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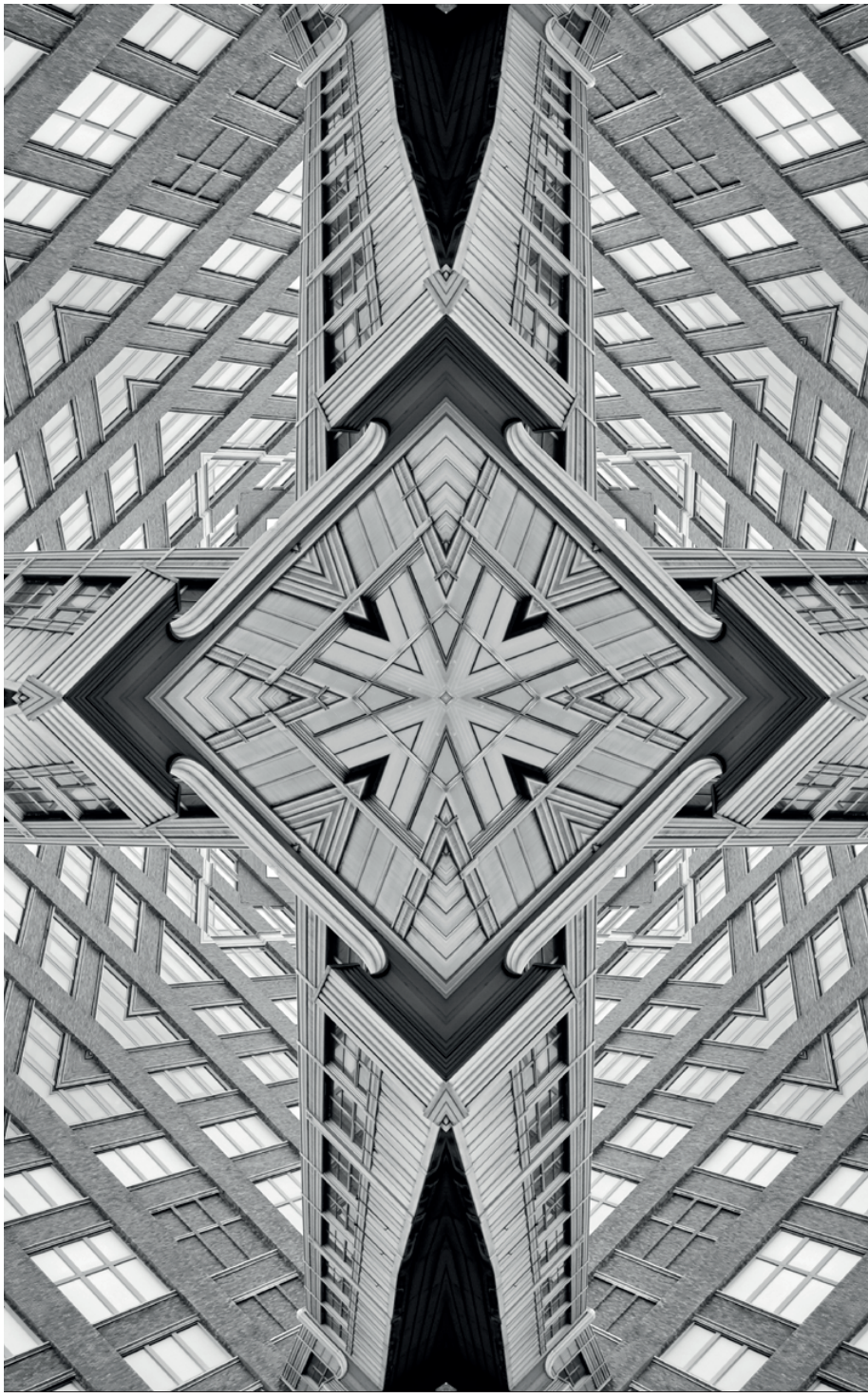

Towards a Systems Approach to the Management of Grasslands in India

Preeti Kapuria

Abstract

Grasslands that provide a variety of ecosystem services for humans—including carbon storage, which is important to mitigating climate change—are among the world's most threatened habitats. In India, grassy ecosystems are not accorded any legal protection. Vast acres of these grasslands are converted for revenue-generating use, altering their ecological dynamics and threatening the livelihoods and cultures of pastoral and agrarian communities that are intimately connected to them. This brief studies the case of the Challakere grasslands in Karnataka, traditionally protected as common grazing land, an extensive portion of which has been diverted for the government's township project called 'Science City'. The brief argues for a systems thinking approach that will treat the protection, restoration and sustainable use of grasslands as policy imperatives.

