

Grassland conservation and restoration in India: A governance crisis

Running Title. *Grassland governance in India*

Sutirtha Lahiri^{1,2}, Anirban Roy^{*3,4,5}, Forrest Fleischman⁵

¹ Department of Fisheries, Wildlife and Conservation Biology, University of Minnesota Twin Cities, 135 Skok Hall, 2003 Upper Buford Circle, St. Paul 55108, MN-USA

² Interdisciplinary Center for the study of Global Change, 537 Heller Hall, 19th Ave South 55455, MN-USA

³ Ashoka Trust for Research in Ecology and the Environment, PO Royal Enclave, Srirampura, Jakkur, Bengaluru 560064, KA-IN (* Corresponding author)

⁴ Manipal Academy of Higher Education, Tiger Circle Road, Madhav Nagar, Manipal 576104, KA-IN

⁵ Department of Forest Resources, University of Minnesota Twin Cities, 115 Green Hall, 1530 Cleveland Ave. N., St. Paul 55108, MN-USA

Author contributions

SL conceived the idea for the article; SL, AR conceptualized the content and design of the study; SL, AR drafted the early versions of the manuscript; the whole process was supervised and manuscripts were regularly edited by FF; all the authors reviewed and approved the final version of the manuscript.

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process which may lead to differences between this version and the [Version of Record](https://doi.org/10.1111/rec.13858). Please cite this article as doi: [10.1111/rec.13858](https://doi.org/10.1111/rec.13858)

This article is protected by copyright. All rights reserved.

Anirban Roy

anirban.roy@atree.org

Ashoka Trust for Research in Ecology and the Environment
Ecosystem Services & Human Well Being
PO Royal Enclave, Srirampura
Jakkur
Bangalore
Karnataka
India

Accepted Article

Abstract

Grasslands are contested ecosystems due to our scant understanding of their ecological and socio-economic roles, and also due to the ambiguity in understanding what exactly constitutes them. This problem escalates in the absence of proper governance. In this paper, we explore the historical accounts of Indian grasslands to trace how they have shaped contemporary grassland conservation and restoration policies. The paper draws from the concept of Biome Awareness Disparity (BAD) and links it to grassland degradation through misleading nomenclature and flawed interventions rooted in misplaced governance. We found that Indian grasslands are negatively affected by India's commitment to global goals (with quantified targets of increasing tree cover) and the involvement of multiple government bodies in grassland management. This conundrum is fueled by the strong forest bias within government bodies and NGOs. Based on the findings, we propose that India needs a more cohesive national policy framework and a robust ecosystem classification system to successfully conserve and restore grasslands.

Keywords

Biome Awareness Disparity, Grassland policy, Grassland governance, Grassland restoration, India, Wasteland, Savannah.

Conceptual Implications

1. Indian grasslands are threatened due to mismanagement and misunderstanding on the part of governments that have their roots in colonialism. Colonial legacies and contemporary incentives may hinder effective restoration programs and policies and require active correction.
2. Effective grassland conservation in India will require a revised governance framework and ecological classification system which recognizes grasslands as a vital ecological and economic resource and supports management through fire, grazing, and other methods.
3. International restoration discourses often support Biome Awareness Disparity by focusing on forests, and this can have profoundly negative consequences on national and local scales.

Introduction

Grasslands are India's most threatened ecosystems, yet they have been neglected in conservation and restoration policy in India. Less than 5% of India's grasslands fall within protected areas (Madhusudan & Vanak 2021), and current government-run restoration programs favor converting natural grasslands to plantation forests. In India, grassland area declined from 18 Mha to 12.3 Mha—a decline of 31%—between 2005–2015 (Pandey 2019). One reason for the decline of grasslands is the long-standing bias toward forest systems enshrined in Indian government policies (Fleischman 2014). This bias toward forests reflects widespread neglect or misunderstanding of grassland and savanna ecosystems and is an example of Biome Awareness Disparity (BAD) which is defined as “a failure to appreciate the significance of all biomes for conservation and restoration policy—and quantify disparities in (a) attention and interest, (b) action and (c) knowledge among biomes in tropical restoration science, practice and policy.” (Silveira et al. 2021).

This disparity causes significant negative consequences for conservation and restoration programs both in India and around the world. For example, millions of Indian herders who rely on grasslands have to migrate longer distances for fodder as grasslands are converted to other land uses (Vanak et al. 2017). Similarly, grassland habitats bear the brunt of neglect and ill-informed afforestation activities in Argentina Chaco grasslands (Grau et al. 2015), and Brazilian *Cerrado* (Overbeck et al. 2015). Indian grasslands harbor globally significant endemic biodiversity (Nerlekar et al. 2022a; Sankaran & Ratnam 2013) and carbon storage (Dad & Ahmed 2022). In some cases, BAD promotes planting trees in grasslands and savannas causing increased incidence(s) of megafires (Buisson et al., 2019) and a decrease in long-term carbon storage (Hurteau & Hungate 2008; Dass et al. 2018). Addressing the negative consequences of BAD requires a deeper understanding of its origins and persistence. Here, we examine the origins of BAD and the attitude of dereliction towards grasslands in India's colonial past and its persistence into the postcolonial era based on the retention of colonial institutions and language. We conclude with policy suggestions for grasslands that will yield better outcomes for these vital and endangered ecosystems in India and globally.

Our analysis points to deep structural roots for BAD in India's colonial history, where grasslands were seen as “wastelands” because production from them could not be easily taxed under colonial-era land taxes that were central to the function of the British Indian state. Idle ‘wasteland’ also meant the possibility of the conquest of such lands, as Whitehead (2010) argues. Present-day India still classifies grasslands as “wastelands” and aims to develop them for other uses, in contrast to programs to restore and protect forests to provide for biodiversity, carbon storage, and forest-based livelihoods. These policy choices are strongly reinforced both by the power granted to foresters – a legacy of colonial institutions – as well as by the international community of conservation scientists and policy-makers whose rhetoric emphasizes the value of dense forests for biodiversity and carbon storage while neglecting the values of other ecosystems (Bond et al. 2019; Silveira et

al. 2020). While some of these conditions of conservation and restoration inattention towards grasslands are unique to South Asia, many are prevalent globally. Addressing these problems requires interventions that raise the value of grassland ecosystems in both international and domestic discourse, and connect the needs of grassland-dependent peoples with the ecological processes they maintain. Grassland management regimes are usually driven by ecological discourses; however, the reality is governance practices dictate the ecological and the social sciences of any landscape. Hence, the significance of this paper lies in revealing how governance affects grassland conservation and restoration in India.

Methodology

The paper is a critical literature review (Grant et al., 2019) focusing on grassland management across the temporal scale of colonial to present-day India. We adopt this method to answer the central question - 'how do governance regimes continue to impact Indian grassland conservation and restoration efforts?' Governance decisions are products of economic, electoral, and social considerations, and are influenced by national and global politics (Lemos & Agarwal, 2006). We analyze information from a pool of current peer-reviewed articles, government policy documents and media reports. We recruit other relevant scholarships through a snowball sampling of references. We used databases like Google Scholar and cross referencing for peer-reviewed articles, as well as scoped additional documents from government and NGO websites (like *Ecological Restoration Alliance*), press releases, policy briefs, book chapters and technical reports. We used this method of literature survey since the intention of this paper is not to provide a systematic review of the literature but instead to critically analyze the drivers behind Indian grassland management efforts and provide science-backed suggestions to improve management.

