

Biodiversity Assessment of Delo Hills, Kalimpong: Evaluating Floristic Diversity amidst Growing Tourism

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ABSTRACT

Kalimpong, a town located in the eastern Himalayas, is renowned for being part of an ecological hotspot, one of three in the entire region of India. Situated between two hills, Darpin and Delo, Kalimpong rests on a ridge and offers breathtaking views of its surrounding areas, including the Teesta river and its valleys. The Delo hills, situated to the northeast of the town, are home to three water reservoirs, two of which serve as the primary source of drinking water for Kalimpong. At an altitude of 1300 metres (about 4200 feet), Delo ark experiences a mild and temperate climate, with maximum summer temperatures reaching 27 degrees Celsius and minimum temperatures dropping to 16 degrees Celsius. (34,35) To gain a comprehensive understanding of the current state of forest biodiversity its conservation, it is crucial to conduct a thorough and diverse analysis. However, there are challenges when it comes to sampling methods, methodologies, sample size, and field measurements that hinder the comparison and compilation of findings. In this paper, we explore the advantages and disadvantages of various sampling techniques used in floristic inventory and diversity analysis. The results suggest a meaningful relationship between Tourism and Floral species Diversity in Delo Hill, Kalimpong,

KEYWORDS: Ecological hotspot, Biodiversity, Conservation, Measurements.

1. INTRODUCTION

The floristic diversity survey of Delo hill, northeast of Kalimpong, West Bengal, aims to explore and document the region's rich diversity of plant species. The survey uses rigorous field surveys and analysis to identify and catalogue the diverse flora, considering features such as species composition, distribution patterns, and ecological roles. The findings are expected to provide valuable insights into the area's unique botanical landscape, aiding in conservation efforts and broadening our knowledge of the area's ecosystems. This book is important for the scientific investigation and sustainable management of the region's fauna, laying the foundation for informed environmental stewardship and conservation efforts. The findings have a major effect on biodiversity protection, ecosystem management, and scientific knowledge, providing valuable insights into the intricate relationships among plant species in the investigated area. Biodiversity refers to the

sequences, species, and ecosystems in a particular area, which are vital to human survival, economic prosperity, and the sustainability of the ecosystem. Estimates indicate that there could be between 13 and 14 million animal and plant species on Earth, with around 25% of all species having died. This study seeks to identify and document the various plant species, giving insight into the region's ecological diversity and conservation needs. (1) [Jayakumar. S. Et all (2011) para 1,2] , (2) .

2. Objectives of the Study:

1. To understand relationship between **Richness** (number of species) and **Evenness** (how equal the populations are).
2. To analysis Floral Richness and Diversity of Delo Hill, Kalimpong.
3. To Understand causes of loss of Bio- Diversity of Delo- Hill, Kalimpong.

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4. To identify of the current state of forest biodiversity its conservation of Deloh Hill, kalimpong
5. To examines to tourism and Bio- Diversity in Delo Hill, Kalimpong.

3. Methodology:

3.1. Quadrat Method: A quadrat is a rectangular area used for ecological or population research, used to accurately estimate population due to challenges like movement, growth, and mortality. It is a small, defined portion of the area, demarcated manually or through aerial photography. Quadrats can be any shape, as long as all marked quadrat are the same size. For large areas, multiple quadrats of equal size are demarcated within the region to estimate the population (11,23).

Density gives an idea of competition and its dominants calculated as follows -

Frequency is the number of sampling unit in which a particular species occurs the frequency of each species is expressed in percentage and it is calculated as follows.

$$\text{percentage of frequency} = \frac{\text{Number of samples unite in which occurred} \times 100}{\text{total number of sample unit employed the study}}$$

3.2. SHANNON WIENER INDEX:

The Shannon-Wiener Index, also known as the Shannon-Weaver Index or Shannon's Diversity Index, is a measure of biodiversity and species richness within a given ecological community. It takes into account both the number of species present (species richness) and their relative abundance. (12, 16) [Nolan .et. al.(2006) para1].