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Introduction

Grasslands—or open regions dominated by grass and characterised by warm, dry climate—are one of the most widely distributed terrestrial biomes[a] globally.[1,2] The proportion of the earth's land area covered by grasslands varies between 20 and 40 percent.[3] Tropical and sub-tropical grassy ecosystems host a range of flora and fauna that have adapted to extreme weather conditions including droughts or wildfires. (For example, grasslands found in Africa, Australia, South America, and India, require seasonal droughts and wildfires to maintain biodiversity).[4] As biodiversity hotspots, grassy ecosystems are home to a rich diversity of plant species, birds, and extant mammalian fauna.[5] They support vital ecosystem services such as water and climate regulation, forage for livestock production, biogeochemical cycling, and carbon storage, as well as cultural and recreational services. Tropical and sub-tropical grasslands store about 15 percent of the world's carbon on land. Nearly 20 percent of the world's population depends on tropical grasslands for their livelihoods. Being a source of fuel and food, grasslands are also prime grazing territory for many animals.[6]

These grassy ecosystems, however, continue to remain under-appreciated in national and global policy discussions on Ecosystem Services.[7] Grasslands are highly degraded amidst manifold threats: excessive grazing by livestock; altered fire regimes; encroachment by invasive plant species; high rates of land clearance and increasing land-use intensity; encroachment by trees; and disruption of the disturbance regimes[b] that maintain ecosystem functions. Compounding their decline is lack of management and, often, complete abandonment.[8]

In India, grassy ecosystems are spread across several biogeographic regions and occupy 24 percent of the overall geographical area.[9] Historically, these grasslands have been poorly understood and, consequently, undervalued.[10] Policymakers wrongly view them as 'seasonally dry tropical forests' or 'degraded forests',[11] or even 'wastelands'. Such lack of understanding dates back to the British era, when the colonists' policy treated grassy ecosystems as unproductive land with no economic value, classifying them as wastelands; forest and agricultural lands, meanwhile, were classified as productive lands because of the revenue they generated.[12] Consequently, communities that depended on these lands—nomadic pastoralists, artisans, and agro-pastoralists—became irrelevant in development policies.[13]

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a A biome is a large area characterised by its vegetation, soil, climate, and wildlife. There are five major types of biomes: aquatic, grassland, forest, desert, and tundra.

b 'Disturbance regimes' refers to disturbance frequency, severity, size, or timing that can trigger rapid reorganisation into new ecosystem states.

Introduction

Between 1880 and 2010, India lost some 20 million hectares (mha) (or 49.4 million acres) of grassland and shrub land, and 26 mha (64.2 million acres) of forests. The rate of loss was highest after the 'green revolution' of the 1960s that sought to 'industrialise' agriculture.[14] Absent a sound management plan for the development of pasture land and protection of existing grasslands, India lost 31 percent, or 5.65 mha (13.9 million acres) of grassland area in only the decade from 2005 to 2015. The total area under grasslands reduced to 12.3 mha (30.3 million acres) from 18 mha (44.4 million acres) between 2005 and 2015. The country also lost around 19 percent of its common lands[c] during the same period. The area under common lands decreased to 73.02 mha (180 million acres) from around 90.5 mha (223.5 million acres) between 2005 and 2015.[15]

The declining common lands including grasslands have serious livelihoods implications for the large rural economy. For example, India has more than 500 million livestock and more than 50 percent of the fodder for this livestock comes from grasslands.[16]

> "Grasslands provide manifold ecosystem services, yet continue to be under-appreciated and neglected."

This brief aims to contribute to the existing global discussion on the importance of grasslands as highly productive, unique ecosystem supporting critical ecosystem services. It studies the case of the Amrit Mahal Kavals[d] in Challakere Taluk of Chitradurga District in Karnataka, where the livelihoods of local communities are deeply interlinked with the grasslands in the region. Like in other arid regions, Challakere, too, depends heavily on livestock-rearing to tide their families over long periods of drought and unpredictable rainfall. Considering the grassland area as 'degraded' land, the state government of Karnataka between 2009-2010 diverted nearly 10,000 acres of Challakere grassland (protected for centuries as Amrit Mahal Kavals) to construct what it calls a 'Science City'—or a hub of military, scientific and commercial establishments. This land conversion is causing the destruction of not only the local socio-cultural institutions built on the principles of sustainability, resilience and integration, but also the ecosystem itself.[17]

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c 'Common land' is land subjected to rights enjoyed by a person or collectively by a number of persons, to take or use part of a piece of land or produce of a piece of land which is owned by someone else.

d Kavals are the common lands that for centuries have been collectively protected and used by traditional norms and have sustained livelihoods of the people in the region. The habitat supports a variety of highly threatened and critically endangered species of flora and fauna that are endemic to arid scrub and grassland ecosystems.