The paper is structured into six major sections- the first section overviews Indian grasslands and how ecological processes shape grassland dynamics. The second section covers the colonial (mis)representations of Indian grasslands and how that led to ecological degradation through agricultural transformations, tree-based plantation activities, and wasteland treatments. The third section explores the post-colonial regime of Indian grassland conservation and restoration practices. We show how semantic distinctions were inherited from British India to post-independent India and argue that multiple stakeholder engagements create confusion over grassland conservation and restoration. The fourth section finds that some international agreements (to which India is a signatory) encourage Indian government agencies to damage grasslands to meet quantified targets (like green cover, which in the Indian context is usually interpreted as equivalent to tree cover). Building on the arguments presented in these sections, the fifth section explores India's efforts toward grassland conservation and restoration leading to the conclusion of the article. The final sixth section offers suggestive policy-based measures that can be undertaken to ensure healthy grassland management in India and beyond.

India's grasslands

Grasslands are among the most threatened ecosystems globally, despite their ecological and social significance. In India, grasslands occupy 24% of the land area (Rawat & Adhikari 2015) and occur across various precipitation, elevational and land-use types (Figure 1). These landscapes are spatially distributed through the high-altitude grasslands in the Himalayas and Western Ghats (Arasumani et al. 2018), to the semi-arid and arid grasslands of the Thar Desert (Kher et al. 2021), from the floodplain grasslands of Indian Himalaya (Lahiri et al. 2021) to the grasslands in peninsular India (Nerlekar et al. 2022a). Recent evidence suggests that many of India's so-called forests are in fact savannas (areas of mixed trees and C4 grasses “defined by fire tolerance and shade intolerance” with trees, Ratnam et al. 2011 p.653). These would have had a continuous grassy understory during the pre-colonial era but were misconstrued as degraded forests (Kapuria, 2021), indicating that our cited estimates of grassland area may in fact be underestimates.

Grasslands are created and maintained through diverse processes, many of which are directly related to human management. Fire and megafaunal herbivory are two of the essential drivers in maintaining tropical grasslands (Buisson et al. 2019). While fire and herbivory pre-date humans, humans played a crucial role in these processes for millennia in India, including hunting herbivores, herbivore grazing, and fire lighting to achieve a broad array of management objectives. Active management of grasslands is often achieved through long-standing human-environment interactions where people who depend on products from grasslands (often domestic animals who graze on those grasslands) manage those systems through fire and grazing in ways that perpetuate their long-term sustainability (Reid et al 2014; Scoones 2021). Climate plays a key role in creating grasslands (particularly in arid systems)- there are many climatic conditions that maintain a balance between grasslands and forests through disturbance regimes (Bond 2008). Besides multiple ecosystem services, grasslands support immense biodiversity and endemism, reflecting their ancient Indian roots. Endemic species like the critically endangered Great Indian Bustard (*Ardeotis nigriceps*), Swamp Grass Babbler (*Prinia cinerascens*), the vulnerable One-horned rhinoceros (*Rhinoceros unicornis*), and the Swamp deer (*Rucervus duvaucelii*), as well as reptiles like *Ophisops* lizards, indicate the antiquity of the Indian grassland biomes (Dutta et al. 2011; Agarwal & Ramakrishnan 2017; Rastogi et al. 2021). Grasslands support the livelihoods and food security of millions of people through agriculture, collection of grass for various purposes, cattle grazing, and sustenance of pastoralism throughout the nation. Grasslands are also effective carbon sinks– Dass et al. (2018) credited grasslands for being a more resilient carbon sink than forests in the current regime of climate crisis, particularly in semi-arid and fire-prone regions.

However, grasslands are increasingly threatened by agricultural conversion (Kher & Dutta 2021), tree-based plantation projects, invasive species, fire suppression, and megadevelopment projects (Arasumani et al. 2018). Some of the major threats to grasslands are presented in figure 2- the spread of invasive species and plantation projects are concurrent to each other as the former is

facilitated by the latter. Mega development projects find an easy way to the grasslands due to a lack of stringent regulations- Sholas grasslands in the Nilgiri hills in southern India have been badly affected by such projects (Sasmitha et al. 2021). India's forest departments have aimed to suppress all fire and make lighting or managing fire a punishable offense (Ratnam et al. 2016) and also restrict grazing of domestic ungulates for protecting forests, which is likely to lead to woody encroachment into grassy ecosystems. All of these factors together threaten the continued maintenance of grasslands.

Much of these initiatives stem from misinformation about the dynamics of grassland biomes. For instance, old-growth grasslands are grassy ecosystems that long predate human influence and have ecological features which require centuries to develop (Nerlekar & Veldman, 2020). Yet these landscapes are either misrepresented as the outcome of human-induced deforestation followed by arrested succession or as degraded forests (Kumar et al. 2020). In the context of government policies that aim to encourage productive land uses through forestry or agriculture, confusion of old-growth grasslands with secondary grasslands (recovering grasslands that are formed through vegetation succession post natural disturbance) encourages tillage agriculture or tree plantations.

In India, removal of plants prior to fire is common management when grasslands are tainted by invasives (Figure 2). Similarly, flooding is a natural and necessary disturbance in wet grasslands, similar to fire lines that are required for dry grasslands (Figure 2). The nature of grassland ecosystems is the decisive factor for the type of management to be performed, but this distinction is often missed in India as a result of the history of Indian land management.

The Colonial (mis)classification of grasslands

The British colonial enterprise in India was fundamentally commercial, and one of the chief sources of money that the British took advantage of was land revenue (Guha 1981). Initially, the British struggled to make money from non-agricultural land. However, they learned that forest production could not only be taxed but was also vital for colonial security because wood was needed for the construction of railroads that enabled rapid troop movements. With that intent, state-run forest departments were created which owned and managed forests primarily to accrue benefits to the colonial government in the form of revenue and wood for public construction (Guha 2000). This led to a tripartite classification of lands: agricultural lands were taxed, forest lands were managed for forest revenue, and other lands were “wastes” i.e. lands that gave no direct benefit to the government (Balooni & Singh 2003). Grasslands fell into all three of these classifications – i.e. many grasslands were converted to agriculture, and others, particularly those which existed in mosaics with forests or were savannas, were classified as forests and were managed for wood production with restrictions on fire and grazing that aimed to maximize wood production (Rangarajan & Sivaramakrishnan 2014). This, along with early plantation schemes, likely led to the conversion of many treed savannas into closed-canopy forests (Agarwala et al. 2019). Yet,

many grasslands – particularly those in arid and semi-arid areas and/or floodplains, where tree growth and agricultural potential were both low- were classified as wastelands (Dove 2004).

In 1780, the British formalized the '*Baze Zameen Daftar*' (wasteland office, Kashwan 2017) in order to bring wastelands to 'productive' use. Following this, the Waste Lands (Claims) Act was created in 1863 to strengthen state ownership of wastelands. The 1860s also saw the initiation of formal government-led forest departments which built on older reforestation practices (Bennett 2014) to attempt to restore "degraded forests" which were often grasslands (Joshi et al. 2018). Wastelands were originally a commercial rather than an ecological classification (Balooni & Singh 2003). Discourses of degradation were widespread among European colonialists (Grove 1995) and that led to conceptual slippage, and soon the term wastelands bore a double meaning: land that did not generate revenue and land that did not generate revenue *because* it was ecologically degraded. Therefore, a key goal of wasteland management was to seek 'improvements' particularly focused on agriculture (Baka 2019). The low value British colonialists placed on grassland ecosystems was perhaps exacerbated by the difficulties the British faced managing grassland people. While sedentary farmers could be taxed, migrating pastoralist people– whose livelihoods depended on open grasslands– were difficult to tax. Migratory habits and accumulation of wealth in the form of animals rather than stationary grain stores made it easier for them to avoid taxation (Saberwal 1999). The activities of pastoral peoples, such as grazing animals and lighting fires (maintaining grassland ecosystems), were labeled as destructive to forests and causing the degradation of wastelands (Rangarajan & Sivaramakrishnan 2014). Thus, many pastoral people were classified as "criminal tribes" and/or subjected to policies like banned fire use(s) and restricted grazing. These policies forced them to settle as permanent agriculturalists or at least not move their animals between traditional grazing grounds that might be classified for other uses, such as timber production in forests or agricultural development in wastelands (Saberwal 1996).

