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Ecosystem Changes in Shola Forest-Grassland Mosaic of the Nilgiri Biosphere Reserve (NBR)

R. Sasmitha, A. Muhammad Iqshanullah and R. Arunachalam

Abstract

The Shola grasslands are tropical montane forests found in the high altitudes of Western Ghats separated by rolling grasslands. These unique ecosystems act as the home for many of the floral and faunal endemic species and also serve as the water reservoir for the Nilgiri Biosphere Reserve. The grassland let the rainwater to flow through the sholas into the stream and provide water to the region throughout the year. The region once covered with tropical montane forest and grassland was transformed into a land of plantation over the centuries. As the grasslands are easy to clear off, tea estates, coffee estates and timber plantations were established by the British and later by the Indian forest department to satisfy the various need of the growing economy. Majority of this region are being replaced by the invasive tree species and agricultural plantations. This led to the loss of major proportion of the shola forest and grassland. Many developmental works have been carried out in the region and these developmental activities results in the gradual disappearance of the ecosystem. These ecosystem need to be conserved and hence, identifying the knowledge gap and application of current state of knowledge is necessary.

Keywords: biodiversity, endangered species, environmental changes, montane forest, shola-grassland

1. Introduction

The shola forest-grassland is the tropical montane forest found in the upper reaches of India's Western Ghats. This mosaic ecosystem is native only to the southern Western Ghats and found in the high altitude mountains of Kerala, Tamil Nadu and Karnataka. This is a unique system where the vast grassland is interspersed with the forest. The forest is made up of evergreen native trees which are dwarf in nature and the hill slopes are covered with native grass species. The vegetation is double layered storey with closed canopy. These ecosystems have high water retention capacity, absorb rains and retain them within their soil. The grassland let the rainwater to flow through the sholas into the stream. The streambed and decaying litter of forest holds the water and release it slowly released to form small streams and these streams joined to form large streams and then rivers throughout the year. Thus it acts as the water reservoir of the region of the Nilgiri Biosphere Reserve. This shola-grassland is the origin to many of the rivers in Tamil Nadu and Kerala region.

2. Shola-grassland ecosystem

Tropical montane evergreen forests, locally called as sholas (borrowed from the Tamil word “Sholai”) naturally coexist with grasslands at an elevation range of 1400–2700 m [1]. The shola-grassland ecosystem mosaic consists of rolling grasslands with shola fragments limited to sheltered folds and valleys in the mountains alienated from the grasslands with a sharp edge. As, sholas commonly have constant cloud cover they can be classified as lower montane cloud forest or upper montane cloud forest depending on elevation [2].

Widespread transformations of shola forest-grasslands into plantations and agricultural lands are increasing and these are the common global phenomenon affecting Africa, southern Asia, Europe, Australia, North America and South America [3–9]. The mega diverse countries like India sheltering about 200,000 of all known species are threatened largely by clearing of vegetation [10–12]. This biodiversity in India, is mostly concerted in the Western Ghats which is a 1600 km long mountain range classified as a biodiversity hotspot with a high degree of species endemism and also with many worldwide threatened species having a very restricted distribution [13–17]. Shola forests-grassland mosaics of the Nilgiri hills are characterized by high level of endemism due to the unique climatic conditions. They are rich in flora and fauna with many of them are endemic to the region.

3. Flora

Sholas contain vegetation species of both tropical and temperate affinities [10] and many of them are endemic to the region. Phytogeographical analysis of shola genera reveals that genus found on the periphery of shola fragments and as isolated trees on grasslands are typically temperate (*Rubus*, *Daphiphyllum* and *Eurya*) or sub-tropical (*Rhododendron*, *Berberis*, *Mahonia* are Himalayan) in origin. On the other hand, species found within shola fragments are IndoMalayan or Indian in origin [18, 19]. Dominant overstory species in the shola include members of Lauraceae, Rubiaceae, Symplocaceae, Myrtaceae, Myrsinaceae and Oleaceae while dicotyledonous understory species are dominated by Asteraceae, Fabaceae, Acanthaceae, [20, 21]. Monocot species in the understory are dominated by members of Poaceae, Orchidaceae and Cyperaceae [21]. Species were found to be significantly influenced by soil moisture (overstory and understory) and soil nitrogen (understory only) alongside the edge-interior gradients in shola fragments [16].