Introduction

The ease with which these grasslands were converted to other uses, was made possible partly because of a crucial gap in the forestry policy of India. Current legislation does not accord any protection to savanna grasslands. Indeed, a report by the task force set up by the Planning Commission on Grasslands and Deserts (2006) noted that grasslands were the most neglected ecosystems by the Ministry of Environment and Forests.[18] More than a decade later, the Draft National Forest Policy 2018, while focusing on increasing forest and tree cover, still continues to undervalue the country's grasslands.[19]

Grasslands are integrated human-nature systems with interdependencies between the social and ecological components. This brief presents an appropriate framework to describe human-nature interactions in order to determine the drivers of change, causes of specific outcomes, and responses that can minimise the impact of change for sustaining grasslands. Taking the case of the Challakere grasslands, the brief illustrates the application of a Driver-Pressure-State-Impact-Response (DPSIR) framework in structuring and organising relevant indicators needed for making decisions on the state of the system and the impact of the decisions made in the past or to be made in the future.[20] The aim is to help policymakers identify options for managing and protecting grasslands in India.

> "Current legislation in India does not accord any protection to grasslands."

Tropical Grassy Ecosystems, Ecosystem Services, and Management Challenges

Tropical grasslands and savannas cover approximately 20 percent of the global land surface in the tropics.[21] Grasslands often lie between forests and deserts.[22] Many factors, including the physical and chemical properties of soil, the frequency of fires, water availability, and livestock grazing and browsing animals are some of the important determinants of grassland distributions and dynamics.[23] The amount and seasonality of rainfall are key determinants of the distribution and structure of grassy ecosystems.[24]

Grasslands (including all forage systems used by grazing livestock) occupy large areas of the world's 117 million sq.km of vegetated lands[25] or 52.54 million sq.km (40.5 percent) of global land area[26] and 69 percent of the world's agricultural land area.[27] The ecosystem provides forage for over 1,800 million livestock units and wildlife populations, and also supports more than 800 million people, globally by producing food, fibre, fuel and medicines.[28] In addition to contributing to the production of goods and services that have direct economic value, grasslands also provide important non-physical services. Tropical and sub-tropical grasslands store approximately 15 percent of the world's carbon on land, account for an estimated 30 percent of total global terrestrial net primary productivity, and have a significant role in global carbon and energy cycles.[29]

Indeed, grasslands perform multiple roles in producing food and rehabilitating crop lands, in environmental management and cultural heritage.[30] Table 1 provides a detailed description of distinct ecosystem services provided by grasslands.

> "Grasslands support more than 800M people globally by producing food, fibre, fuel, and medicines."

Table 1
Ecosystem Services from Grasslands

Ecosystem services	Details
Provisioning services	Fodder and livestock production, forage quantity and quality, other products (wild food, plant based raw-materials), fresh water supply, fuel supply, habitat supply, genetic library/seed bank, other biotic material (e.g. medicinal, fibers), species diversity
Regulating services	Amelioration of weather, carbon sequestration, erosion control, water regulation, air quality regulation, soil accumulation/formation and stability, nutrient cycling, pest control, pollination service, regulation of hydrological flows
Cultural services	Recreation and tourism, aesthetic appreciation, ecological knowledge/education, cultural identity, valued species and habitats, archaeological heritage, grazing for rare livestock breeds

Source: Zhao et al (2020)[31]; Bengtsson et al (2019)[32]

Grasslands also affect ecological processes at landscape (e.g., pollination), regional (e.g., water regulation, recreation), and global scales (e.g., climate regulation). There are misconceptions about the origins and ecology of these systems.[33] They have been neglected, misclassified and misunderstood, as a result.[34]

Ironically, the Clean Development Mechanism (CDM) and the Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD+) schemes that seek to reduce CO_2 and protect biodiversity are extensively applied to grassy ecosystems. The CDM focuses on afforestation and reforestation, whereas REDD+ aims to prevent degradation and reduction in the extent of tropical forests. In response to both these programmes and following the UN Food and Agriculture Organization (FAO) vegetation classification system to define forests,[35] afforestation of grasslands has been put forward as a legitimate climate mitigation strategy.[36] These activities, however, continue to promote tree plantations in ecologically inappropriate sites and conditions.

Considered either as a degraded form of forest created due to tree clearing, burning and grazing, or a subclimax or secondary successional stage, grasslands have been misclassified, causing them immense human-induced irreversible destruction. The disturbances are compounded by a policy focus on trees, rather than ground layer composition and function. A glaring example of human activity and institutional structures destroying tropical grassy ecosystems is the Brazilian cerrado—the second richest botanical savannah region on earth, which has been reduced to dysfunctional fragments over time.[37]

In India, grasslands are the least protected ecosystems. Less than 1 percent of grasslands in the country lie in the protected area network. To secure legal protection, these areas have to be notified as Protected Areas under the Wild Life (Protection) Act, 1972 or notified as Protected or Reserve Forest under the Indian Forest Act,1927. As grasslands have spontaneous natural vegetative growth like forestland, their conversion must be restricted under the Forest Conservation Act, 1980.[38] However, there has been little effort on the part of the government to protect grasslands against conversions.