Along that time, *Jardinage* (French word for gardening) forestry derived from European thought was also introduced in the Indian grasslands (Roy & Fleischman 2022). This practice-maintained uniformity in tree structures and distribution just the way a garden looks (Davis & Robbins 2018). In addition to that, colonial officials both encouraged the agricultural conversion of grasslands into plowed fields and the planting of imported grasses for increasing grassland productivity (Upadhyaya 2021). Colonial policies and practices towards grasslands were, therefore, marked with measures that focused on fiscal benefits to the state with no clear grounding in science.

Post-colonial to present-day continuity of grassland misperceptions

India's freedom was a watershed political event, yet led to little change in grassland management. The colonial misconception of grasslands as degraded forests (Kumar et al. 2020) continued post-independence, creating an ostensible need to 'reforest' those landscapes that remained (Vanak et al. 2017). Wastelands, in post-colonial parlance, allude to any 'unproductive' or 'degraded' land,

generally understood to be land that is neither forest nor agriculture. The colonial policies, as we saw, focused on purely economic incentives for converting grasslands to forests. However, post-colonial policies aim to reclaim these lands to mitigate climate change, food insecurity, and ecological degradation, thus accelerating the transformation of grasslands to annual crops and closed-canopy forests.

The move to transform these lands to remediate food insecurity and loss of forest cover gained traction immediately after independence in 1947 (Watve et al. 2021). It began with the National Forest Policy of 1952 which established a goal of 33% forest cover across the country (Joshi et al., 2010). However, these targets were never realistic (Rana & Varshney, 2022). Large-scale investments in afforestation programs were announced in the 1970s and 1980s (Saigal 2011), inappropriately targeting grassland sites for tree planting (Rana et al. 2022). The forest department's relatively high status at national and local administrative levels as well as its staff presence in remote rural areas bestowed it a high influence over land-use decision-making (Fleischman 2014). The structure of forest department training carried a militaristic perspective of forest law enforcement and a (timber) silviculture-centric view of forests (Hannam 2000). Their dominion over forestry research and education meant that new ecological notions of non-equilibrium dynamics and disturbance processes– and eventually restoration ecology– still have not reached Indian forest and land management decision-making in spite of their dominance in international ecological science for at least half a century. Post-independent India aimed to cultivate more food and/or reform the distribution of land, stirring more conversion of village common lands and open habitats like grasslands and savannas to annual crops (Sarin 2005; Kurosaki 2011).

Though agricultural conversions became more difficult following the passage of the Indian Forest Conservation Act (1980), this did not pause the degradation of grasslands, which were not explicitly protected in this law. In fact, recent analyses suggest that the loss of grasslands increased after 1980, after holding relatively stable for much of the 20th century, suggesting that the factors leading to grassland degradation are accelerating. Tian et al. (2014) estimated a total of 20 million hectares of grassland loss in India between 1880 to 2010. Estimates in Tian et al. (2014) likely underestimate the extent of grassland degradation as many areas identified as forests in their paper are categorized as savannas or grasslands in more recent analyses. Similarly, Arasumani et al. (2018) reported that agricultural expansion was largely responsible for the depletion of Shola grasslands from 1993 to 2003. Such large-scale land-use changes are driven by ambiguities in the nomenclature and classification of grasslands- the aspect inherited from the British *raj*. Such has been the repercussion(s) of these ambiguities that the onus of grassland governance is now spread across different government bodies, thus, '*making it easier to bypass land acquisition laws for greening*' (Pardikar 2021).

Table 1 provides an overview of roles played by multiple government entities in grassland conservation and restoration bracketing their broader goals in land management. The table shows that government agencies have conflicting goals for grasslands management. As a result, decisions often take many years. Moreover, government agencies perpetuate misclassifications. For instance, the nodal authority in wasteland mapping in India is the National Remote Sensing Agency (NRSA) which prepares the wasteland Atlas of India (Department of Land Resources-Wastelands Atlas of India). A close look at their mapping criteria reveals a high overlap of grasslands and grassland-type ecosystems with wasteland categories, including dense and open scrubby lands, and degraded pastures/grazing lands, and waterlogged and marshy regions (interpretations similar to Watve et al., 2021). Likewise, the Ministry of Environment, Forest and Climate Change (MoEFCC) - the nodal authority in environment conservation in India - oversees the management of grasslands that occur within protected areas (PAs) and reserve forests but typically focuses on grasslands only to the extent that they support conservation of large herbivores and/or prey for tigers. The Indian Council of Agricultural Research (ICAR)- India's National Institution for agricultural research, education, and extension under the Ministry of Agriculture and Farmers' welfare- in their report on 'Degraded and Wastelands of India: Status and spatial distribution', states-

"Since land resources are finite, requisite measures are required to reclaim degraded and wastelands so that areas going out of cultivation due to social and economic reasons are replenished by reclaiming these lands and by arresting the further loss of production potential." (Indian Council of Agricultural Research and National Academy of Agricultural Sciences). For fluvial landscapes like wet grasslands, which depend on flooding regimes and annual inundation, classifying these habitats as water-eroded wastelands erases their existence from conservation and restoration narratives. This is more relevant for grasslands occurring outside PAs, and are thus susceptible to conversion to 'productive' agricultural lands. The report's description of 'natural vegetation' focuses exclusively on forested habitats, with limited attention to grasslands as a natural vegetation type. Furthermore, the document encourages tree-based solutions for wastelands while ignoring techniques that might restore grasslands: *"Cultivation of biofuel producing plants and fuel trees/crops should be encouraged in the degraded lands and wastelands. This is an essential step for environmental protection"*. In some sense India's stand on grasslands goes beyond the purview of BAD, as grassland ecosystems are not even officially recognized in governmental land classifications.

Are India's future commitments detrimental to grassland conservation and restoration?

India's current environmental commitments promise a future of grassland degradation. This promise is the result of historical neglect of grasslands, as well as a lack of administrative and political recognition that grasslands exist or are important. Ironically, while the historical agenda to transform grasslands into forest plantations and agricultural fields stemmed from economic pursuits, much current, and future grassland conversion stems from global and national climate

change and environmental targets. To achieve land degradation neutrality (Kust et al. 2017), increase carbon stock, improve green cover, or salvage wastelands, and in line with global commitments such as the Bonn Challenge, the ‘30 by 30’, the Trillion trees campaign, and others, the Indian government has committed to massive scale afforestation and reforestation (Davis & Robbins 2018). These tree-based restoration activities often diminish- or actively sabotage- efforts toward grassland conservation and restoration, and fail to include the voices and concerns of local communities or meet socio-economic targets (Coleman et al. 2021). Additionally, Dove (2004) argued that tree planting on grasslands is a political action that enables government control over local land tenure.

India is a signatory to the Bonn Challenge and the United Nations Convention to Combat Desertification (UNCCD), where it pledged to bring 13 million hectares of land under restoration by 2020, and an additional 8 million by 2030 (This was, in 2019, raised to 26 million hectares of degraded land). Being a party to the United Nations Framework Convention on Climate Change (UNFCCC) further paved the way for commitments for ‘*aggressive strategies on forestry management*’ (Ministry of Environment & Forests, 2012). India’s Intended Nationally Determined Contributions (INDCs)- in line with the global goals- aimed to create additional forest carbon sinks of 2.5-3 billion tons of CO₂ by investing in afforestation projects as a means toward climate change mitigation and climate justice (Ministry of Environment, Forest and Climate Change, 2018). These INDCs were international climate agreements signed by nations as a part of their post-2020 climate actions (in conclusion to the UNFCCC’s Conference of the Parties (COP 21), Paris 2015). India’s INDCs included the onset of the National Mission for a Green India, granting funds for CAMPA (Compensatory Afforestation Fund Management and Planning Authority through Compensatory Afforestation Fund Act 2016) to the tune of USD 6 billion, and declaring plantation schemes along rivers and highways.

