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Study of Water Quality and Ecological Status of Serpar Pond of Deori Tehsil of Gondia District (M.S.), India

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Abstract: ***The present study evaluates the seasonal variation in physico-chemical characteristics and ecological status of Serpar Pond located in Deori Tehsil of Gondia district in the Vidarbha region of Maharashtra, India. Monthly sampling was conducted over a one-year period (January–December 2025) to analyze twelve key water quality parameters, including temperature, pH, turbidity, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total hardness, alkalinity, nitrate, and phosphate using standard methods. The results revealed distinct seasonal patterns influenced by climatic conditions. Water temperature ranged from 22°C to 35°C, with highest values during summer, while dissolved oxygen exhibited an inverse trend (5.8–8.3 mg/L), indicating temperature-dependent oxygen solubility. The pH remained slightly alkaline (7.2–8.0), suggesting stable buffering conditions favourable for aquatic life. Turbidity showed pronounced increase during monsoon (up to 52 NTU), reflecting runoff-induced sediment influx. Electrical conductivity (305–380 µS/cm) and TDS (205–255 mg/L) demonstrated moderate mineralization, particularly during summer due to evaporation effects. BOD (2.0–4.1 mg/L) and COD (11–24 mg/L) values indicated moderate organic load within permissible limits. Nutrient concentrations, particularly nitrate (0.80–1.50 mg/L) and phosphate (0.10–0.35 mg/L), increased during monsoon, suggesting agricultural runoff influence. Correlation analysis revealed strong positive relationships among EC, TDS, BOD, COD, hardness, and alkalinity, while dissolved oxygen showed strong negative correlation with temperature and organic load parameters. Principal Component Analysis (PCA) identified three major gradients: mineralization (summer), nutrient enrichment (monsoon), and oxygen-rich conditions (winter). Overall, the pond exhibited moderate productivity with slight eutrophic tendencies during monsoon. The water quality parameters were within acceptable limits, indicating suitability for fisheries and irrigation. However, continuous nutrient input may pose long-term ecological risks, necessitating regular monitoring and sustainable management practices.***

Keywords: Freshwater pond; Limnology; Physico-chemical parameters; Seasonal variation; Serpar Pond; Vidarbha; Water quality

1. Introduction

Freshwater ecosystems are among the most dynamic and productive natural systems on Earth, supporting a wide array of biological diversity and providing essential ecosystem services to human populations. Ponds, lakes, reservoirs, and wetlands serve as habitats for various aquatic organisms, including phytoplankton, zooplankton, fishes, amphibians, and macrophytes. These ecosystems play a crucial role in maintaining ecological balance, nutrient cycling, groundwater recharge, and climate regulation. In addition to their ecological significance, freshwater bodies are indispensable for human activities such as agriculture, aquaculture, drinking water supply, and recreation. In developing countries like India, small freshwater bodies such as ponds are particularly important for sustaining rural livelihoods and ensuring water security [1][2]

The physico-chemical characteristics of water are important indicators of aquatic ecosystem health. Parameters such as temperature, pH, dissolved oxygen, and nutrient concentration regulate the biological productivity and ecological stability of freshwater bodies. Changes in these parameters can influence species distribution, metabolic activities, and trophic status of aquatic ecosystems [3][4].

In tropical regions like India, freshwater ecosystems exhibit pronounced seasonal variations due to climatic factors such as temperature, rainfall, evaporation, and runoff. The monsoon plays a particularly significant role in altering water quality by introducing nutrients, suspended solids, and organic matter from surrounding catchments. During summer, high temperatures and evaporation lead to concentration of dissolved salts, while in winter, lower temperatures enhance oxygen solubility and improve water quality conditions. Such seasonal fluctuations strongly influence the physico-chemical dynamics and biological productivity of freshwater bodies [5][6]..

Studies conducted in the Vidarbha region have highlighted the close relationship between physico-chemical parameters and biological components of freshwater ecosystems. For instance, zooplankton diversity has been widely used as an indicator of water quality and trophic status in ponds and lakes of Gondia district [7].

