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INTEGRATING BIOLOGICAL RICHNESS AND ANTHROPOGENIC PRESSURE FOR CONSERVATION PRIORITIZATION IN TWO HIMALAYAN LANDSCAPES OF UTTARAKHAND

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Abstract: Landscape-based conservation priority classification should take into consideration not only ecological value but also human disturbance in an integrated manner. This paper overlays the existing Biological Richness (BR) and Disturbance Index (DI) classifications of Darma-Byans Valley and Gangotri-Govind landscapes of Uttarakhand to produce a village-level conservation-priority classification. Very High or High biological richness is found in 12.36% of the area of Darma-Byans Valley (1,770.58 sq.km) and 14.71% of Gangotri-Govind (4,702.94 sq.km), and High or Very High human disturbance occurs only in 2.35% and 1.23%, respectively, of the same landscapes, so that the two classifications do not overlap spatially in most parts of these landscapes. Overlaying of the two classifications at village level (67 villages in Darma-Byans Valley, 23 villages in Gangotri-Govind) shows that there are 12 villages, including Dongrula, Gunda Dangsu, Urthing, Harsil, Mukhba and Panwani, where High or Very High Biological Richness overlaps with High or Very High Disturbance, and such villages should be put in the category of Critical Monitoring/Pressure Reduction. There are 8 villages in Darma-Byans Valley where High or Very High Biological Richness overlaps with Low or Very Low Disturbance and such villages should be put in the category of Conservation and Monitoring Priority.

Index Terms - Biological Richness; conservation prioritization; Darma-Byans Valley; Disturbance Index; Gangotri-Govind; Himalayan landscapes; landscape ecology; spatial overlay; Uttarakhand; village-level assessment.

1. INTRODUCTION

The landscape-based approach to conservation, in contrast to a pure species-based approach to conservation, needs to identify those landscapes in which the overlap of ecological value and human pressure takes place, for these are the places where action is required most desperately, and those landscapes of high ecological value and little pressure, where the need is more of protective surveillance than any sort of interventionist approach. The field biodiversity studies of landscapes yield both halves of this equation: a layer of biological richness or biological value, and a layer of disturbance or pressure. And yet these two layers are usually reported as separate findings, rather than being combined in an overall priority map.

In the cases of the Darma-Byans Valley and Gangotri-Govind landscapes in the state of Uttarakhand, a Biological Richness layer (a combination of the ecosystem uniqueness, species richness, biological value, landscape complexity and disturbance index) and a separate Disturbance Index layer were produced from field studies and remote sensing data and tabulated at the village level. In this paper, the two have been combined into a single classification for conservation priorities at the village level where data for both classifications is available. Since Disturbance Index is one of the five factors that make up Biological Richness, the two partially overlap; the map presented here is therefore a cross-tabulation of two interrelated spatial classifications, not two completely independent factors.

1.1 Objectives

1. To describe the spatial distribution of biological richness based on the current classification system. 2. To describe the spatial distribution of human-induced disturbances. 3. To study the intersection of biological richness and human disturbance at the village level. 4. To classify villages of both landscapes into conservation priority based on village wise Biological Richness and Disturbance Index tables.

2. STUDY AREA

The two landscapes selected for comparison in this study include Darma-Byans valley (1,770.58 sq.km, Pithoragarh district, Kumaun) and Gangotri-Govind (4,702.94 sq.km, Uttarkashi district, Garhwal), which are two high altitude landscapes located in Uttarakhand. These landscapes have broadly similar biophysical characteristics, including glaciated headwaters, sub-alpine and alpine vegetation, and coniferous/deciduous forests at lower altitudes. However, the two landscapes vary widely in terms of their governance. The Gangotri-Govind landscape includes Gangotri National Park (1,553 sq.km) and Govind Wildlife Sanctuary, along with their eco-sensitive zones. The other landscape (Darma-Byans valley) does not have any such designation currently, which is significant for this study.

3. MATERIALS AND METHODS

3.1 Existing layers used

Biological Richness was calculated through the process of integration, by means of typical GIS overlay procedures, based on the five-class values of Ecosystem Uniqueness, Species Richness, Biological Value, Terrain Complexity, and Disturbance Index for both landscapes (classes Very Low to Very High). The Disturbance Index was classified into five classes, and the same villages were used for tabulation. Village table values are presented as class names (not scores) because it is the scale of the overlay procedure.