While these goals recognize the importance of climate change and land degradation in India, much of the land designated for large-scale afforestation programs- is adapted from large-scale maps like the World Resource Institute (Chaturvedi et al. 2018) or from the forest-biased mapping efforts of the Forest Survey of India- are grasslands (Madhusudan & Vanak 2021). For example, The World Resources Institute maps identify the entire stretch of wet Terai grasslands in north India as areas for ‘restoration’ which in the Indian context is almost always considered synonymous with afforestation for reasons described above. Balooni & Singh (2003) argue for bringing wastelands under afforestation in order to achieve forest cover targets, highlighting the need to “*develop tree species to suit different edaphic conditions...like ravines and deserts,*” thereby disregarding the ecological significance of deserts and ravines. While tree planting projects that are socially and ecologically relevant are definitely required in sites that have a documented forest loss, enthusiasm for planting in sites noted as deserts and ravines may be a reason for widespread planting failures (Rana et al. 2022). A key point here is that even when these global targets do not focus on forests, as is the case with restoration and land degradation agreements which are neutral

to ecosystem type, in the Indian context they are interpreted to be about forests and trees, often at the expense of grasslands.

Ecological restoration efforts in India are undertaken primarily by government departments such as state forest departments, and to a lesser extent by NGOs and CSR (Corporate Social Responsibility) initiatives and mostly focus on tree planting. The CAMPA (INR 480 billion disbursed to date, The Hindu, 2021), National Afforestation and Eco-Development Board (which implements the National Afforestation Programs, INR 1.578 billion), and National Mission for a Green India (INR 5.94 billion) (Ministry of Environment, Forest and Climate Change, 2022) are programs aimed to increase “green cover” and restore degraded habitats, in line with the national and international targets described above. Many other programs- indirectly related to restoration goals- also contribute to the greening efforts. These include plantations for biofuel energy (*Jatrofa* plantations) or plantations of *Prosopis juliflora* to tackle salt ingress and desertification in the grasslands of Banni (Gujarat) (which now occupy 50% of the total grasslands, Nerlekar et al. 2022b). Irrigation projects, such as the Indira Gandhi Canal, have also been pivotal in their efforts to “green” the deserts and scrublands of India, especially in the state of Rajasthan where policies aim to combat desertification, alleviate poverty, improve agricultural yield, and protect animal wealth. The National Mission for a Green India aims to put a third of the country’s area under forest cover, no matter what natural vegetation existed originally. Large areas of natural grassland-forest mosaics are being replaced with tree plantations. To the extent that restoration programs do address grasslands, it is through planting “improved” fodder grasses for cattle grazing (Shinde & Mahanta, 2020), which while potentially economically beneficial, does not contribute to the restoration of native grasslands. A detailed flow of the various programs is given in Figure 3, where we have extensively mapped the national and global goals India is signatory to, how they mandate restoration policies in India, and what policy initiatives India has taken to address restoration of habitats to either mitigate climate change or achieve Land Degradation Neutrality.

India’s grassland conservation and restoration programs

While most of India’s environmental and restoration programs deny even the existence of grasslands, there is recent recognition of grasslands as integral landscapes worth protecting. The ‘Overview of Detailed Project Reports for Rejuvenation of Major Indian Rivers through Forestry Interventions’ by the Indian Council of Forestry Research and Education (ICFRE), and the ‘Bonn Challenge and India’ (Borah et al. 2018) both recognize the value of grasslands in theory. The ICFRE documents grasslands as natural landscapes that are integral to a river basin, and includes them along with other ecologically sensitive habitats. The term ‘grassland degradation’ encompasses soil erosion and sedimentation. For example, in the Yamuna floodplains of Madhya Pradesh, the report designates INR 0.016 billion for ‘grassland development in wildlife areas’ or ‘development of riverine grasslands (Godavari, Telangana)’ or ‘grassland development in riverine areas (Krishna, Telangana), or ‘Shola forest and grassland restoration’ (Cauvery, Kerala, Tamil Nadu).

Grasslands in India are mostly conserved and restored with the intention to sustain the dependent fauna. In protected areas, state forest departments often manage grasslands for conservation purposes. These initiatives are undertaken to sustain herbivore populations (Like Asiatic One-horned Rhinoceros, Asiatic Water Buffalo, Swamp Deer), or prey base (Like Spotted Deer, Sambar) for charismatic predators, particularly tigers (Parliamentary Standing Committee Report 363). These include fencing grasslands at certain times of the year to prevent herbivory and promote grass regeneration, manual removal of woody encroaching species like *Bombax ceiba*, *Cassia sp*, *Prosopis sp.*, *Acacia sp.*, fire management through patch burning and grass growth via seed bombing (Kumar 2013) as well as controlling cattle grazing. Removal of invasive *Lantana camara* has also been successfully implemented in Corbett Tiger Reserve to restore grassland communities as a means to achieve Land Degradation Neutrality (Singh & Tewari 2021) Many protected areas undertake research for grass species inventory that inform the maintenance of grassland mosaics instead of monocultures. Grasslands in Blackbuck National Park, Gujarat are harvested on a rotation to sustain Blackbuck, which prefer shorter grasses, (Rawat & Adhikari 2015). The Desert and Grassland Task Force, constituted in 2006 by the Planning Commission (Now, *Niti Aayog*), recommended creating ‘Project Bustard’ (in line with India’s flagship megafauna conservation programs: ‘Project Tiger’ and ‘Project Elephant’), writing a National Grazing Policy that aided securing land tenure for pastoralists, expanding on the legal definition of ‘forests’-in line with the Godavarman V. Union of India case- under the Forest Conservation Act to also protect grasslands.

NGOs and research institutions are also making efforts toward the scientific restoration of grasslands. Removal of invasive species is at the forefront of such activities, with examples from grasslands of Banni (Nerlekar et al. 2022b), and Shola grasslands of the Nilgiri hills (Ecological Restoration Alliance (ERA), NCF & VCT, 2006), wet grasslands of Manas Tiger Reserve, Assam (Sinha et al. 2022). Grasslands outside protected areas are also maintained by local or nomadic communities who depend on them mainly for pastoralism, grazing, grass collection for housing material, farming, and other livelihood activities.

Improving policies for grassland conservation and restoration in India and beyond

The positive grassland conservation and restoration actions outlined in the previous section are outweighed by the bulk of public actions which undermine grassland conservation – and related values including pastoral livelihoods and grassland-dependent endangered species. Given the dire condition of India’s grasslands and their dependent species and livelihoods, India needs to prioritize protecting existing grasslands and restoring those degraded by a variety of processes. Significant changes are needed in Indian policy-making to address these concerns – and significant changes in global science communication and policy-making can support these changes in India and elsewhere.

As we have shown in this paper, India's neglect of its grasslands arises from three interconnected factors. First is the longstanding bias built into India's natural resource management, a legacy of colonial priorities, which places forests above other ecosystems. Second is a related colonial legacy that classifies grasslands and other non-forest ecosystems as "wastelands" and assumes that their present condition is the result of degradation, rather than separating ecosystem types from ecosystem conditions. The third is a global system of environmental science and communication around conservation and restoration that prioritizes forests over other ecosystems, a phenomenon described as Biome Awareness Disparity (BAD – see Silveira et al. 2021), which provides India continuing incentives to focus on afforestation as part of global environmental commitments at the expense of grasslands.