Such studies emphasize the importance of integrating physicochemical and biological assessments for comprehensive evaluation of freshwater ecosystems. Gondia district of Vidarbha region of Maharashtra, located in central India, experiences a tropical monsoon climate characterized by three distinct seasons: summer, monsoon, and winter. This region is known for its large number of natural and man-made ponds that support agriculture, fisheries, and domestic water requirements. Limnological studies focusing on water quality assessment help in understanding ecological conditions and managing freshwater resources effectively. Monitoring physico-chemical parameters is also essential for determining water suitability for fisheries, irrigation, and domestic use [6][8]

The present study of Serpar Pond was undertaken to evaluate the seasonal variations in physico-chemical parameters of the freshwater ecosystem. The study also aimed to perform statistical analysis of the observed water quality parameters in order to understand their interrelationships and patterns of variation. Furthermore, the research focused on interpreting seasonal trends influencing the pond ecosystem throughout the year. Another important objective of the study was to assess the ecological status and overall productivity of the pond based on the observed physico-chemical characteristics of the water.

2. Materials and Methods

2.1 Study Area

Serpar is a small village belonging to Deori Tehsil of Gondia District. Serpar is located on 21.0318537(Latitude), 80.3719545(Longitude) coordinates. The nearest pond is situated at outskirt of Serpar village, hence locally known as Serpar pond. The pond is spread over 35 Acres of land. The maximum depth of the pond at centre is 8 feet. Pond receives water from monsoon rain hence water level is high in rainy season but at the end of summer season the water level considerably decreases. The local fisherman community is exploiting a pond for capturing the various commercially important fishes.

2.2 Sampling Procedure

Water samples were collected monthly from January 2025 to December 2025. Samples were collected in clean polyethylene bottles during morning hours (8:00–10:00 AM).

2.3 Parameters Analysed

Total 12 physico-chemical parameters were analyzed using standard limnological methods which are Water Temperature (°C), pH, Turbidity (NTU), Electrical Conductivity (µS/cm), Total Dissolved Solids (mg/L), Dissolved Oxygen (mg/L), Biological Oxygen Demand (mg/L), Chemical Oxygen Demand (mg/L), Total Hardness (mg/L), Total Alkalinity (mg/L), Nitrate (mg/L) and Phosphate (mg/L).

2.4 Methodology

Table 1: Standard Methodology adopted for Physico-chemical parameters [9]

Sr. No.	Parameter	Method used	Instrument/reagent
1	Temperature	Thermometric Method	Digital thermometer
2	pH	Electrometric method	Digital pH Meter
3	Turbidity	Nephelometric Method	Turbidity Meter
4	Electrical Conductivity (EC)	Conductometric method	Conductivity Meter
5	Total Dissolved Solids (TDS)	Gravimetric Method	Evaporating dish, Oven
6	Dissolved Oxygen (DO)	Winkler's iodometric titration method	Manganous sulfate, alkaline iodide azide reagent, sodium thiosulphate
7	Biological Oxygen Demand (BOD)	5-day incubation method	BOD incubator, DO reagents
8	Chemical Oxygen Demand (COD)	Chemical Oxygen Demand (COD)	Dichromate reflux method
9	Total Hardness	EDTA Titrimetric Method	EDTA Solution, Eriochrome Black T
10	Total Alkalinity	Acid Titration Method	Standard Sulfuric Acid, Methyl Orange indicator
11	Nitrate	Spectrophotometric Method	UV Spectrophotometer
12	Phosphate	Spectrophotometric Method	UV Spectrophotometer