3.2 Village-level overlay procedure

For each village found on both the Biological Richness and Disturbance Index tables of villages, two classes (Very Low = 1 and Very High = 5) were used to classify villages into conservation priorities based on the following classification scheme: villages with High/Very High BR and Low/Very Low DI were classified under Conservation and Monitoring Priority; villages with High/Very High BR and High/Very High DI were classified under Critical Monitoring / Pressure Reduction; Medium BR with High/Very High DI were classified under Pressure Management / Restoration; Low/Very Low BR with High/Very High DI were classified under Restoration / Land-use Management; Low/Very Low BR with Low/Very Low DI were classified under Long-term Monitoring (Low Priority); all other combinations were classified under Moderate Monitoring (Table 3). There is no validation data available for this classification system and hence should be interpreted as a preliminary screening tool.

4. RESULTS

4.1 Biological Richness distribution

Very High Biological Richness occurs within an area of 114.84 sq.km (6.49%) of Darma-Byans Valley and 515.32 sq.km (10.96%) of Gangotri-Govind; the total coverage by the High category in addition to Very High Biological Richness amounts to 12.36% of Darma-Byans Valley and 14.71% of Gangotri-Govind. The area of the Low Biological Richness category is noticeably smaller in Gangotri-Govind (0.42%) as compared to that in Darma-Byans Valley (7.27%), which indicates the higher biological richness of vegetation in that landscape. Medium Biological Richness covers 7.45% of Darma-Byans Valley and 2.38% of Gangotri-Govind (Table 1, Fig. 1).

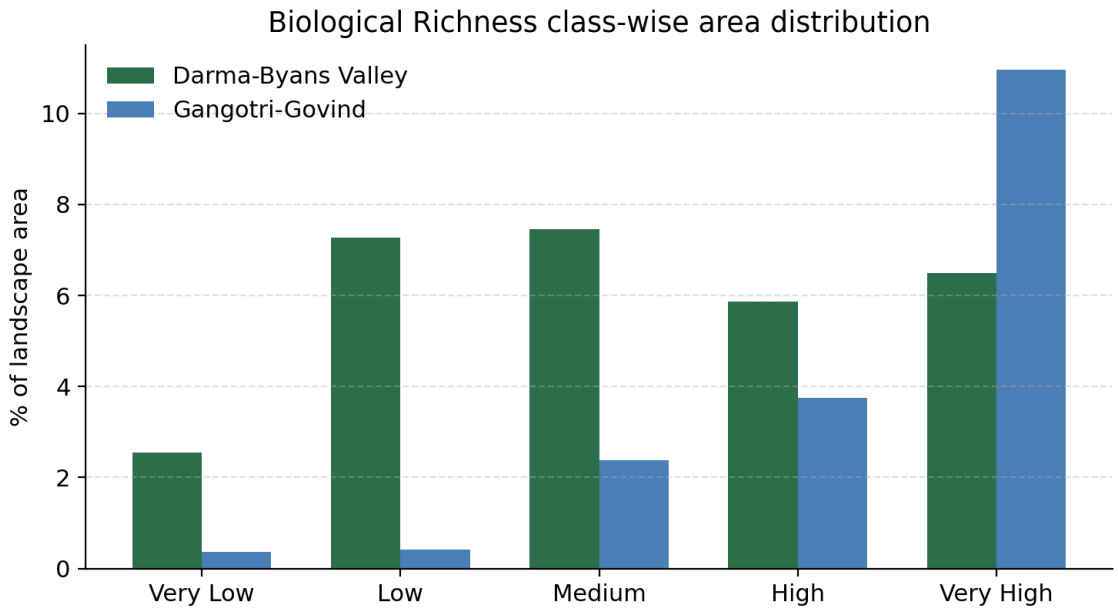

Figure 1. Biological Richness class-wise area distribution as a percentage of each landscape.