The formula for calculating the Shannon-Wiener Index (H) is:

$$H' = -\sum_{i=1}^s P_i \cdot \ln p_i$$

Where:

- Σ : A Greek symbol that means "sum"
- H : the Shannon diversity index
- S: The total number of species
- P_i : The proportion of species in population
- Ln: Natural log (12, 16)[Nolan .et. al. (2006) Para 1].

3.3. SIMPSON INDEX:

The Simpson Diversity Index, often simply referred to as the Simpson Index, is a measure of biodiversity that quantifies the probability that two individuals randomly selected from a sample will belong to the same species. It takes into account both the number of species present and their relative abundances. (13,15)(Demonz, G. para 8,9)

- The formula for calculating the Simpson Index (D) is:

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

Where:

- N: Total number of species, D: Diversity Index, n: Number of species (13,15)(Demonz, G. Para 8,9)

- Result: $D = \frac{N(N-1)}{\sum n(n-1)}$

- $D = 2.110$ [where, $N = 655$, $n = 12, 444, 29, 44, 47, 3, 8, 6, 6, 1, 9, 32, 10, 1, 1, 1, 1$]

Formula -

Density =total numbers of individuals of all the species in all the sampling/total number of sample unit study.

Density refers to the abundance of a specific species within a community, measured per unit area. This is determined by counting the number of individuals of the species in a given area. The result is often expressed as the number of individuals per unit area. Dividing the measured area by the number of individuals provides the average area occupied by each individual(11).

Frequency focuses on the uniformity of the occurrence of individuals of a species in a plant community. It is measured by observing the presence of a species in random sample areas distributed as widely as possible throughout the study area. Frequency represents the number of sampling units in which a particular species occurs. (11)

4. Data Analysis:

Observation Table:1

Plant species name	Plant family name	Total number of individuals plant species	Total number of quadrat study (Q)	Density (D) [S/Q]	Number of quadrates which species in present (N) [N = species present in quadrat/ Q]
<i>Mentha arvensis</i>	Lamiaceae	12	10	1.2	60%
<i>Herminium monorchis</i>	Orchidaceae	444	10	44.4	70%
<i>Oberonia sp.</i>	Orchidaceae	29	10	2.9	50%
<i>Orchis militaris</i>	Orchidaceae	44	10	4.4	60%
<i>Liparis loeselii</i>	Orchidaceae	47	10	4.7	70%
<i>Quercus lamellosa</i>	Fagaceae	3	10	0.3	20%
<i>Cephaelis ipecacuanha</i>	Rubiaceae	8	10	0.8	60%
<i>Alcimandra cathcartii</i>	Magnoliaceae	6	10	0.6	20%
<i>Dioscorea balcanica</i>	Dioscoreaceae	6	10	0.6	30%
<i>Lyonia ovalifolia</i>	Ericaceae	1	10	0.1	10%
<i>Cinchona sp.</i>	Rubiaceae	9	10	0.9	50%
<i>Abutilon indicum</i>	Malvaceae	32	10	3.2	60%
<i>Mussaenda treutferi</i>	Rubiaceae	10	10	1	40%
<i>Alnus nepalensis</i>	Betulaceae	1	10	0.1	10%
<i>Acer palmatum</i>	Sapindaceae	1	10	0.1	10%
<i>Castanopsis sieboldii</i>	Fagaceae	1	10	0.1	10%
<i>Betula alnoides</i>	Betulaceae	1	10	0.1	10%
		$\Sigma=655$			

Source: Field Survey (03.04.23).