The vast tracts of grasslands of Challakere, despite being declared as District Forests per Rule 33 of the Karnataka Forest Rules, 1969[39] have systematically been diverted for developmental projects. This has led to the degradation of this common grazing pasture and grassland ecosystem.

“There has been little effort on the part of the government to protect grasslands against conversions.”

Challakere Grasslands: History and Value

The Challakere grasslands protected as Amrit Mahal Kavals are semi-arid grasslands in the Challakere Taluk of Chitradurga district in the Indian state of Karnataka (see Map 1).[40] Amrit Mahal Kavals are distributed across six districts and 62 places of Chikkamagaluru, Chitradurga, Hassan, Tumkur, Mandya and Davanagere of the state.[41] Kavals are common grazing pastures and grassland ecosystems that form a critical support system and habitat for the sustenance of livelihoods of agrarian and pastoral communities; they are also sites of rich biodiversity.[42] These kavals were originally set aside several centuries ago, during the Vijayanagara empire, and protected as grazing pastures for a strong, fast breed of indigenous cattle called Amrit Mahal that could tolerate harsh dry conditions and was once a military draft animal.[43,44] This makes the Kaval area perhaps the only largest grassland in the world that is dedicated to the protection of a species of cattle.[45]

The kaval grasslands have long provided ecological and livelihoods services to the local communities of this region. Apart from cattle and goats, sheep-rearing and allied activities of shearing, spinning and weaving woolen blankets and baskets from palm fronds are mainstays of the local economy. Because of dry conditions, groundnuts and millets are commonly grown which not only form a basis of an edible oil industry, but millets are also the staple diet of local communities. Over 250,000 people from about 70 villages who live around the Kaval sustain their livelihoods from these commons. The villagers collect fruits, greens, water, medicinal plants and firewood that are important for their food, nutritional and health security. The grasslands are also an integral part of local culture. People consider grasslands as sacred spaces and celebrate them through various festivals.[46] The Kavals form watersheds of irrigation tanks that capture surface water flow, and are also a source for groundwater recharge.

Map 1
Challakere in Chitradurga District, Karnataka

Source: http://164.100.238.9/images/hyr.jpg

The Conversion of Challakere Amrit Mahal Kaval Post-Independence

At the time of Independence, the state of Karnataka had about 400,000 acres of Amrit Mahal Kavals. After 1947, these kavals have been systematically diverted to different urban and industrial projects in addition to expansion of agriculture. Today only 60,000 acres of kaval land remain,[47] managed by the Animal Husbandry and Veterinary Science Departments of the state. Around 14,500 acres of protected grassland area, which also harbour vast biodiversity, were preserved over centuries for the Amrit Mahal cattle in Challakere in Chitradurga district. During 2007-2009, some 9,394 acres of this protected area were appropriated by the Union government and the state government of Karnataka for the 'science city' project, and another 21,976 acres were allotted to various institutions.[48] What remains now is a mere 30,000 acres of fragmented parcels across several districts of Karnataka.

The following were the allocations of the kaval land:

- Defence Research Development Organisation/Aeronautical Development Establishment (promoting a weaponised drone testing and manufacturing facility) - Land allocated: 4,290 acres
- Bhabha Atomic Research Centre (promoting a special materials and nuclear enrichment facility, for both civilian and defence purposes). A nuclear fuel enrichment and re-processing plant linked to India's nuclear weapons and nuclear submarine project - Land Allocated: 1,810 acres
- Indian Institute of Science (promoting a Synchrotron and Advanced Aerospace Research Centre). Now used for a solar energy research centre and teacher training unit - Land Allocated: 1,500 acres
- Indian Space Research Organisation (setting up a centre for Spacecraft Technologies) - Land Allocated: 573 acres
- Karnataka Small Scale Industries Development Corporation (promoting various ancillary industrial units) - Land Allocated: 300 acres
- Sagitaur Ventures India Pvt. Ltd. (promoting a solar park along with Grid Connected 25MW solar PV power project) - Land Allocated: 1,250 acres.

The appropriation did not involve any government body or even village panchayats whose consent is essential under the Panchyat Raj Act and revenue laws.[49] Moreover, issues concerning compensation, rehabilitation and resettlement were ignored. From common grazing lands to degraded parcels

of grassland, this large-scale conversion of the Challakere grasslands was set mainly on the ground that these grasslands are unproductive wastelands which can have value with new plantations and construction of facilities of national importance.

