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Original Article

Comparative Assessment Of Overgrazing And Tourism-Related Land Degradation In The Western Himalaya

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ABSTRACT

Land degradation in the alpine and sub-alpine ecosystems of Western Himalaya is an important environmental issue having ecological and socio-economic repercussions. The current study highlights the comparative geospatial analysis of the degraded land due to two main anthropogenic causes – overgrazing by livestock and unregulated tourism – in two important ecosystems: Darma-Byans landscape (Pithoragarh district, Uttarakhand) and Gangotri-Govind landscape (Uttarkashi district, Uttarakhand). The degradation sites identified through field observations were plotted through GPS coordinates along with area calculation (m^2) in various villages in both ecosystems. In total, there were 15 sites of overgrazing degradation in Darma-Byans and 14 sites of overgrazing degradation in Gangotri-Govind landscapes; 7 sites of tourism-related degradation in Gangotri-Govind and 5 sites of tourism-related degradation in Darma-Byans landscapes; and 22 sites of forest degradation in Gangotri-Govind landscape. Analysis based on quantitative area depicts that overgrazing leads to the generation of dispersed degradation areas varying from 11,632 m^2 to 1,643,102 m^2, whereas tourism-related degradation is highly localized with individual areas exceeding 2.38 km^2.

Keywords: Land degradation, overgrazing, tourism impact, Western Himalaya, geospatial assessment, alpine ecosystems, Uttarakhand.

INTRODUCTION

The Himalayan mountain ecosystem that has been identified as a global hotspot for biodiversity 1 and serves as the headwaters for several rivers is increasingly experiencing pressure from human activities. Western Himalayas, covering the regions of Himachal Pradesh, Uttarakhand, and Jammu & Kashmir, contains diverse alpine meadows, coniferous forests, and riverine environments that sustain local populations and fauna ranging over long distances[3]. However, land use change resulting from customary livestock grazing and the expansion of ecological tourism has degraded the land over many years and poses threat to ecological stability and mountain communities[4].

Land degradation in mountain ecosystems includes loss of vegetation, soil compaction, erosion and biodiversity loss. Overgrazing – a common disturbance caused by excessive grazing on pastures beyond their capacity to sustain animals- is the most common form of disturbance in Himalayas. Altitide pastures called "bugyals" in local terms face the greatest challenge because they serve as summer pastures for migratory livestock from lower elevations, leading to serious trampling and depletion of herbaceous vegetation[5]. On the other hand, trekking, pilgrimage and adventure tourism has given rise to a unique form of anthropogenic disturbance associated with trail erosion, degradation of camping grounds and accumulation of solid waste[6].

Darma-Byans and Gangotri-Govind landscapes constitute some of the most ecologically diverse but vulnerable regions of Uttarakhand. The Darma-Byans landscape comprises the Darma and Byans valleys in the district of Pithoragarh, whereas the Gangotri-Govind landscape consists of the Gangotri National Park buffer zones and the Govind Pashu Vihar of the district of Uttarkashi. Both landscapes have been subject to high pressure due to overgrazing and tourism activities. However, little is known about the spatial patterns of these degradation phenomena, since systematic, spatially explicit comparative studies on degradation extents have not been carried

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out. This study aims to fill this gap by using geospatial mapping techniques in the field to identify, measure, and comparatively evaluate sites of degradation due to overgrazing and tourism.

This study seeks to (i) identify and quantify degradation sites due to overgrazing and tourism in the Darma-Byans and Gangotri-Govind landscapes; (ii) identify forest degradation hotspots in the Gangotri-Govind landscape; and (iii) comparatively evaluate the spatial patterns of degradation associated with each activity.

MATERIALS AND METHODS

Study Area

This study was carried out in two landscapes of Uttarakhand, India. The first landscape is that of Darma-Byans (30°05'-30°20'N, 80°25'-80°55'E), which is situated in the district of Pithoragarh and includes many high-altitude villages such as Sipu, Marcha, Tidang, Dugtu, and Garbyang. The Darma-Byans landscape falls in the upper catchment of the Kali (Mahakali) river in close proximity to Indo-Nepal border, comprising of alpine meadows, glacial landforms and transitional conifer-oak forests. On the other hand, the second landscape, that of Gangotri-Govind (30°55'-31°15'N, 78°05'-78°50'E), includes the Gangotri National Park buffer zone and Govind Pashu Vihar Wildlife Sanctuary of Uttarkashi district. The prominent villages of the landscape include Liwari, Osla, Sukki, Jaspur, Jhala, Harshil, Mukhawa, and Satta.

Data Collection

Field surveys were carried out for identification and delimitation of degraded land patches in both landscapes. Selection of field sites was based on prior reconnaissance and consultations with the locals and forest department officials. Geographic coordinates (latitude and longitude) of each site of land degradation were determined through handheld GPS device. The spatial extent of each land degradation patch was measured in the field and expressed in terms of its total area in square metres (m²).