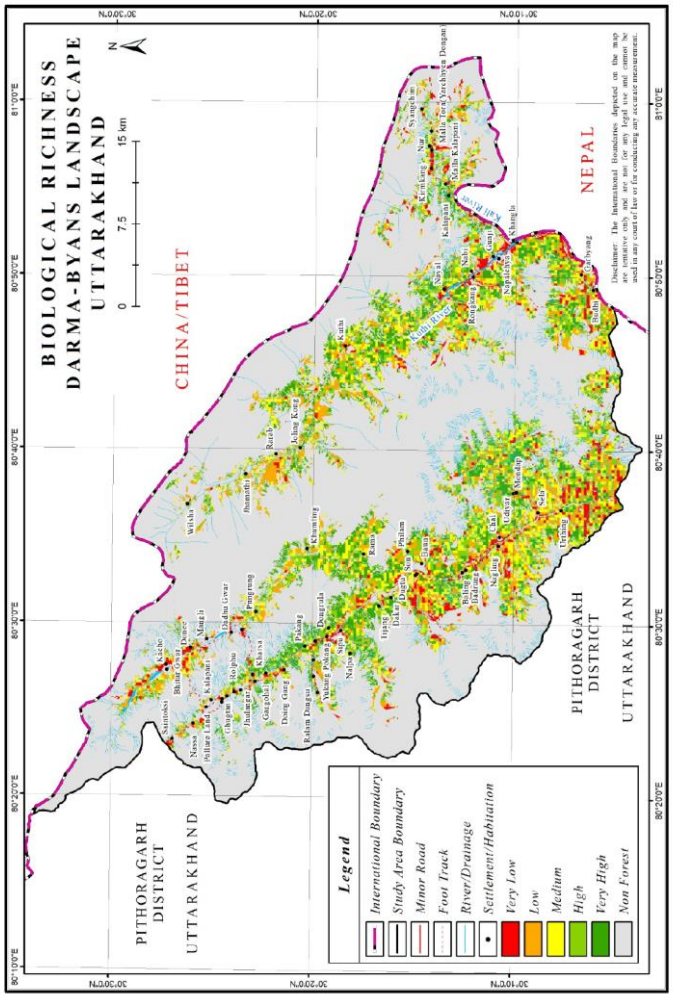

Figure 2a. Biological Richness map of Darma-Byans Valley landscape.

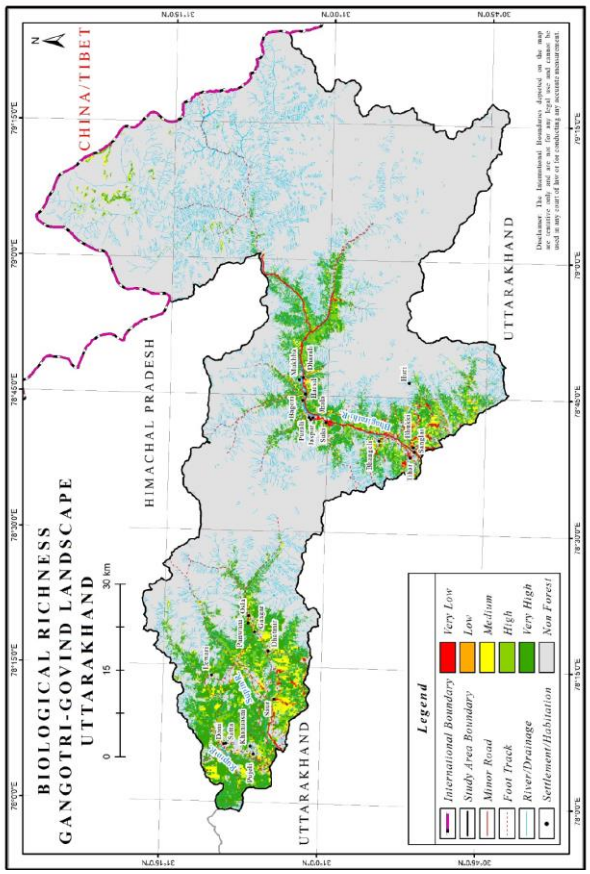

Figure 2b. Biological Richness map of Gangotri-Govind landscape.

Table 1. Biological Richness classes and spatial extent in the two landscapes.

BR Class	Darma-Byans (sq.km)	Darma-Byans (%)	Gangotri-Govind (sq.km)	Gangotri-Govind (%)
Very Low	45.03	2.54	16.86	0.36
Low	128.75	7.27	19.78	0.42
Medium	131.90	7.45	111.99	2.38
High	103.99	5.87	176.48	3.75
Very High	114.84	6.49	515.32	10.96

4.2 Disturbance distribution

High or Very High Disturbance Index covers a small share of both landscapes: 2.35% of Darma-Byans Valley (41.61 sq.km) and 1.23% of Gangotri-Govind (58.13 sq.km). This is important context for the overlay below: because acutely disturbed area is a small fraction of either landscape, the number of villages where High/Very High Biological Richness coincides with High/Very High Disturbance is necessarily limited, and most villages combine moderate-to-high richness with low-to-moderate disturbance (Table 2).

Table 2. Disturbance Index classes and spatial extent in the two landscapes.