The plans ignored not only the ecological significance and constraints of a grassland ecosystem, but also the potential impacts of such activities. Indeed, over the years, the diversion of the grasslands has undermined the capacity of the ecosystem to deliver ecosystem services. After all, grasslands represent an integrated human-nature system where people live, work, and interact. Therefore, the management of such systems requires an understanding of the dynamics of an integrated human-nature system with reciprocal feedbacks and interdependencies. This lends such systems to analyses based on *systems theory* and *complex systems science*.[50] Frameworks that can explain and organise human-nature interactions are needed in order to determine the drivers of change, causes of specific outcomes, and responses that can minimise the impact of change.[51]

In this context, a DPSIR framework can be considered as a way of structuring complex environmental problems by incorporating cause-and-effect relationships. The framework has proven to be vital in building a comprehensive understanding of the relationship between the state of the ecosystem and the drivers of threats leading to that state. It provides an organised method for analysing the causes, consequences, and responses to changes in the system.

> "The management of grasslands requires an understanding of the dynamics of an integrated human-nature system."

DPSIR: A Decision Support System for the Management of Grassland Ecosystems

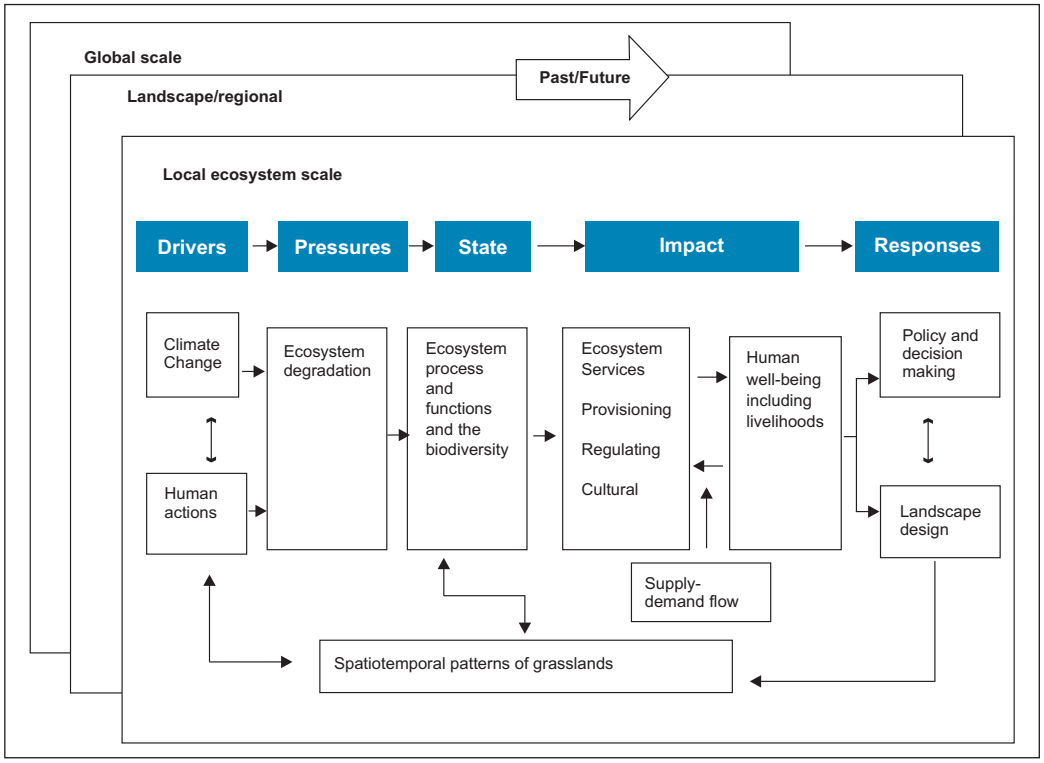
The nature of interactions between humans and their immediate environment is complex. This brief adopts a straightforward approach to organise and link the broad elements of the degradation of Challakere grassland in a Driver-Pressure-State-Impact-Response (DPSIR) model.

DPSIR is a systems-thinking approach that assumes a cause-and-effect relationship between interacting components of an integrated human-nature system.[52] The DPSIR framework presents a causal chain of the driving forces originating from the underlying needs of society, economy and development, which exert increasing pressure on the environment. This in turn results in environmental changes that have cascading impacts on human well-being and the ecosystem. These undesired impacts generate responses to reduce or contain the pressures and improve the condition of the changing environment.

The framework has been adopted by several international organisations, such as US Environmental Protection Agency, UN Environment Programme (UNEP), and the European Union for structuring environmental information and developing interaction indicators. It brings together and summarises information in a standard, logical, and hierarchical way.[53] Advancement to the DPSIR framework has come from the ecosystem-based model of the Millennium Ecosystem Assessment, which includes the ecosystem processes and functions along with ecosystem services supported by such processes and their impact on human well-being. Figure 1 offers an overview of an extended DPSIR framework that can be used to study the cause-and-effect relationship of disturbances to the ecosystem and their impact on the ecosystem itself and human well-being.

