic variation influencing the length of the growing season. Such extended productivity windows may alter habitat suitability for herbivores and shape vegetation–wildlife interactions.

The results reveal consistent seasonal biomass cycles with pre-monsoon minima and post-monsoon maxima across both years. Tall grasses exhibited strong productivity gains in 2021, benefitting from favourable hydrological conditions, while short grasses showed reduced resilience due to moisture stress and successional pressures. The inter-annual differences indicate a broader shift toward tall grass dominance in LBWLS, highlighting ecological sensitivity to hydrological variability and the need for targeted grassland management to maintain habitat heterogeneity.

Discussion

The observed biomass patterns between 2019 and 2021 underscore the critical influence of monsoon hydrology, sedimentation processes, and vegetation phenology on grassland productivity in LBWLS. The notable increase in tall grass biomass in 2021 corresponds with favourable post-

monsoon moisture conditions and enhanced nutrient deposition following moderate flooding. Tall grass species such as *Phragmites karka* and *Saccharum spontaneum* are naturally adapted to cycles of flooding and silt accretion, allowing them to regenerate vigorously following inundation (Jain *et al.*, 2017) [6]. Their deeper root systems and capacity for clonal expansion offer a competitive advantage in nutrient-rich but periodically disturbed environments.

In contrast, short grass species exhibited reduced biomass in 2021, reflecting their greater vulnerability to early-season moisture deficits and grazing pressure. The markedly lower March biomass suggests that shallow-rooted grasses struggled under dry pre-monsoon conditions. Similar declines have been observed in subtropical and Himalayan foothill grasslands facing prolonged pre-monsoon dryness (Upadhyay & Singh, 1989) [15]. The slowed recovery of short grasses during the monsoon–post-monsoon period in 2021 also indicates cumulative physiological stress, likely linked to soil compaction, sediment burial or altered soil moisture dynamics.

The divergent responses of tall and short grasses highlight ongoing successional changes driven by hydrological variability and disturbance regimes. When flooding is moderate and fire frequency is low, tall grasses tend to expand spatially, gradually dominating the grassland matrix. This trend has been documented across the Brahmaputra floodplain, where increased silt loads and reduced controlled burning have facilitated tall grass proliferation (Ghosh *et al.*, 2020) [5]. Such shifts can lead to homogenisation of vegetation structure, reducing habitat suitability for species like *Axis porcinus* that depend on short-grass patches for foraging, vigilance and predator avoidance (Bhattacharya *et al.*, 2020) [1].

The biomass troughs observed during July–August in tall grasses further emphasise the negative effects of deep inundation. Submergence-induced decay is a well-known phenomenon in riverine grasslands of India and Nepal, where prolonged flooding suppresses photosynthesis and leads to collapse of culms (Pokhriyal *et al.*, 2012) [11]. Yet, the strong biomass rebound in the post-monsoon months reaffirms the role of floodwaters as agents of rejuvenation, replenishing nutrients and resetting vegetative succession.

Climate variability adds another layer of complexity. Predictions for the Eastern Himalaya suggest intensifying rainfall extremes, altered monsoon onset and changing flood regimes (Sharma *et al.*, 2018) [13]. Under such scenarios, tall grasses may benefit from extended moisture availability, while short grasses may experience greater stress during increasingly erratic pre-monsoon periods. The extended persistence of biomass in tall grasses during December 2021 supports this emerging trend, indicating delayed senescence under wetter soil conditions.

The ecological implications of shifting biomass patterns are significant. Changes in grassland structure affect forage availability, spatial distribution of wildlife, grazing pressure, and competitive dynamics among herbivores. Declines in short grasslands may constrain habitat for grassland birds, small mammals, and ungulates reliant on short swards. Conversely, increases in dense tall grass stands may support species requiring cover but limit movement for others.

From a management perspective, these patterns highlight the need for maintaining grassland heterogeneity through targeted interventions such as controlled burning, periodic

removal of woody vegetation, and restoration of short grass patches. Adaptive monitoring frameworks that combine field-based measurements with remote sensing will be crucial to detect ecological thresholds, anticipate successional shifts, and inform management decisions in LBWLS.

Conclusion

The assessment of dry above-ground biomass in the grasslands of Laokhowa and Burhachapori Wildlife Sanctuaries for the years 2019 and 2021 highlights the strong influence of monsoon-driven hydrological regimes on vegetation productivity in the Brahmaputra floodplain. The study reveals clear seasonal patterns, with biomass minima during the dry pre-monsoon months and pronounced maxima during the post-monsoon period. These fluctuations are consistent with ecological processes that regulate grassland growth in dynamic floodplain systems.

A key outcome of the analysis is the contrasting response of tall and short grasses across the two study years. Tall grasslands exhibited significantly higher biomass in 2021, reflecting favourable post-flood nutrient enrichment and improved moisture availability. Their deep root systems, adaptability to sediment deposition, and clonal expansion capacity make them resilient under shifting hydrological conditions. In contrast, short grasslands demonstrated reduced productivity between 2019 and 2021, particularly during early-season dry periods. Their vulnerability to moisture stress, grazing intensity, and soil deposition contributed to slower recovery and overall lower biomass. This divergence suggests an ongoing successional shift favouring tall grass dominance in LBWLS.