4. Fauna

The shola-grassland ecosystem mosaics are home to many threatened faunal species due to their unique climate, evergreen nature and high altitude. They act as the home for many faunal species of conservation concern including the tiger (*Panthera tigris tigris*), dhole (*Cuon alpinus*), gaur (*Bos gaurus gaurus*) Nilgiri langur (*Trachypithecus johnii*) and Nilgiri marten (*Martes gwatkinsii*). The Nilgiri tahr (*Nilgiritragus hylocrius*) which is endemic to the ecosystem-mosaic has been studied thoroughly over the years [11, 14, 20, 22–25]. Through habitat preferences, faunal species also have been observed to reflect the shola-grassland ecosystem mosaic pattern. Despite a lack of resource-driven interspecific competition, small mammal communities in the Nilgiris showed a high degree of preference for either shola or grassland. On the other hand, these patterns were masked in exotic plantations [26]. Invasive species in the shola-grassland

ecosystem mosaic also observed with strong habitat selection patterns and show a strong preference for shola cover.

5. Diminishing shola forest-grassland ecosystem: causes

The shola grasslands act as the water harvesting and water storage structures and they store large quantities of water from the mountains. These ecosystems are home to many floral and faunal species and they are rich in biodiversity. As the grasslands are depleting, flora and fauna which are endemic to the region are under severe threat. Many of the perennial rivers of Tamil Nadu and Kerala are originating from this forest-grassland mosaic. With the depletion of these unique ecosystems, the water streams are drying up and impacted the region.

The shola-grassland ecosystem is one of the most diverse but threatened landscape of the Western Ghats. These ecosystems are very sensitive to climate and climate changes have greater influence on this forest-grassland. These unique ecosystems are being degraded by many natural and anthropogenic pressures. Since the mid-nineteenth century, land use changes fragmented the Nilgiri shola forest grassland. Land management of the Nilgiri Hills is considerably changed by British company and crown governments [27] and beginning in 1837, tea and eucalyptus plantations were established and expanded them. During World War II, wattle, eucalyptus and pine plantations were promoted at the expense of highly diverse and resource-rich grasslands and shola forests by the colonial state. Grasslands and sholas were gradually cleared to provide plantation lands and wood [27–29]. Planting of timber-yielding exotic trees mainly Black wattle (*Acacia mearnsii*) and eucalyptus has been a cause of distress in these landscapes. As the grasslands are easy to clear off, tea estates, coffee estates and timber plantations were established by the British and later by the Indian forest department to satisfy the various need of the growing economy. This resulted in the loss of major proportion of the shola forest and grassland. Many developmental works have been carried out in the region and these developmental activities results in the gradual loss of the ecosystem. Between 1973 and 2014 Shola grasslands area had seen a 66.7% decline. A study carried out in the region revealed that the plant diversity and quality of the natural environment were very much affected in the highland region. Exotic weeds, conversion of native forest into timber plantations, encroachment of forest areas by midlands and lowlands, grazing of natural forest areas by domestic animals, poaching by encroachers, human population growth, ecotourism and pilgrimage, industrial effluent affected areas, pollution and contamination, forest fires and illicit felling were the reasons pointed out as the changing trend of biodiversity [30].

In the shola grasslands of state Kerala, the recent demographic changes have increased dependence on firewood, at the same time, the introduction of new crops like lemongrass and higher livestock stocking rates have put further pressure on these systems [31]. In Nilgiri also the grasslands are extremely threatened, as they are widely afforested with exotic tree plantations, mainly for energy needs [32]. According to various studies, eucalyptus-afforested grasslands in the Nilgiri suffered from significant hydrological impacts, such as reduced water yield and stream flow, and reduced seasonal runoff volume [33–36]. These disequilibria have relentlessly affected native sholas and grasslands through increased incidence of fire and expansion of invasive species [37, 38].