These problems can be overcome. First, Indian government agencies can adapt a new system of classification that separates the classification of ecosystems from the analysis of degradation. This classification should focus on the many Indian ecosystems that are typified by grass cover and maintained through fire, grazing, and other natural disturbance processes that are currently assumed as degradation. This new classification system- which can be in line with recent advances in grassland mapping like Madhusudan & Vanak 2021- is essential for the development of proper legislation regarding Indian grasslands as this would recognize (and define) grasslands for both ecological and policy narratives. Such a classification system would move Indian natural resource management into line with modern understandings of non-equilibrium dynamics in disturbance ecology. Apart from providing a more specific language to speak about different kinds of Indian ecosystems, this would also encourage a more careful analysis of processes of degradation, currently obscured by the catch-all terminology "wastelands," which is needed for successful ecological restoration – avoiding some of the failures documented recently (Coleman et al. 2021; Rana et al. 2022)

Second, following Rawat & Adhikari (2015), India needs a national policy framework for grassland conservation and restoration which integrates the values of grasslands and other non-forest ecosystems, including both their use for conservation and the many benefits they bring to people into the broader legal framework. While India's current legal framework for managing forests is flawed, it at least provides formal processes for protecting forests and granting and regulating a variety of forest rights under laws such as the Indian Forest Act of 1927, the Forest Conservation Act of 1980, and the Forest Rights Act of 2006. In practice, many grasslands already fall under this regulatory framework because they lie on legally designated forest land, however lack of recognition of their non-forest nature means that they are often placed at low priority for protection, and are treated as degraded forests in need of reforestation. Indeed, for many grasslands, a key component of restoration might involve decreasing tree cover through some mixture of logging, fire, and grazing (Wilcox et al. 2022). For those grasslands falling outside of legally designated forest land, a protection and restoration regime that recognizes their unique

values and relationships to livelihoods – prioritizing the rights and livelihood needs of pastoralists whose lives are threatened by the loss of grassland ecosystems– would go a long way towards improving grassland management.

Third, international scientific enterprises and restoration agreements need to move away from their current forest-centric structure. The harm is particularly strong when international agreements implicitly incorporate forest-centric concepts that trickle down to countries like India which already have strong internal forest biases. Concepts like “Forest Landscape Restoration,” promoted by many international organizations as part of global restoration initiatives, may contain subtle messages to consider the entire landscape– including the non-forested parts. Unfortunately, such subtlety is lost in India when interpreted through a political and administrative structure that literally has no language or law for treating non-forest ecosystems as anything other than waste. We concur with Dudley et al. (2020) who argue for the need to make the case for grassland restoration in national and international targets as it may otherwise set a perverse incentive for afforestation as a remedy for restoration of habitats. Thus, while India seeks new terminology and definitions, so too do the international organizations promote ecological restoration around the globe.

Acknowledgments

The authors thank Ninad Mungi, Neeraj Mahar, Subhashini Krishnan, Bhavya Iyer, and Kushagra Meshram for fruitful discussions, researchers from ATREE Bengaluru- Anoop NR, Nirav Mehta (as a tribute), and Ramya Ravi for grassland pictures.

SL’s work is supported by the Interdisciplinary Center for the Study of Global Change (ICGC) fellowship. AR’s work is supported by J. William Fulbright Foreign Scholarship Board (FFSB) and the Fulbright Commission in India (USIEF) and FF’s work is supported by (NASA) Award #NNX17AK14G.

References

- Agarwal I, Ramakrishnan U (2017) A phylogeny of open-habitat lizards (Squamata: Lacertidae: *Ophisops*) supports the antiquity of Indian grassy biomes. *Journal of Biogeography*, 44 (9): 2021-2032. <https://doi.org/10.1111/jbi.12999>
- Agarwala M, DeFries R, Jhala YV, Qureshi Q (2019) *Threats to Coexistence of Humans and Forests in Central India*
- Arasumani M, Khan D, Das A, Lockwood I, Stewart R, Kiran RA, Muthukumar M, Bunyan M, Robin VV (2018) Not seeing the grass for the trees: Timber plantations and agriculture shrink tropical montane grassland by two-thirds over four decades in the Palani hills, a Western Ghats sky island. *PLOS ONE*, 13 (1): e0190003. <https://doi.org/10.1371/journal.pone.0190003>
- Baka J (2019) Do Wastelands Exist? Perspectives on " Productive" Land Use in India's Rural Energyscapes. *RCC Perspectives*, 2: 57-64. <https://www.jstor.org/stable/26631562>
- Balooni K, Singh K (2003) Financing of wasteland afforestation in India. In: *Natural Resources Forum*, 27 (3): 235-246. <https://doi.org/10.1111/1477-8947.00058>
- Bawa KS, Sengupta A, Chavan V, Chellam R, Ganesan R, Krishnaswamy J, Mathur VB, Nawn N, Olsson SB, Pandit N, Quader S, Rajagopal P, Ramakrishnan U, Ravikanth G, Sankaran M, Shankar D, Seidler R, Shaanker RU, Vanak AT (2021) Securing biodiversity, securing our future: A national mission on biodiversity and human well-being for India. *Biological Conservation*, 253: 108867. <https://doi.org/10.1016/j.biocon.2020.108867>
- Bennett BM (2014) The origins of timber plantations in India. *Agricultural History Review*, 62 (1): 98–118. [The origins of timber plantations in India: Ingenta Connect](https://www.ingentaconnect.com/ahri/article/62/1/98)
- Bond WJ (2008) What limits trees in C₄ grasslands and savannas? *Annual review of ecology, evolution, and systematics*, 39: 641-659. <https://www.jstor.org/stable/30245180>
- Bond WJ, Stevens N, Midgley GF, Lehmann CE (2019) The trouble with trees: afforestation plans for Africa. *Trends in Ecology & Evolution*, 34 (11): 963-965. <https://doi.org/10.1016/j.tree.2019.08.003>
- Borah B, Bhattacharjee A, Ishwar NM (2018) Bonn challenge and India: Progress on restoration efforts across states and landscapes. New Delhi, India: IUCN and MoEFCC, Government of India. <https://doi.org/10.2305/IUCN>

Buisson E, Le Stradic S, Silveira FA, Durigan G, Overbeck GE, Fidelis A, Fernandes GW, Bond WJ, Hermann J-M, Mahy G, Alvarado ST, Zaloumis NP, Veldman JW (2019) Resilience and restoration of tropical and subtropical grasslands, savannas, and grassy woodlands. *Biological Reviews*, 94 (2): 590-609. <https://doi.org/10.1111/brv.12470>

Chaturvedi R, Duraisami M, CB JKM abd K, Singh R, Segarin S, Rajagopal P (2018) Restoration opportunities atlas of india. Technical report, *World Resources Institute– India*

Coleman E, Schultz B, Ramprasad V, Fischer H, Rana P, Filippi A, Güneralp B, Ma, A, Rodriguez SC, Guleria V, Rana R, Fleischman F (2021). Decades of tree planting in Northern India had little effect on forest density and rural livelihoods. *Research Square*, [Decades of tree planting in Northern India had little effect on forest density and rural livelihoods - Abstract - Europe PMC](https://doi.org/10.21956/rsos.21011)

Dad JM, Ahmad MZ (2022) Role of Grasslands in Soil Carbon Storage: Case Study from Alpine Grasslands of North-Western Kashmir Himalaya. In: Öztürk M, SM Khan, V Altay, R Efe, D Egamberdieva, FO Khassanov (eds) *Biodiversity, Conservation and Sustainability in Asia* (pp. 23-32). Springer, Cham. https://doi.org/10.1007/978-3-030-73943-0_2

Dass P, Houlton BZ, Wang Y, Warlind D (2018) Grasslands may be more reliable carbon sinks than forests in California. *Environmental Research Letters*, 13 (7): 074027. doi: 10.1088/1748-9326/aac339

Davis DK, Robbins P (2018) Ecologies of the colonial present: Pathological forestry from the taux de boisement to civilized plantations. *Environment and Planning E: Nature and Space*, 1 (4): 447-469. <https://doi.org/10.1177/2514848618812029>

Department of Land Resources (2019) Wastelands Atlas- Cover, preface, contents, project team, executive summary, introduction. *Technical report, Government of India*

Dove MR (2004) *Anthropogenic grasslands in Southeast Asia: Sociology of knowledge and implications for agroforestry*, pp. 423–435. Springer Netherlands.