Analysis

The extent of degraded areas was computed per each landscape and for each degradation type. The descriptive statistics such as total area, average size of the sites, minimum size of the sites, and maximum size of the sites were computed for comparative analysis. The extent of degradation was computed as the total area degraded by each driver per landscape.

RESULTS AND DISCUSSION

Degradation caused by Overgrazing in Darma-Byans Landscape

The 15 sites of overgrazing-induced degradation were mapped out of which five villages within the Darma-Byans Landscape were found to have been affected (Table 1). These villages include Sipu (3 sites), Marcha (3 sites), Tidang (4 sites), Dugtu (2 sites) and Garbyang (2 sites). In this landscape, there exists a widespread problem of degradation as a result of overgrazing. The extent of degradation caused by overgrazing in this landscape is estimated to be around 4.19 km² of area while the size of the individual site varies from 11,632 m² (Tidang Site 4) to 1,643,102 m² (Dugtu Site 1). The unusually high site of Dugtu can be attributed to the meeting point of various livestock herding trails in the nodal village of Dugtu. Garbyang Village with its relatively lower elevation close to the Kali river confluence also experiences a high degree of degradation (682,837 m² and 472,059 m²).

S.No.	Village	Site	Latitude / Longitude	Area (m²)
1	Sipu	Site 1	30°18'14.97"N, 80°29'37.66"E	515,113.82
		Site 2	30°18'11.77"N, 80°29'59.22"E	138,222.35

		Site 3	30°17'50.21"N, 80°29'47.37"E	137,298.99
2	Marcha	Site 1	30°17'43.27"N, 80°30'11.11"E	92,306.50
		Site 2	30°17'35.90"N, 80°30'30.04"E	192,459.65
		Site 3	30°17'47.29"N, 80°30'40.44"E	23,457.19
3	Tidang	Site 1	30°16'46.27"N, 80°32'10.06"E	51,387.10
		Site 2	30°16'28.99"N, 80°31'6.28"E	72,620.33
		Site 3	30°16'29.22"N, 80°31'27.52"E	17,000.54
		Site 4	30°16'5.29"N, 80°30'25.96"E	11,632.54
4	Dugtu	Site 1	30°13'27.03"N, 80°32'15.82"E	1,643,102.80
		Site 2	30°14'6.88"N, 80°30'51.51"E	158,730.89
5	Garbyang	Site 1	30°6'32.04"N, 80°49'55.11"E	682,837.15
		Site 2	30°7'35.87"N, 80°47'19.41"E	472,059.95

Table 1: Degradation Sites Due To Overgrazing In The Darma-Byans Landscape

Overgrazing-Related Degradation in Gangotri-Govind Landscape

Fifteen overgrazing sites have been observed in five villages from the Gangotri-Govind landscape –Liwari (4 sites), Osla (3 sites), Sukki (3 sites), Jaspur (2 sites) and Jhala (1 site) -having a total degraded area of 6.27 km² (Table 2). Liwari and Osla had the maximum degradation area. The Osla Site 2 (1,431,107 m²) is the largest overgrazing site in this landscape. This reflects the heavy load of pastoralism in the Har-ki-Dun valley, which is also used as a popular trekking destination. Similarly, there is significant overgrazing activity in Sukki having three sites with the total degraded area of 2.15 km².

S.No.	Village	Site	Latitude / Longitude	Area (m²)
1	Liwari	Site 1	31°12'1.90"N, 78°16'17.45"E	169,804.08

		Site 2	31°10'38.63"N, 78°17'13.94"E	676,164.41
		Site 3	31°10'14.76"N, 78°15'39.34"E	408,513.26
		Site 4	31°9'46.23"N, 78°16'20.85"E	123,540.39
2	Osla	Har ki Doon	31°8'34.57"N, 78°24'50.32"E	312,662.29
		Site 2	31°6'59.11"N, 78°24'15.48"E	1,431,107.92
		Site 3	31°8'5.58"N, 78°22'33.50"E	100,897.35
3	Sukki	Site 1	31°0'11.72"N, 78°41'28.00"E	1,028,885.04
		Site 2	30°59'13.66"N, 78°38'16.27"E	915,156.84
		Site 3	31°0'30.82"N, 78°39'10.23"E	210,210.13
4	Jaspur	Site 1	31°1'7.54"N, 78°41'51.85"E	104,825.27
		Site 2	31°0'55.30"N, 78°43'55.34"E	142,189.07
5	Jhala	Site 1	31°1'54.88"N, 78°42'1.14"E	177,652.69

Table 2: Degradation Sites Due To Overgrazing In The Gangotri-Govind Landscape

Forest Degradation in the Gangotri-Govind Landscape

There was another type of forest degradation that was unique only to the Gangotri-Govind landscape with 22 occurrences spread across eight villages (Table 3). The total degraded forest area within this landscape was around 6.27 km², while the largest patch of forest degradation was noted at Satta (1,116,384 m²). The village of Harshil located along the main Gangotri highway corridor had four instances of forest degradation covering an approximate total of 1.92 km². The occurrence of such a situation indicates that the development of infrastructure like roads makes it easier for forest degradation through illegal felling and tourism constructions among other causes. There was a large extent of forest degradation in Mukhawa and Satta villages, both being located along the pilgrimage routes.