A documentation study carried out in the region revealed that factors responsible for the diminishing shola forest grassland ecosystem include extensive land conversion such as conversion into agricultural plots, commercial plantations, developmental activities, plantation of exotic trees and burning practices, annual fires.

As the grasslands are easy to clear off, tea estates, coffee estates and timber plantations were established by the British and later by the Indian forest department to satisfy the various need of the growing economy. Exotic trees such as eucalyptus, wattle, cinchona and pine and shrubs like *Lantana camara*, *Parthenium*, *Scotch broom* and *Gorse* are fast growing in nature and hence they easily compete with native plant species and grasslands by invading the forest-grassland ecosystem [39]. The indigenous mixed forests in the Nilgiris district were replaced by commercial and industrial crops which affect the ecological balance of the region [40]. Except in protected areas, conversion of land into commercial plantations, agricultural lands and construction activities such as hydrological dams has resulted in extensive deforestation. The latest Draft Forest Policy of the central government promotes these plantations, even though the State Forest Department has stopped promoting them and there has a ban on them officially since 1996 [1].

The statistical data on the climate variability and future projections for shola forest of the Nilgiris revealed that rainfall pattern was likely to reduce during southwest monsoon and increase towards northeast monsoon and the extreme rainfall events could further results in higher flooding. The overall temperature expected to increase more in 2050 and 2070 due to manmade pressures and some intolerant endemic species could get loss due to increasing greenhouse gas emission and fires would result in the loss of endemic habitat of shola forests. The climate change also expected to shift and alter fruiting and flowering pattern of the endemic species [41]. There had been decrease in dense forest cover (32 km^2), open forest (2.38 km^2), scrub class ($1\text{--}24 \text{ km}^2$), grass land (11.54 km^2), dense tree cover (4.93 km^2), plantation crops (5.73 km^2) and meager level of water bodies, increase in rocky surface (16.60 km^2), estates (26 km^2) and also expansion of urban areas (14.47 km^2). The results also showed that the montane grasslands and shola forests of the Nilgiris has been destroyed by widespread tea plantations and commercial plantations, easy vehicle access and the extensive monoculture [32]. Projected climate change would likely to multiply the invasion intensity of alien species. Also the montane grasslands and shola forests of the Nilgiris has been destroyed by widespread tea plantations and commercial plantations, easy vehicle access and the extensive monoculture [39]. The area once covered with native forests was transferred into land of plantation over centuries. This led to the loss of major proportion of the ecosystem. Many developmental works also have been carried out in the area. The region is being affected by various kinds of encroachment. This resulted in loss of endemic species of birds and animals by affecting their food reserve, gradual disappearance of wild edible fruits and other plant species and the native forest is reducing in a faster manner which also results in man-animal conflicts thus ultimately affects the biodiversity of the region. A documentation study carried out in the region revealed that the area is facing soil related issues such as loss of soil fertility, loss of soil beneficial microbial activity, subsoil compactness, incidence of frequent soil erosion and unsuitability of the soil to produce profitable crop. The study also stated indiscriminate use of fertilizers and pesticides, soil transportation, repeated application of chemical inputs beyond recommended level, use of heavy farm machineries, cultivation of exotics, loss of local natural vegetation, faulty land resettlement, loss of natural wind breaks, mono-cropping and loss of healthy soil biological process have contributed high damage to the natural soil ecosystem of the region [42].

6. Conclusion

The shola grasslands are tropical montane forests found in the high altitudes of Western Ghats separated by rolling grasslands. The shola-grassland ecosystem has undergone severe habitat loss mainly due to exotic tree plantations, widespread

commercial plantations, extensive monoculture, harvesting of shola species and cattle grazing. The ecosystem is likely to undergo extinctions in plant and animal species due to loss of habitat. Further, climate change is also expected to modify the equilibrium between the forest and grassland. Shola is a very sensitive type of vegetation. As it is sensitive to climate, once it vanishes from its original habitat, it is very difficult to make it reappear. Identifying the knowledge gap and application of current state of knowledge is necessary for responding to these issues. There is an urgent need to map the extent of loss of grasslands, exotic plantations and spread of invasive species in each forest division.

Conflict of interest

The authors declare no conflict of interest.

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