Dudley N, Eufemia L, Fleckenstein M, Periago ME, Petersen I, Timmers JF (2020) Grasslands and savannas in the UN Decade on Ecosystem Restoration. *Restoration Ecology*, 28 (6): 1313-1317. <https://doi.org/10.1111/rec.13272>

Dutta S, Rahmani AR, Jhala YV (2010) Running out of time? the great Indian bustard *Ardeotis nigricaps*—status, viability, and conservation strategies. *European Journal of Wildlife Research*, 57(3): 615–625. <https://doi.org/10.1007/s10344-010-0472-z>

Ecological Restoration Alliance (ERA): <https://era-india.org/project/shola-grassland-restoration/>

Fleischman FD (2014) Why do foresters plant trees? Testing theories of bureaucratic decision-making in central India. *World Development*, 62: 62-74. <https://doi.org/10.1016/j.worlddev.2014.05.008>

Ghosh-Harihar M, An R, Athreya R, Borthakur U, Chanchani P, Chetry D, Dutta A, Harihar A, Karanth KK, Mariyam D, Mohan D, Onial M, Ramakrishnan U, Robin VV, Saxena A, Shahabuddin G, Thatte P, Vijay V, Wacker K, Mathur VB, Pimm SL, Price TD (2019) Protected areas and biodiversity conservation in India. *Biological Conservation*, 237: 114-124. <https://doi.org/10.1016/j.biocon.2019.06.024>

Grant MJ, Booth A (2009) A typology of reviews: an analysis of 14 review types and associated methodologies. *Health information & libraries journal*, 26 (2): 91-108. <https://doi.org/10.1111/j.1471-1842.2009.00848.x>

Grau HR, Torres R, Gasparri NI, Blendinger PG, Marinaro S, Macchi L (2015). Natural grasslands in the Chaco. A neglected ecosystem under threat by agriculture expansion and forest-oriented conservation policies. *Journal of Arid Environments*, 123: 40-46. <https://doi.org/10.1016/j.jaridenv.2014.12.006>

Grove R, Grove RH (1995) *Green imperialism: colonial expansion, tropical island Edens and the origins of environmentalism, 1600-1860*. Cambridge University Press.

Guha R (2000) *The unquiet woods: ecological change and peasant resistance in the Himalaya*. University of California Press.

Guha R (1982) *A rule of property for Bengal: An essay on the idea of permanent settlement*. Orient Blackswan.

Hannam K (2000) Utilitarianism and the identity of the Indian Forest Service. *Environment and History*, 6 (2): 205-228. <https://doi.org/10.3197/096734000129342280>

Hurteau MD, Koch GW, Hungate BA (2008) Carbon protection and fire risk reduction: toward a full accounting of forest carbon offsets. *Frontiers in Ecology and the Environment*, 6 (9): 493-498. <https://doi.org/10.1890/070187>

Indian Council of Agricultural Research and National Academy of Agricultural Sciences (2010) Degraded and wastelands of india: Status and spatial distribution. *Technical report, Ministry of Agriculture and Farmers Welfare, Government of India.*

Joshi AK, Pant P, Kumar P, Giriraj A, Joshi PK (2011) National forest policy in India: critique of targets and implementation. *Small-Scale Forestry* 10 (1): 83-96. <https://doi.org/10.1007/s11842-010-9133-z>

Joshi AA, Sankaran M, Ratnam J (2018) 'Foresting' the grassland: Historical management legacies in forest-grassland mosaics in southern India, and lessons for the conservation of tropical grassy biomes. *Biological conservation*, 224: 144-152. <https://doi.org/10.1016/j.biocon.2018.05.029>

Kapuria P (2021) *Towards a systems approach to the management of grasslands in India*. Issue Brief (Observer Research Foundation).

Kashwan P (2017) *Democracy in the woods: Environmental conservation and social justice in India, Tanzania, and Mexico*. Oxford University Press.

Kher V, Dutta S (2021) Rangelands and crop fallows can supplement but not replace protected grasslands in sustaining Thar desert's avifauna during the dry season. *Journal of Arid Environments*, 195: 104623. <https://doi.org/10.1016/j.jaridenv.2021.104623>

Kumar D, Pfeiffer M, Gaillard C, Langan L, Martens C, Scheiter S (2020) Misinterpretation of Asian savannas as degraded forest can mislead management and conservation policy under climate change. *Biological Conservation*, 241: 108293. <https://doi.org/10.1016/j.biocon.2019.108293>

Kumar H (2013) Management of tall wet grasslands in Dudwa national park, Uttar Pradesh, Indian Terai protected areas-conservation implications. In: *Revitalising grasslands to sustain our communities: Proceedings*, 22nd International Grassland Congress, Sydney, New South Wales Department of Primary Industry, pp. 1678–1681.

Kurosaki T (2011) Compilation of agricultural production data in areas currently in India, Pakistan, and Bangladesh from 1901/02 to 2001/02. *Technical report, Citeseer.*

Kust G, Andreeva O, Cowie A (2017) Land Degradation Neutrality: Concept development, practical applications and assessment. *Journal of environmental management*, 195 (1): 16-24. <https://doi.org/10.1016/j.jenvman.2016.10.043>

Lahiri S, Pathaw NA, Krishnan A (2021) Convergent acoustic community structure in South Asian dry and wet grassland birds. *Biology open*, 10 (6): bio058612. <https://doi.org/10.1242/bio.058612>

Lemos MC, Agrawal A (2006) Environmental governance. *Annual review of environment and resources*, 31(1): 297-325. doi: 10.1146/annurev.energy.31.042605.135621

Madhusudan MD, Vanak A (2021). Mapping the distribution and extent of India's semi-arid open natural ecosystems. [Mapping the distribution and extent of India's semi-arid open natural ecosystems \(researchgate.net\)](https://www.researchgate.net/publication/354111111)

Ministry of Environment and Forests (2012) India second national communication to the united nations framework convention on climate change. *Technical report, Government of India*.

Ministry of Forest, Environment and Climate Change (2018) India's intended nationally determined contributions towards climate justice. *Technical report, Government of India*.

Ministry of Forest, Environment and Climate Change (2022) Steps to control desertification. *Technical report, Government of India*.

NCF & VCT (2006). *Principles for rainforest and grassland restoration in the Anamalai hills*. Nature Conservation Foundation, Mysore, and Vattakanal Conservation Trust, Kodaikanal.