> “DPSIR is a systems-thinking approach that assumes a cause-and-effect relationship between components of a human-nature system.”

Figure 1
An Extended DPSIR Framework for Studying the Cause-and-Effect Relationship of Disturbances to Grassland Ecosystem



Note: Modified by the author

Source: Zhao[54]

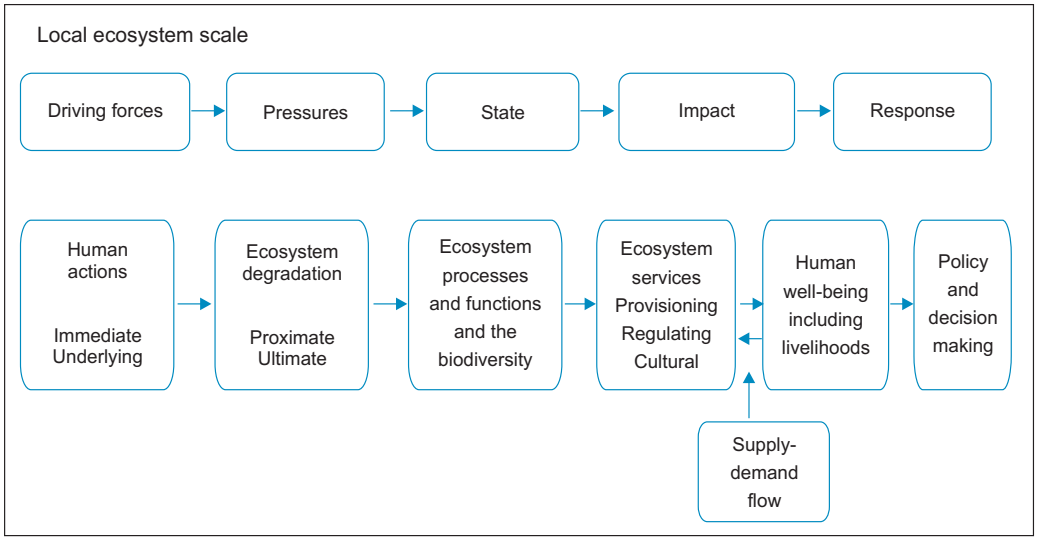
The application of DPSIR illustrated here can contribute to the understanding of relationships between state and driver factors that can then facilitate the generation of indicators relevant for managing grassland ecosystems. The definitions in the framework's information category are sufficiently general and subject to interpretation for them to be utilised in other contexts.

A View of the Degradation of Challakere Using a DPSIR Framework

The framework used in the present context of the Challakere grassland is presented in Figure 2. It is extended to include the connection between ecosystem services and human well-being, the recognition of which is crucial to the conservation of the ecosystem and sustenance of human life. The ecosystem services provided by grasslands are scale-dependent since the structure and function of grassland ecosystems, as well as human demands for ecosystem services, vary with spatial and temporal scales.[55] The impact of climate change on grassland modification is not considered, and the analysis is confined to local ecosystem scale.

Figure 2

The DPSIR Framework in the Context of the Degradation of Challakere Grassland



Source: Author's own

Adopting such a framework makes explanations more concrete and describes conceptual relationships that can be estimated. It is acknowledged that the actual relationship between two categories may be non-monotonic and indirect. Nevertheless, a description like this can serve as a basis for identifying relevant variables and models at a scale appropriate to the context of the study.

The DPSIR categories are explained taking Challakere grassland as a case in point. The challenge is to understand better the multifunctionality of grasslands in order to enhance their conservation value in India.

a. Driver category

This category focuses on human activities that give rise to threats (pressure) on natural systems. Drivers can be categorised into "immediate drivers" (those proximate to Pressures) and "underlying drivers" that influence the level and nature of immediate threats. The underlying driver can be thought of as the "least protected ecosystem" status of grasslands in India. Immediate driver is identified as the search for location by the government of India to construct an establishment of national importance.

b. Pressure category

Pressures (or threats) connect drivers to environmental state. Ecological threats to grasslands can be defined as either proximate or ultimate. Ultimate threats are the vulnerability of grasslands to state change, the perception of grasslands as "wastelands or degraded forest land", while proximate threats include climate change, land-use change, and invasive species that influence ecosystem structure and functioning. In the context of the Challakere grassland, pressures are defined by land-use change because of the unilateral decision of the Government of India to divert 9,394 acres of grassland area for the 'science city' project.