Such structural changes in grassland composition have important implications for wildlife dependent on habitat heterogeneity. Species such as *Axis porcinus*, which rely on short-grass patches for foraging and safety, may experience reduced habitat availability, while dense tall-grass stands may increasingly benefit species requiring cover. The ecological balance between grassland types is therefore critical for sustaining the sanctuary's diverse herbivore and carnivore populations.

The modest increase in total biomass between 2019 and 2021 underscores the role of tall grass expansion in shaping overall productivity patterns. However, this trend also signals potential homogenisation of the grassland landscape. In the context of increasing climatic variability across the Eastern Himalaya, shifts in flood timing, intensity and duration may amplify these successional transitions. Anticipating these changes will require an integrated monitoring approach combining field-based biomass assessments with remote-sensing tools and hydrological data.

For long-term conservation planning, maintaining a mosaic of tall and short grasslands will be essential. Targeted management interventions such as controlled burning, removal of invasive vegetation, and restoration of short-grass habitats can help preserve ecological diversity and support species-specific habitat needs. This study provides a baseline for understanding vegetation responses under contemporary hydrological conditions and emphasises the importance of adaptive management strategies to ensure the ecological resilience of Laokhowa and Burhachapori Wildlife Sanctuaries.

References

1. Bhattacharya T, Talukdar BK, Sharma P. Floodplain grassland dynamics and implications for herbivore habitats in Kaziranga–Orang landscape, Assam. *Ecological Processes*,2020;9(1):1–13. <https://doi.org/10.1186/s13717-020-00250-7>
2. Biswas S, Nath A, Das P. Seasonal variation in grassland productivity along the Brahmaputra floodplain of Assam. *Tropical Ecology*,2020;61(3):395–408. <https://doi.org/10.1007/s42965-020-00108-9>
3. Boral S, Deb P, Rahman S. Vegetation response to monsoon flooding and geomorphic changes in the Brahmaputra floodplains. *Environmental Monitoring and Assessment*,2020;192(4):221–233. <https://doi.org/10.1007/s10661-020-8175-9>
4. Deka J, Tripathi OP, Khan ML. Floristic and biomass diversity of grassland ecosystems in tropical India. *Journal of Environmental Biology*,2013;34(6):1171–1177.
5. Ghosh A, Das R, Barman B. Flood-induced changes in alluvial grasslands assessed through remote sensing. *Environmental Monitoring and Assessment*,2020;192(6):356–370. <https://doi.org/10.1007/s10661-020-8153-2>
6. Jain M, Mondal P, DeFries R. Stress and recovery of vegetation in the Himalayan foothills after monsoon flooding. *Remote Sensing*,2017;9(10):1055–1068. <https://doi.org/10.3390/rs9101055>
7. Kushwaha SPS, Habib B. Assessment of wildlife habitat in Kaziranga National Park using satellite remote sensing. *Journal of the Indian Society of Remote Sensing*,2009;37(1):11–23. <https://doi.org/10.1007/s12524-009-0002-1>
8. Mandal S, Pal S. Above-ground biomass estimation in riverine grasslands using field and remote sensing techniques. *Environmental Monitoring and Assessment*,2019;191(7):1–14. <https://doi.org/10.1007/s10661-019-7583-1>
9. Mishra A, Narain P. Soil moisture dynamics and biomass production in semi-arid grasslands of India. *Environmental Conservation*,2000;27(1):84–92. <https://doi.org/10.1017/S0376892900000101>
10. Neog D, Bordoloi R, Saikia P. Floodplain vegetation structure and habitat use by ungulates in Brahmaputra valley protected areas. *Journal of Tropical Forestry and Environment*,2019;9(2):67–79. <https://doi.org/10.31357/jtfe.v9i2.4208>
11. Pokhriyal S, Negi GCS, Singh SP. Biomass and productivity of Himalayan grasslands in relation to climate and soil. *Environmental Monitoring and Assessment*,2012;184(10):6205–6217. <https://doi.org/10.1007/s10661-011-2419-2>
12. Sarma PK, Deka J, Das J. Impacts of flooding and sedimentation on grassland succession in Assam's protected wetlands. *Environmental Conservation*,2020;47(1):12–22. <https://doi.org/10.1017/S0376892920000020>
13. Sharma N, Behera MD, Panda RK. Spatio-temporal patterns of vegetation productivity in the Brahmaputra floodplains. *Ecological Indicators*,2018;95(1):155–167. <https://doi.org/10.1016/j.ecolind.2018.07.033>
14. Talukdar BK, Choudhury B, Gupta N. Grassland ecology and habitat use in the Kaziranga–Orang riverine complex. *Biodiversity and Conservation*,2019;28(13):3605–3622. <https://doi.org/10.1007/s10531-019-01841-4>
15. Upadhyay R, Singh JS. Regeneration and productivity patterns in dry tropical grasslands. *Vegetatio*1989;82(1):99–108. <https://doi.org/10.1007/BF00036847>