DI Class	Darma-Byans (sq.km)	Darma-Byans (%)	Gangotri-Govind (sq.km)	Gangotri-Govind (%)
Very Low	170.22	9.61	123.06	2.62
Low	184.70	10.43	457.19	9.72
Medium	127.96	7.23	202.06	4.30
High	30.16	1.70	44.42	0.94
Very High	11.45	0.65	13.71	0.29

4.3 Overlap between Biological Richness and Disturbance: village-level priority classification

Using the overlay method on all the villages in the two landscapes—Darma-Byans Valley having 67 villages and Gangotri-Govind having 23 villages—leads to the following distribution (Figs. 3–4). Out of the 67 villages in the Darma-Byans Valley, 8 villages—namely, Jhamathi, Joling Kong, Khumling, Nalpa, Ralam Dangsu, Rarab, Talla Tora and Tijang—have High or Very High Biological Richness with Low or Very Low Disturbance and therefore belong to the Conservation and Monitoring Priority category, while 7 villages, namely Dongrula, Gunda Dangsu, Kalapani (near Kuti), Kharsa, Pakang, Urthing and Yukang Pokang have High or Very High Biological Richness with High or Very High Disturbance and thus belong to the Critical Monitoring / Pressure Reduction category. Of the 23 villages in the Gangotri-Govind landscape, 5 villages—namely Gangar, Harsil, Mukhba, Panwani and Sanglai—are categorized under Critical Monitoring; none of the villages from this landscape has High or Very High richness with Low or Very Low disturbance (Tables 4–5, Figs. 3–4).