Observation Table: 2

Plant species name	Plant family name	Total number of individuals plant species (A)	$P_i \left(\frac{A}{\Sigma} \right)$	Log p_i	$P_i * \log p_i$
<i>Mentha arvensis</i>	Lamiaceae	12	0.018	-4.017	-0.072
<i>Herminium monorchis</i>	Orchidaceae	444	0.677	-0.390	-0.264
<i>Oberonia sp.</i>	Orchidaceae	29	0.044	-3.123	-0.137
<i>Orchis militaris</i>	Orchidaceae	44	0.067	-2.703	-0.181
<i>Liparis loeselii</i>	Orchidaceae	47	0.071	-2.645	-0.187
<i>Quercus lamellosa</i>	Fagaceae	3	0.004	-5.521	-0.022
<i>Cephaelis ipecacuanha</i>	Rubiaceae	8	0.012	-4.422	-0.053
<i>Alcimandra cathcartii</i>	Magnoliaceae	6	0.009	-4.710	-0.042
<i>Dioscorea balcanica</i>	Dioscoreaceae	6	0.009	-4.710	-0.043
<i>Lyonia ovalifolia</i>	Ericaceae	1	0.001	-6.907	-0.006
<i>Cinchona sp.</i>	Rubiaceae	9	0.013	-4.342	-0.056
<i>Abutilon indicum</i>	Malvaceae	32	0.048	-3.036	-0.145
<i>Mussaenda treutferi</i>	Rubiaceae	10	0.015	-4.199	-0.062
<i>Alnus nepalensis</i>	Betulaceae	1	0.001	-6.907	-0.006
<i>Acer palmatum</i>	Sapindaceae	1	0.001	-6.907	-0.006
<i>Castanopsis sieboldii</i>	Fagaceae	1	0.001	-6.907	-0.006
<i>Betula alnoides</i>	Betulaceae	1	0.001	-6.907	-0.006
		$\Sigma=655$			$\Sigma P_i * \ln p_i = -1.293$

Source: Field Survey (03.04.23).

The study utilized **quadrat sampling** (10 samples) to assess 17 different plant species. Key biodiversity metrics used include:

- **Dominant Species:** *Herminium monorchis* (Orchidaceae) is the most abundant, with 444 individuals and a density of 44.4 per unit area.

- **Shannon-Wiener Index** : Calculated at **1.293** (referenced in your text as roughly 1.075).
- **Simpson Index** : Calculated at **2.537**.

4.1. Biodiversity Status

The results indicate **high floral richness**. In ecological terms, a Shannon-Wiener value above 1 in a localized study and a Simpson Index between 1.5 and 3.5 suggest a healthy, diverse ecosystem.

The report identifies **dark brown soil** at Delo Park, indicating high organic carbon content. This fertile soil supports a complex web of life, including several species of the **Orchidaceae** (orchid) family and **Rubiaceae** family, which are characteristic of the Eastern Himalayan foothills.

4.2. Ecosystem Services

The high biodiversity at Delo Hill performs critical "invisible" work:

- **Soil Stability:** Root systems prevent soil erosion and landslides—major risks in the Kalimpong terrain.
- **Hydrological Balance:** Maintaining groundwater levels and preventing rapid runoff.
- **Climate Regulation:** Supporting nutrient cycles that keep the local air and water clean.

The "Dominance" Factor

These data shows a high density for *Herminium monorchis* (\$44.4\$) compared to several species with a density of only \$0.1\$ (like *Acer palmatum*).

- **Shannon-Wiener Index** : This score is influenced heavily by the fact that you have 17 species. Even though one species is very dominant, the presence of many "rare" species keeps the diversity score healthy.
- **Simpson Index** : This specifically reflects that if you picked two plants at random in Delo Park, there is a high probability they would be different species. This "diversity buffer" protects the park from total collapse if a single disease were to strike one plant family.

Through the source we used a random spot to collect data. The size of first quadrat area is 1 metre × 1 metre and the highest quadrat area is 10 metre × 10 metres. There is 17 kinds of species in plant community... In plant community the dominant plant species is *Herminium monorchis* which is 444. We are calculating Delo Park in Kalimpong floral richness and biodiversity followed by Shannon Winner index and Simpson index formula. According to Shannon winner index if floral richness is '0-1', it's means that floral richness of this biodiversity is high. (30,31) On the other hand Simpson index if the

floral biodiversity is '1.5 -3.5' so it's means floral biodiversity is high.(32,33)

The Shannon winner index and Simpsons index results is 1.075 and 2.537. According to the result we conclude that there floral richness and biodiversity is high. During the assessment we were found that the soil of the Delo Park is dark brown which indicates high level of organic carbon in that soil, it is one of the reason of presence of high floral richness.