The greatest threat to grasslands is the perception of grasslands as degraded landscapes or wastelands that require human intervention to acquire value. Such narratives and perceptions that lack scientific evidence, affect the way land-use and management decisions concerning this ecosystem are made. [56]

c. State category

This covers indicators against which the condition of the ecosystem that has undergone change in structure and functionality can be assessed. The information created under this category indicates the status at a given point in time, which refers both to the effects on the ecosystem and to stock of available resources. The diversion of the Challakere grassland has pushed the system toward critical thresholds. The grassland has been built over, replaced with plantations, or invaded by invasive species.[57] The adverse impacts of diversion of the Kavals have also affected highly threatened fauna. The populations of Black Bucks, the critically endangered Great Indian Bustard, and the Lesser Florican, for whom such grazed commons were a perfect habitat, have now nearly disappeared from the region.

d. Impact category

Impacts include both ecosystem and human well-being effects. The proposed projects are highly sensitive and hazardous, disrupting the watershed and the associated groundwater recharge and destroying the wildlife habitat and the self-sustained rural economic life of the region. Agriculture has declined as much of the area's water has been diverted for the Science City. The development of a solar park has destroyed hundreds of check dams[e] built inside the grasslands by the village assemblies, resulting in the drying up of the lake in the area.[58] Polluting industries are widespread, such as stone crushers that provide construction material to the projects. Some of the groundwater sources are beginning to show contamination of toxic arsenic and fluorides.[59]

With the establishment of military-nuclear-science-industrial complex, local communities have been denied physical access to commons by enclosing the grasslands with a 100-km-long security wall reinforced with barbed-wire fences. Locals are forced to migrate to cities in search of viable livelihoods as farming and related activities have become unfeasible with the deterioration of the commons.[60] With the destruction of the grassland, the population of Deccani sheep, whose wool is used to make blankets, for example, has also reduced drastically. This has deprived local artisans income-generating opportunity.

e. Response category

This includes the initiatives intended to reduce and mitigate at least one impact or contain the threats caused by the driving forces. The response may also be built around creating awareness about the social and ecological significance of grassy ecosystems and the need to sustainably protect this ecosystem. Challenged by civil society groups in the National Green Tribunal (South Zone), the initial response in 2013 was in the form of a stay order on the projects on grounds that the proposed projects have violated environmental and social justice norms. Later, in August 2014, the stay was lifted and the projects were accorded conditional clearance by the Ministry of Environment and Forests to proceed only after securing necessary environmental clearances.

To be sure, the discussions on the diversion of kavals in the National Green Tribunal has helped draw attention to the extensive degradation of grassland ecosystem, and the recognition of the loss of traditional rights of access to kavals. In reality, however, the consequences of the diversion have been devastating for farming, pastoral and artisanal communities.

e A check dam is a small, sometimes temporary, dam constructed across a drainage ditch, swale, or channel to lower the velocity of flow. Reduced runoff velocity reduces erosion and gullying in the channel and allows sediments to settle out. A check dam may be built from stone, sandbags filled with pea gravel, or logs.

The application of DPSIR presented here is a linear representation of complex real-world problems. Nevertheless, the strength of the DPSIR model is that it makes it easier to visualise and explain the interactions between changes in the biophysical environment and human systems. It is only when such interactions are captured, presented and explained, can a well-informed response be sought. Finally, the framework sets a basis for studying each component of the framework as a sub-system or a complete system with complex interlinkages. An exercise like this would then be closer to the processes on the ground.

> "The DPSIR model makes it easier to visualise the interactions between the biophysical environment and human systems."

Policy Recommendations

Globally, the fragmentation and degradation of grasslands is threatening progress towards multiple goals. These include the Biodiversity Targets of the Convention on Biological Diversity (CBD) of 2020 and the United Nations Sustainable Development Goals, specifically SDG 15 (protecting, restoring and promoting sustainable use of terrestrial ecosystems) and SDG 13 (climate change mitigation). Arresting grassland degradation is also central to the UN Decade on Ecosystem Restoration (2021–2030) that stresses on the importance of adopting restoration strategies for degraded ecosystems.[61]

The United Nations Convention to Combat Desertification considers grassland degradation to be broadly associated with two underlying drivers: climate change and human activities.[62] The conversion of grasslands to other uses such as farmlands, built infrastructure, and forestry, contributes significantly to their degradation not only in India but in many other parts of the world.

Moreover, the lack of a national policy on grassland management also hampers grassland conservation in India, along with poor land use planning, invasive species, and inadequate coverage of grassland habitats under a protected area network. At present, management practices outside protected areas are designed to supply fodder, with a focus on livestock.[63] India has the highest livestock population in the world with high levels of dependence on grassy ecosystems. Yet, despite this visible dependence, the country does not have a comprehensive policy on management and conservation of this ecosystem. Grasslands in India have been historically undervalued in national policies, and continue to be considered as unproductive wastelands, making them vulnerable to land conversion.[64] These fragmented and human-dominated landscapes which are also home to endangered and endemic wildlife require management approaches that can incorporate multiple human uses of natural resources along with wildlife conservation. [65]

This brief offers the following recommendations for developing an effective management plan for grassland conservation in India.