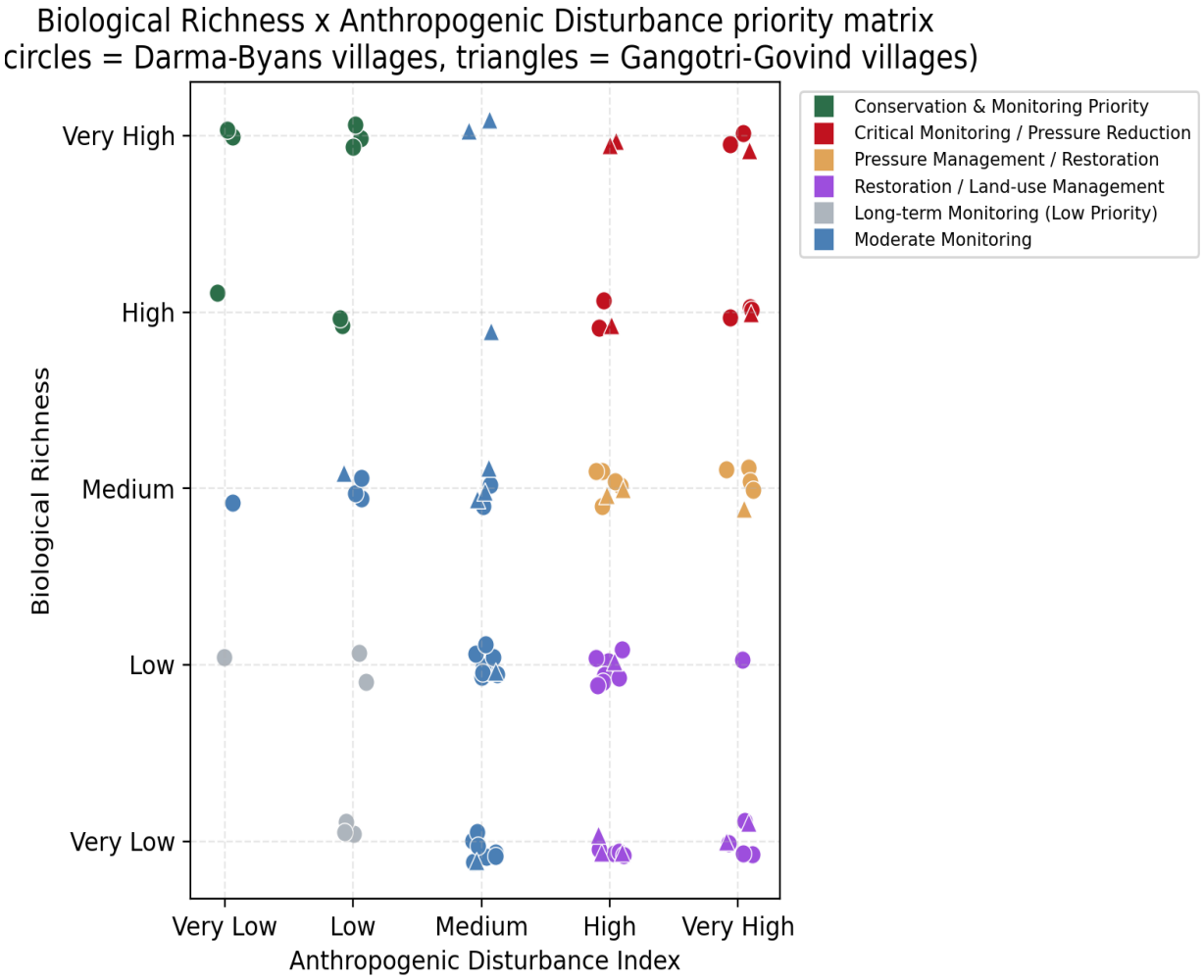

Figure 3. Biological Richness × Disturbance Index priority matrix for all villages with both classifications tabulated (67 in Darma-Byans Valley, 23 in Gangotri-Govind).

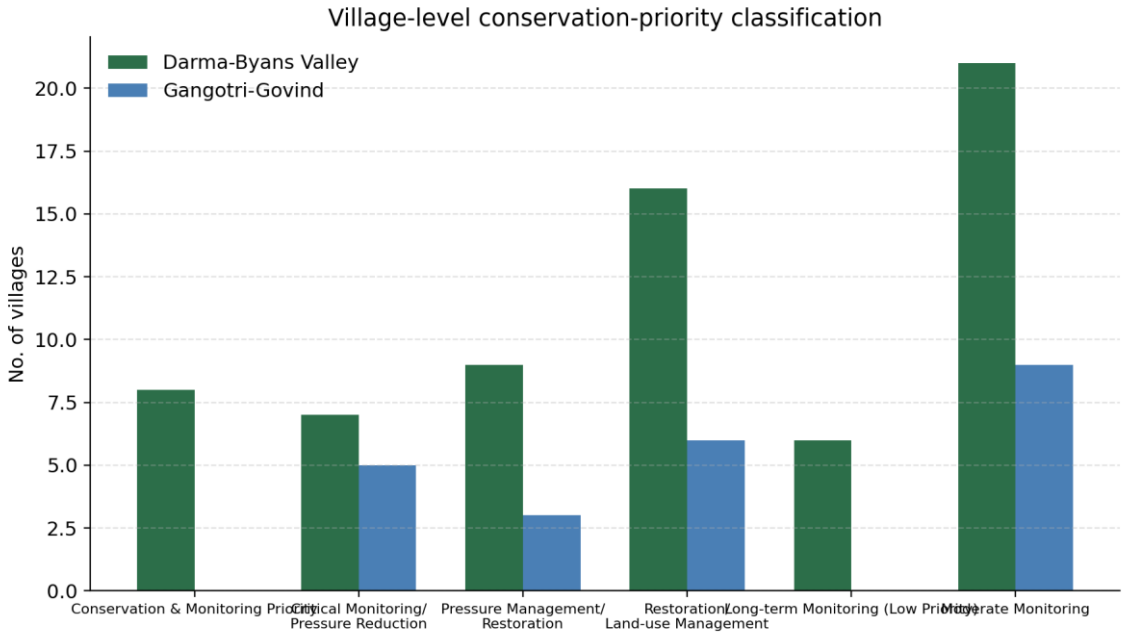

Figure 4. Village-level conservation-priority classification counts by landscape, derived by overlaying village-wise Biological Richness and Disturbance Index tables.

Table 3. Conservation-priority classification framework applied in this study.

Biological Richness	Anthropogenic Pressure	Priority Category	Management Emphasis
High / Very High	Low / Very Low	Conservation and Monitoring Priority	Conservation and monitoring
High / Very High	High / Very High	Critical Monitoring / Pressure Reduction	Critical monitoring; pressure reduction
Medium	High / Very High	Pressure Management / Restoration	Pressure management; restoration
Low / Very Low	High / Very High	Restoration / Land-use Management	Restoration; land-use management
Low / Very Low	Low / Very Low	Long-term Monitoring (Low Priority)	Long-term monitoring
All other	combinations	Moderate Monitoring	Moderate monitoring

Table 4. Villages classified as Critical Monitoring / Pressure Reduction (High/Very High Biological Richness with High/Very High Disturbance).