The death of an ecosystem occurs when biodiversity is lost. This loss occurs when green plants, which extract water and minerals from the soil through their roots, are no longer present. As a result, soil quality deteriorates, leading to environmental issues such as earthquakes, soil erosion, and landslides. Additionally, air and water quality also degrade, causing pollution.

Furthermore, the depletion of the groundwater level occurs. When biodiversity is lost, ecosystem processes such as energy flow, food chains, and food webs are disrupted, leading to changes in climate and environmental damage. By maintaining high biodiversity, the soil's nutrient and organic matter levels are increased, promoting the conversion of soil into a healthy state. Soil fertility is crucial for crop production and preventing soil erosion, while also helping to maintain nutrient and biological cycles.

5. Relationship to Tourism in Delo Hill, Kalimpong.

This ecological data is directly linked to the **Tourism Industry** in Kalimpong in several ways:

5.1. Ecotourism and "The Orchid Circuit":

Delo Park is a primary tourist attraction. Your data shows a high prevalence of orchids (*Herminium monorchis*, *Orchis militaris*, *Liparis loeselii*). High biodiversity makes Delo Hill a destination for **nature photographers, botanists, and birdwatchers** (as high plant diversity usually supports high bird diversity).

5.2. Tourism Work:

Tourism thrives on the "greenery" of Delo Park. However, the data shows several species (like *Lyonia ovalifolia* or *Acer palmatum*) have very low density (0.1). Tourism management must ensure that foot traffic and park development do not trample these rare species. If biodiversity is lost, the "aesthetic appeal" that draws tourists to Delo Hill will vanish.

5.3. Disaster Prevention for Infrastructure:

losing biodiversity leads to **landslides and soil erosion**, Tourism in Kalimpong depends on road connectivity and safe viewpoints. High biodiversity acts as **natural infrastructure protection**. Without the root systems of the 17+ species have been identified, the roads leading to Delo Hill would be more prone to collapse during monsoon seasons, crippling the local tourism economy.

5.4. Soil-Plant Feedback Loop:

The **dark brown soil** have been observed is a "Carbon Sink." Decomposition that is the high variety of plants (Lamiaceae, Orchidaceae, etc.) drops diverse leaf litter. Microbial Wealth This litter breaks down into organic carbon, giving the soil its dark color. High organic matter acts like a sponge, which is why Delo Hill stays lush even when rainfall is inconsistent.

5.5. Disaster Risk Management (DRM):

In the Himalayas, tourism is often disrupted by **landslides**. The species have been identified, particularly the trees like *Alnus nepalensis* and *Quercus lamellosa*, have deep "anchor" roots and These plants act as natural engineering. They stabilize the slopes upon which the hotels, roads, and paragliding take-off points at Delo Hill are built. Losing this biodiversity would require millions of rupees in artificial concrete retaining walls.

5.6. Orchid Tourism: A Niche Market:

Kalimpong is globally famous for orchids. The survey found four different orchid-related species (*Herminium*, *Oberonia*, *Orchis*, *Liparis*). This suggests Delo Park could be marketed as a **Botanical Heritage Site**. Promoting "Orchid Trails" during peak blooming seasons can bring in high-spending niche tourists (botanists and nature trekkers), diversifying the local economy beyond general sightseeing.

5.7. Warning of Dead Ecosystem:

The report mentions that losing plants leads to earthquakes and pollution. While plants don't prevent earthquakes (which are tectonic), they drastically reduce the damage caused by them. In a healthy ecosystem (High Simpson Index) indicate the soil is held tight. During a tremor, the land is less likely to slide. In a dead ecosystem or the "loose" soil has no structure. A small tremor or heavy rain leads to catastrophic landslides that can destroy tourist infrastructure instantly.

Conclusion:

➤ High Species Richness, Stable food webs and nutrient cycles means high aesthetics value, attracts Birdwatchers and Photographers.

- Dark Brown soil, high carbon storage and fertility maintain the Green look of the park Year round.
- Orchid Diversity is potential for high value Botanical Tour.

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