1. Acknowledge and value the benefits provided by grasslands to humans on a par with other ecosystems such as forests. These benefits are in the form of ecosystem services such as food production, water supply and regulation, carbon storage and climate mitigation, soil erosion control, and a variety of cultural services. Efforts are required in integrating ecosystem and biodiversity value in national and local planning and change perceptions of grasslands as waste spaces. Misplaced narratives that have led to this perception need to be replaced with science-based evidence that conveys the complexity of grassy ecosystems.

Policy Recommendations

2. Classify grassy ecosystems as a major land use type alongside forestlands and wetlands. This is important given their high ecological and conservation value.

3. Review and update current laws and policies on conservation of grassy ecosystems in India to provide them adequate legal protection.

4. Take periodic stock of the extent, condition, and the capacity of grasslands to provide goods and services in the future.[66] Depending on the context of investigation, natural and socioeconomic factors can both lead to degradation by driving loss in biodiversity, ecosystem functions or services. Similarly, degradation can be defined both in terms of ecological and socioeconomic indicators wherein tradeoffs among combinations of ecosystem services may be prioritised. A social-ecological perspective of degradation can be adopted, following which degradation can be assessed in terms of the gap between supply and demand in ecosystem services.

5. Formulate standardised indicators of grassland condition to facilitate effective decision-making on strategies related to conservation, restoration and sustainable use of grasslands. The indicators must consider the local environmental conditions, global and local drivers of change, and their social and ecological impacts, as well as broad management and restoration objectives and the cost-effectiveness of such strategies.

6. Create mechanisms for the sharing of scientific knowledge underpinning grassland management within different biogeographic regions of the country and across different parts of the world. This can help advance the ecological understanding of grasslands and place discussions around grassy ecosystems on national and global platforms.

7. Devise a National Grassland Development and Grazing Policy that will complement the grassland management efforts focused on sustainable use of grasslands and biodiversity conservation.

8. Create institutional capacity which is multidisciplinary in its approach in order to understand the threat dynamics in grassy ecosystems, and subsequently direct management responses towards improving the resilience of these ecosystems against the impacts of threats.

Conclusion

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Grasslands have significant ecological value, including acting as a carbon sink which is imperative for climate action. However, there is inadequate operational ecological knowledge for decision-making concerning grasslands,[67] partly because they are diverse and difficult to define since apart from grasses, other forms of plant life contribute to their species richness and diversity.[68] This brief has shown how a succession of policymakers have adopted a simplified view of grassland conservation—one that considers only the tree layer and leaving out grassy ground layer from any conservation efforts and policy discourses. These systems therefore continue to be lost to human settlements, agriculture, excessive grazing by livestock, altered fire regimes, and even large-scale conversions for development purposes.

Conceptual frameworks are needed to capture, organise, visualise, explain and draw attention to the complex links between humans and nature, and in particular, as they apply to grassy ecosystems. The DPSIR framework suggested in this brief is one such conceptual framework that can explain the ecological significance of grasslands, and how intricately they are tied to human lives and local economies.

The development at Challakere in Karnataka, studied in this brief, reinforces the forestry-centric bias that has existed since the colonial era: protect forests for the timber they provide, and neglect grasslands that have no productive or economic value. Most traditional institutions ensuring sustainable management of grasslands in the past have since broken down. Legal protection must be accorded to grassy ecosystems, which from hereon must be included in sustainable development strategies. This in turn requires a systems perspective that will arrest the degradation of grasslands.

Endnotes

1 Following World Resources Institute (WRI), definitions for grasslands vary. Some studies have classified grasslands only on the basis of vegetation while others characterise them by climate, soils, and human use of the ecosystem. However, in the literature certain limits and descriptions have been used to distinguish between forest, grassland and different structural savanna types. Accordingly, forest represent complete tree canopy cover and three or more overlapping vegetation strata; woodlands: 50-100 percent tree canopy cover, and a graminaceous layer; savannas: 10-15 percent cover by woody plants and well developed grass; grasslands: less than 10 percent tree cover. The grassland major habitat types (MHTs) can be divided into six categories: tropical and subtropical grasslands, savannas, and shrublands; temperate grasslands, savannas, and shrublands; flooded grasslands and savannas; montane grasslands and shrublands; Mediterranean shrublands; and tundra.

2 Yuanyuan Zhao et al., " Grassland Ecosystem Services: A Systematic Review of Research Advances and Future Directions," *Landscape Ecology* 35(2020):793-814

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