Tourism-Related Degradation: Gangotri-Govind and Darma-Byans

Tourism degradation was observed in 7 sites from the Gangotri-Govind landscape and 5 sites from the Darma-Byans landscape (Table 4 and Table 5). In the case of Gangotri-Govind, the areas of individual sites varied from 37,549 m² to 2,384,224 m², which gives a cumulative area of tourism-affected land surpassing

5.32 km². The biggest affected area (Site 1, 2,384,224 m²) belongs to the camping and congregational site in the surroundings of the Gangotri temple. It comprises almost 45% of tourism-related degradation in the landscape due to the intensive influx of pilgrims.

In the Darma-Byans landscape, the cumulative tourism degradation area comprised almost 1.78 km², with an area of 37,549 m² to 682,837 m². It is obvious that the location of several sites close to Garbyang indicates the presence of pilgrimage-based tourism as well. Even though tourism degradation area in this landscape is smaller than the one caused by overgrazing, its distribution is much more compact, which means higher soil compaction and vegetation trampling.

Landscape	Degradation Driver	No. of Sites	Total Area (m²)	Mean Site Area (m²)	Max Site (m²)
Darma-Byans	Overgrazing	15	4,190,169	279,344	1,643,102
Gangotri-Govind	Overgrazing	14	6,276,608	448,329	1,431,107
Gangotri-Govind	Forest Degradation	22	6,268,618	284,937	1,116,384
Gangotri-Govind	Tourism	7	5,318,915	759,845	2,384,224
Darma-Byans	Tourism	5	1,776,847	355,369	682,837

Table 3: Summary -Degradation Area By Landscape And Driver

Comparative Synthesis

Patterns evident when comparing the total area affected by drivers in the two landscapes include:

Overgrazing continues to be the most geographically widespread driver, impacting many sites spread out through many different villages. The geographically widespread pattern results from the fact that the livestock moves around extensively over high-altitude pastures. On the other hand, tourism-related degradation although not many in site numbers is marked by higher mean site areas compared to overgrazing, especially in the Gangotri-Govind landscape. The geographically concentrated degradation although few in terms of sites is severe environmental impact since it occurs in environmentally sensitive areas like riparian buffer areas, meadows, and forest fringes near trails and camping grounds.

The occurrence of an extra forest degradation class specific to the Gangotri-Govind scenario reflects the higher cumulative anthropogenic stress in the region, whereby the development of tourism-related infrastructure like roads, bridges, and accommodation facilitates indirect deforestation. Studies from similar Himalayan regions have supported these findings, where Rawat & Adhikari7 found high levels of above ground biomass loss from bugyals of Uttarakhand due to overgrazing, and Negi et al8 noted soil erosion and compaction due to trekking in Uttarkashi. Together, the stress of overgrazing and tourism, particularly in the Gangotri-Govind scenario, causes the combined effect of anthropogenic degradation to amount to over 17.86 km² – well above that of the Darma-Byans scenario at 5.97 km².

CONCLUSION

This research paper is an organized and field data-based comparison of land degradation owing to overgrazing and tourism in two of the most prioritized landscapes in the Western Himalayas. The Darma-Byans and Gangotri-Govind landscapes have more than 61 degraded locations identified on maps, covering an area of more than 23 km². The main cause of spatially widespread land degradation is overgrazing, whereas tourism causes land degradation in particular spots or nodes where there is an intense flow of tourists and which are ecologically sensitive zones.

The conclusions above have significant implications for conservation and land management. In case of overgrazing affected zones, the mitigation measures need to be in form of seasonal pasture rotation regimes, assessment of the carrying capacity of each bugyal zone, and grazing management practices in the communities. The mitigation measures in case of tourist-affected areas would be in the form of regulating campsite densities, installing proper waste management structures, and creating buffer zones around sensitive habitats. Furthermore, the restoration of degraded zones through plantations of local species, terracing and soil bioengineering needs to be incorporated in the land management strategy.

Further research needs to consider a temporal dimension, involving multi-date remote sensing datasets (for example Sentinel-2 or Landsat) in order to estimate the rate of degradation expansion, as well as vegetation condition indices such as NDVI, EVI to analyze the state of degradation and non-degraded zones.

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