Nerlekar AN, Veldman JW (2020) High plant diversity and slow assembly of old-growth grasslands. *Proceedings of the National Academy of Sciences*, 117 (31): 18550-18556. [High plant diversity and slow assembly of old-growth grasslands | PNAS](https://doi.org/10.1073/pnas.2008111117)

Nerlekar AN, Chorghe AR, Dalavi JV, Kusom RK, Karuppusamy S, Kamath V, Pokar R, Rengaiyan G, Sardesai MM, Kambale SS (2022a) Exponential rise in the discovery of endemic plants underscores the need to conserve the Indian savannas. *Biotropica*, 54 (2): 405-417. <https://doi.org/10.1111/btp.13062>

Nerlekar AN, Mehta N, Pokar R, Bhagwat M, Misher C, Joshi P, Hiremath AJ (2022b) Removal or utilization? Testing alternative approaches to the management of an invasive

woody legume in an arid Indian grassland. *Restoration Ecology*, 30 (1): e13477. <https://doi.org/10.1111/rec.13477>

Overbeck GE, Vélez-Martin E, Scarano FR, Lewinsohn TM, Fonseca CR, Meyer ST, Müller SC, Ceotto P, Dadalt L, Durigan G, Ganade G, Gossner MM, Guadagnin GL, Lorenzen K, Jacobi CM, Weisser WW, Pillar VD (2015) Conservation in Brazil needs to include non-forest ecosystems. *Diversity and distributions*, 21 (12): 1455-1460. <https://doi.org/10.1111/ddi.12380>

Pandey K (2019) India lost 31% of grasslands in a decade. *Down To Earth*: <https://www.downtoearth.org.in/news/agriculture/india-lost-31-of-grasslands-in-a-decade-66643>

Pardikar R (2021) As India maps wasteland, environmentalists debate definition. *The Third Pole (Nature)*. <https://www.thethirdpole.net/en/nature/as-india-maps-wasteland-environmentalists-debate-definition/>

Parliamentary Standing Committee Report 363: http://c.rajyasabha.nic.in/rsnew/Committee_site/Committee_File/ReportFile/19/165/363_2022_3_14.pdf

Rangarajan M, Sivaramakrishnan K (2014) *Shifting ground: people, animals, and mobility in India's environmental history*. Oxford University Press.

Rastogi S, Chanchani P, Sankaran M, Warriar R (2022) Grasslands half-full: investigating drivers of spatial heterogeneity in ungulate occurrence in Indian Terai. *Journal of Zoology*, 316 (2): 139-153. <https://doi.org/10.1111/jzo.12939>

Rana P, Fleischman F, Ramprasad V, Lee K (2022) Predicting wasteful spending in tree planting programs in Indian Himalaya. *World Development*, 154: 105864. <https://doi.org/10.1016/j.worlddev.2022.105864>

Rana P, Varshney LR (2022). Exploring limits to tree-planting as a natural climate solution. *Journal of Cleaner Production*, 384: 135566. doi: 10.1016/j.jclepro.2022.135566

Rawat GS, Adhikari BS (2015) Ecology and management of grassland habitats in India. *ENVIS Bulletin, Wildlife & Protected Area*, 17. [Rawat-Adhikari-Ecology-and-Management-of-Grassland-Habitats-in-India.pdf \(researchgate.net\)](#)

Reid RS, Fernández-Giménez ME, Galvin KA (2014) Dynamics and resilience of rangelands and pastoral peoples around the globe. *Annual Review of Environment and Resources*, 39 (1): 217–242. <https://doi.org/10.1146/annurev-environ-020713-163329>

Roy A, Fleischman F (2022) The evolution of forest restoration in India: The journey from precolonial to India's 75th year of Independence. *Land Degradation & Development* 33 (10): 1527-1540. <https://doi.org/10.1002/ldr.4258>

Saberwal VK (1996) Pastoral politics: Gaddi grazing, degradation, and biodiversity conservation in Himachal Pradesh, India. *Conservation Biology*, 10 (3): 741-749. <https://doi.org/10.1046/j.1523-1739.1996.10030741.x>

Saberwal VK (1999) *Pastoral Politics*. Oxford University Press.

Saigal S (2011) Greening the 'wastelands': Evolving discourse on wastelands and its impact on community rights in India. In: *13th Biennial Conference of the International Association for the Study on Commons*.

Sarin M (2005) Laws, lore and logjams: Critical issues in Indian forest conservation. *International Institute for Environment and Development*, London. [Laws, lore and logjams: critical issues in Indian forest conservation. Gatekeeper Series No. 116 | Publications Library \(iied.org\)](https://www.iied.org)

Sawa RK, Ranjan R, Verma K, Verma RK (2020). Grassland productivity during early winter in Ladakh, India. *Current Science*, 119 (7): 1195-1197. [EBSCOhost | 146407068 | Grassland productivity during early winter in Ladakh, India.](https://www.ebscohost.com/EBSCOhost|146407068)

Scoones I (2021). Pastoralists and peasants: perspectives on agrarian change. *The Journal of Peasant Studies*, 48 (1): 1-47. <https://doi.org/10.1080/03066150.2020.1802249>

Sankaran M, Ratnam J (2013) African and Asian savannas. In *Encyclopaedia of Biodiversity*, pp. 58–74. Elsevier.

Sasmitha R, Iqshanullah AM, Arunachalam R (2021) Ecosystem Changes in Shola Forest-Grassland Mosaic of the Nilgiri Biosphere Reserve (NBR). In: *Environmental Issues and Sustainable Development*. IntechOpen.

Shinde AK, Mahanta SK (2020) Nutrition of small ruminants on grazing lands in dry zones of India. *Range Management and Agroforestry*, 41 (1): 1-14. [Nutrition-of-small-ruminants-on-grazing-lands-in-dry-zones-of-India.pdf \(researchgate.net\)](https://www.researchgate.net/publication/354111111)

Silveira FAO, Arruda AJ, Bond W, Durigan G, Fidelis A, Kirkman K, Oliveira RS, Overbeck GE, Sansevero JBB, Siebert F, Siebert SJ, Young TP, Buisson, E. (2020). Myth-busting tropical grassy biome restoration. *Restoration Ecology*, 28 (5): 1067-1073. <https://doi.org/10.1111/rec.13202>

Silveira FAO, Ordóñez-Parra CA, Moura LC, Schmidt IB, Andersen AN, Bond W, Buisson E, Durigan G, Fidelis A, Oliveira RS, Parr C, Rowland L, Veldman JW, Pennington RT (2021) Biome awareness disparity is BAD for tropical ecosystem conservation and restoration. *Journal of Applied Ecology*, 59 (8): 1967-1975. <https://doi.org/10.1111/1365-2664.14060>

Singh K, Tewari SK (2022) Does the road to land degradation neutrality in India is paved with restoration science?. *Restoration Ecology*, 30 (5): e13585. <https://doi.org/10.1111/rec.13585>

Sinha A, Nath A, Lahkar BP, Brahma N, Sarma HK, Swargowari A (2022) Understanding the efficacy of different techniques to manage *Chromolaena odorata* L., an Invasive Alien Plant in the sub-Himalayan tall grasslands: Toward grassland recovery. *Ecological Engineering*, 179: 106618. <https://doi.org/10.1016/j.ecoleng.2022.106618>

Special Correspondent (2021) INR 48,000 crore released to 32 states for afforestation.

Syre NF (2017) *The Politics of Scale: A History of Rangeland Science*. University of Chicago Press.

Tian H, Banger K, Bo T, Dadhwal VK (2014) History of land use in India during 1880–2010: Large-scale land transformations reconstructed from satellite data and historical archives. *Global and Planetary Change*, 121, 78-88. <https://doi.org/10.1016/j.gloplacha.2014.07.005>

Upadhyaya H (2021) *On grazing lands and cultivated fodder 1*. Routledge India.

Vanak AT, Hiremath AJ, Krishnan S, Ganesh T, Rai ND (2017) Filling in the (forest) blanks: the past, present and future of India's savanna grasslands. *Transcending Boundaries: Reflecting on Twenty Years of Action and Research at ATREE*. Ashoka Trust for Research in Ecology and the Environment, Karnataka, 189: 88-93.