Village	Landscape	Biological Richness	Disturbance Index
Dongrula	Darma-Byans Valley	High	Very High
Gunda Dangsu	Darma-Byans Valley	Very High	Very High
Kalapani (near Kuti)	Darma-Byans Valley	High	Very High
Kharsa	Darma-Byans Valley	High	High
Pakang	Darma-Byans Valley	High	Very High
Urthing	Darma-Byans Valley	Very High	Very High
Yukang Pokang	Darma-Byans Valley	High	High
Gangar	Gangotri-Govind	High	High
Harsil	Gangotri-Govind	Very High	Very High
Mukhba	Gangotri-Govind	Very High	High
Panwani	Gangotri-Govind	Very High	High
Sanglai	Gangotri-Govind	High	Very High

Table 5. Villages classified as Conservation and Monitoring Priority (High/Very High Biological Richness with Low/Very Low Disturbance).

Village	Landscape	Biological Richness	Disturbance Index
Jhamathi	Darma-Byans Valley	Very High	Low
Joling Kong	Darma-Byans Valley	Very High	Low
Khumling	Darma-Byans Valley	High	Low
Nalpa	Darma-Byans Valley	High	Very Low
Ralam Dangsu	Darma-Byans Valley	Very High	Low
Rarab	Darma-Byans Valley	High	Low
Talla Tora	Darma-Byans Valley	Very High	Very Low
Tijang	Darma-Byans Valley	Very High	Very Low

5. DISCUSSION

In terms of the village-level overlay, both the landscapes contrast not only in the amount of High Biological Richness, which is higher in Gangotri-Govind at 14.71% compared to 12.36%, but in the exposure to which these rich ecosystems are subjected. At that, while in Darma-Byans Valley the same number of villages belongs to Critical Monitoring (7) and Conservation Priority (8) categories, it means that high-richness ecosystems in this landscape are equally divided between the ones that currently face pressures and those which have not been disturbed yet. This situation is explained by the double role played by Darma-Byans Valley as the pilgrimage and trade corridor and a landscape without any Protected Areas.

As regards the Critical Monitoring and Conservation Priority designations for villages in the Gangotri-Govind landscape, all of the five high richness and high pressure villages are in the Critical Monitoring category with none of them falling in the Conservation Priority category from among the listed ones. This implies that while high richness areas in Gangotri-Govind may suffer from disturbance, the latter is confined to some specific villages (Harsil, Mukhba, Panwani, Gangar, Sanglai) and not distributed among other high richness villages of the landscape. The presence of a Protected Area system in most part of the Gangotri-Govind landscape is also in line with this finding.

Since Disturbance Index itself is among the five parameters used to compute Biological Richness in the GIS-based methodology, the two layers are not entirely independent of each other. The overlay is thus a cross-tabulation of the two spatial classifications, and the villages that appear in both the list of Critical Monitoring in this case and that of high land use intensity from the disturbance study (Harsil, Mukhba, Panwani) validate each other within these two independent lists.

6. MANAGEMENT IMPLICATIONS

The 12 villages in Table 4 constitute a sensible choice of first tier for intervention, as the association between high ecological value and high disturbance levels suggests that any biodiversity benefit would be most immediately threatened by ongoing disturbance, and most immediately safeguarded by reducing it. Possible measures include regulated grazing and MAP harvesting schedules, tourism carrying capacity evaluation for gateway villages (especially Harsil, Mukhba and Panwani in Gangotri-Govind), and road development assessment for the Darma-Byans Valley villages experiencing Very High disturbance (Dongrula, Gunda Dangsu, Urthing).

In the case of the 8 villages from Table 5, an approach relying more on monitoring would be more appropriate - re-evaluation at certain intervals to make sure that disturbance does not rise above its current levels - because the high richness-low disturbance levels combination they exhibit is exactly the one that the broader landscape management strategy should seek to replicate elsewhere in the landscape. The fact that the Darma-Byans Valley at the moment does not have any Protected Area designation, despite the presence of both types of village categories in equal proportions, provides a concrete, village-level foundation for any future management regime for this landscape.

7. CONCLUSION

Combining biological richness and disturbance index layers from existing datasets for each of the villages in the Darma-Byans Valley and Gangotri-Govind landscapes of Uttarakhand yields an easily implemented conservation prioritization system for the regions without any additional survey or spatial analysis being performed. Twelve villages in total within the two landscapes fall into the category of possessing high ecological value and high pressure, requiring urgent action to be taken in order to monitor and reduce the pressures. Another eight villages in total in the Darma-Byans Valley alone have been identified as possessing high ecological value but little pressure, thus necessitating protective monitoring of those areas.

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