[Filling-in-the-forest-blanks-the-past-present-and-future-of-Indias-savanna-grasslands.pdf \(researchgate.net\)](https://www.researchgate.net/publication/317111111)

Watve A, Athreya V, Majgaonkar I (2021) The Need to Overhaul Wasteland Classification Systems in India. *Economic Political Weekly*, 56 (40): 36-40. [The Need to Overhaul Wasteland Classification Systems in India | Economic and Political Weekly \(epw.in\)](#)

Whitehead J 2010. John Locke and the governance of India's landscape: The category of wasteland in colonial revenue and forest legislation. *Economic and Political Weekly*, 45 (50): 83-93. <https://www.jstor.org/stable/25764218>

Wilcox BP, Fuhlendorf SD, Walker JW, Twidwell D, Wu XB, Goodman LE, Treadwell M, Birt A (2022) Saving imperiled grassland biomes by recoupling fire and grazing: a case study from the Great Plains. *Frontiers in Ecology and the Environment*, 20 (3): 179-186. <https://doi.org/10.1002/fee.2448>

Tables

Entity	Role
Ministry of Environment, Forest and Climate Change	Conservation and Management of grasslands/savannas within protected areas (PAs). Controlled burning, afforestation, and restoration activities undertaken by the Forest department.
National Remote Sensing Authority	Prepares the Wasteland Atlas and associated spatial databases
Indian Council of Agricultural Research	Part of the Ministry of Agriculture and Farmers' welfare. Involved in research, education, and extension, including research on <i>wastelands</i> and how to tackle land degradation.
Ministry of Rural Development	Implements plantations/afforestation/restoration activities of wastelands or degraded lands through the MGNREGA
Department of Land resources	Situated within the Ministry of Rural Development. Erstwhile National Wasteland Development Board and Department of Wasteland Development. Primary authority in the Wasteland management of India, including mapping, inventory, recommending, and implementing reforms.
Ministry of Agriculture and Farmers Welfare	It is concerned with land-use change, agricultural expansion, and operationalizing programs that have consequences for grassland biomes.
National Mission on Biodiversity and Human Well-being	Under program 3, NMBHW will “... <i>determine the contributions of these diverse ecosystems (rivers, wetlands, estuaries, forests, and grasslands) to mitigating the impacts of extreme weather events and climate change-related disasters</i> ”. It also emphasized the restoration of ‘wastelands’ and the evaluation of ecosystem services of non-forested habitats like grasslands. (Bawa et al. 2021)
Ministry of Jal Shakti	It is concerned with river and riverine habitat rejuvenation & restoration, indirectly having a stake in grasslands along rivers like the Terai grasslands.
Government research Institutes- Wildlife Institute of India, Zoological Survey of India, Botanical Survey of India, Forest Research Institute	Undertaking research and conservation initiatives on various ecosystems, including grasslands.

Niti Aayog (Formerly Planning Commission of India)	Commissioned the “Desert and grassland task force” affecting the grassland conservation and restoration
--	---

Table 1

*A list of government bodies that have a stake in grassland governance in India
Note that only the roles pertinent to their direct or indirect links with grassland are mentioned*

Figure captions

Figure 1: Types of Indian grasslands– (top left) Terai grassland, (top right) Central Indian grassland, (bottom right) Shola grassland, (bottom left) Banni grassland

Figure 2: Aspects of vulnerabilities in Indian grasslands-- (first row- from left to right) Major threats- woody encroachment, development projects, plantations, and invasive species; (second row- from left to right) Natural and anthropogenic management- fire lines, active grass removal prior to the fire, flooding, and pastoralism

Figure 3: Positive and negative implications of global and national goals on Indian grasslands

Accepted Article

Figures



Figure 1



Figure 2

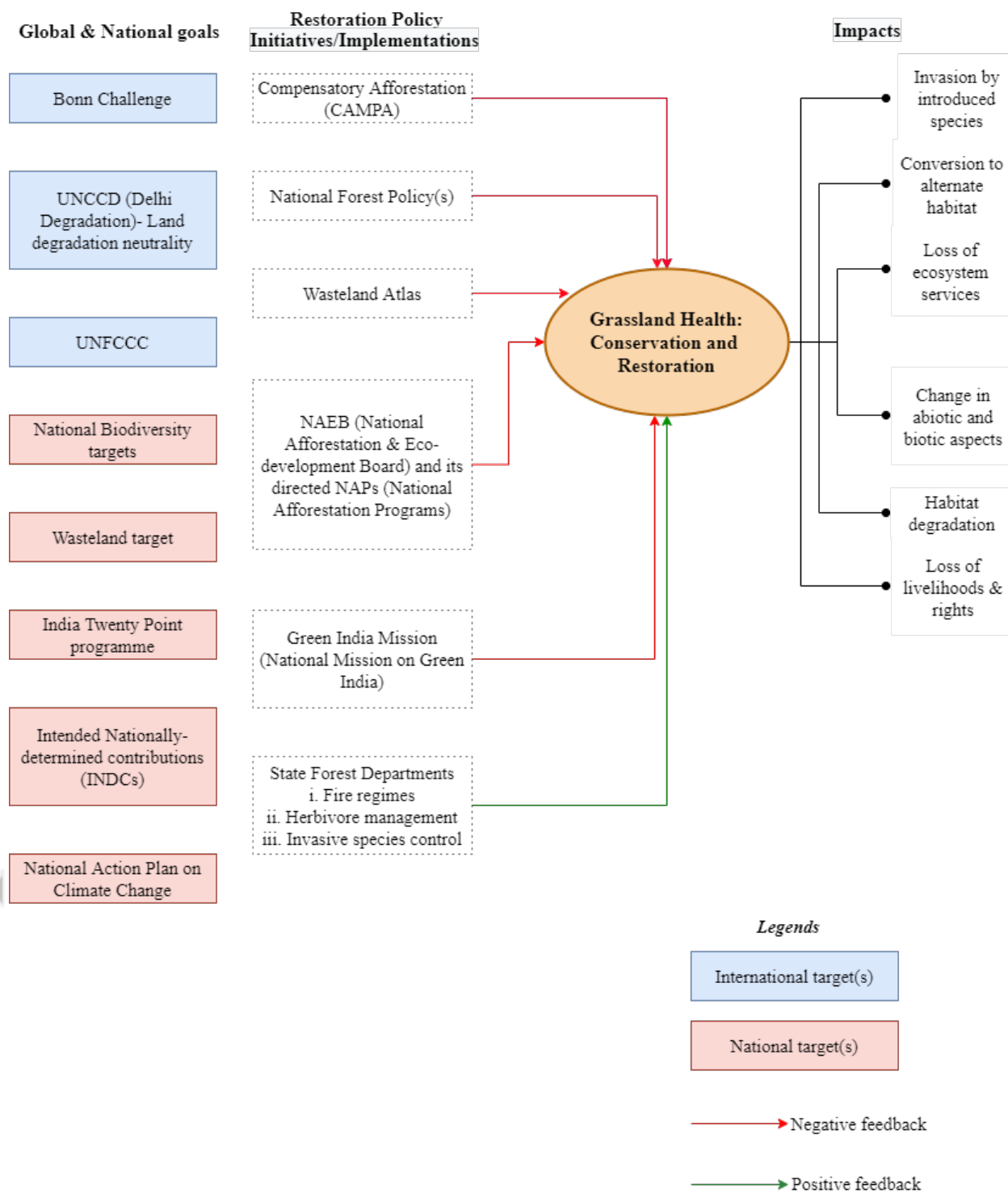


Figure 3