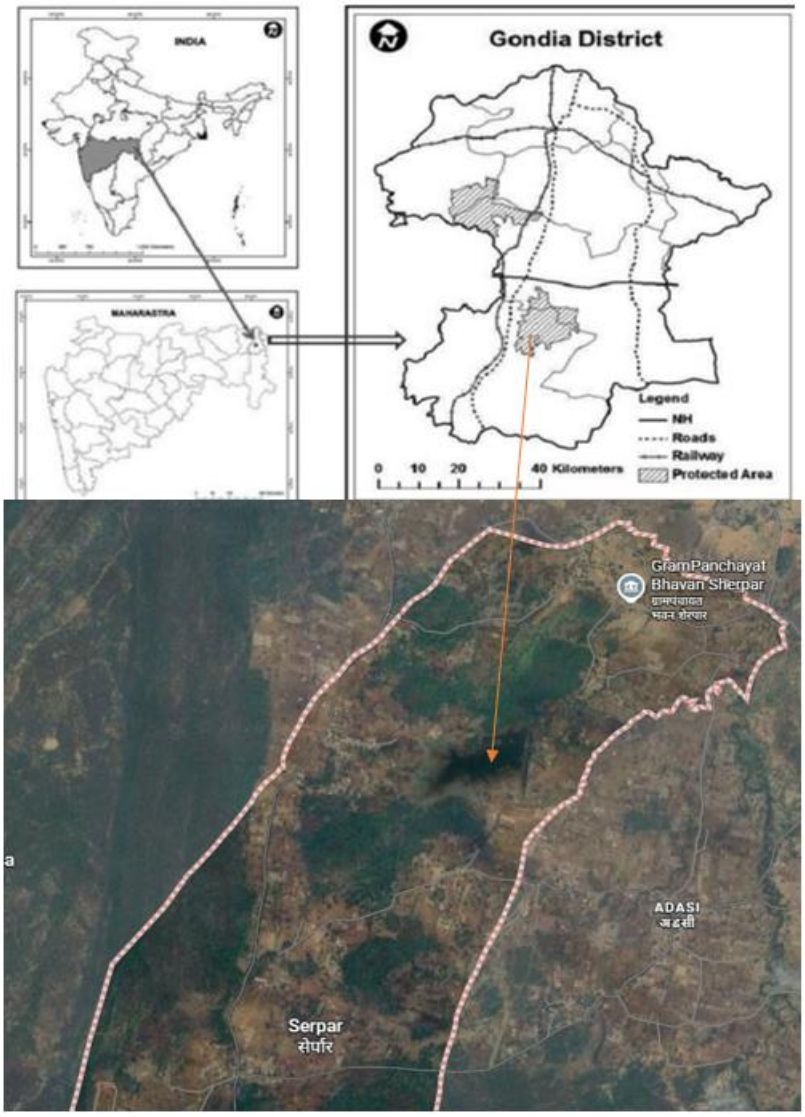


Photo 1: Map of Serpar pond, inset showing map of India, Maharashtra and Gondia

Photo 2: GPS photograph of Serpar pond

3. Results and Discussion

Table 1: Monthly values of Physico-chemical Parameters of a Serpar Pond with mean and standard Deviation

Month / Parameter	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Mean	+/-S.D.
Temp	22	24	28	32	35	30	27	26	27	29	25	23	27.3	4.2
pH	7.4	7.5	7.6	7.8	8.0	7.7	7.3	7.2	7.4	7.6	7.5	7.4	7.53	0.24
Turbidity	12	10	14	18	22	35	48	52	40	20	15	11	24.8	15.2
E.C.	310	320	340	360	380	370	350	330	325	335	315	305	336.7	24.1
TDS	210	215	225	240	255	245	235	225	220	228	212	205	226.3	14.7
D.O.	8.2	7.9	7.2	6.5	5.8	6.8	7.4	7.8	7.6	7.1	7.8	8.3	7.37	0.82
BOD	2.1	2.3	2.8	3.4	4.1	3.6	3.2	2.9	2.7	2.6	2.4	2.0	2.84	0.63
COD	12	14	16	20	24	21	18	16	15	14	13	11	16.2	3.9
Total Hardness	145	150	155	165	175	170	160	155	150	148	142	140	154.6	10.9
Alkalinity	110	115	118	125	130	128	120	115	112	110	108	105	116.3	8.2
Nitrate	0.85	0.90	1.05	1.20	1.35	1.40	1.50	1.45	1.30	1.10	0.95	0.80	1.16	0.24
Phosphate	0.12	0.15	0.18	0.22	0.25	0.30	0.35	0.32	0.28	0.20	0.16	0.10	0.22	0.08

*Temp is in ^{O}C, pH has no unit, Turbidity is in NTU and rest all the parameters are in mg/L

Table 2: Pearson correlation matrix between the physico-chemical parameters of Serpar Pond

Parameter	Temp	pH	Turbidity	E.C.	TDS	D.O.	BOD	COD	Total Hardness	Alkalinity	Nitrate	Phosphate
Temp	1.00											
pH	0.81	1.00										
Turbidity	0.18	-0.40	1.00									
E.C.	0.92	0.71	0.31	1.00								
TDS	0.93	0.68	0.36	0.97	1.00							
D.O.	-0.99	-0.86	-0.10	-0.91	-0.92	1.00						
BOD	0.92	0.64	0.41	0.95	0.96	-0.94	1.00					
COD	0.90	0.68	0.34	0.96	0.94	-0.92	0.96	1.00				
Total Hardness	0.86	0.65	0.35	0.95	0.93	-0.88	0.95	0.96	1.00			
Alkalinity	0.82	0.67	0.27	0.96	0.93	-0.86	0.94	0.97	0.99	1.00		
Nitrate	060	0.06	0.88	0.71	0.75	-0.55	0.78	0.73	0.73	0.66	1.00	
Phosphate	0.48	-0.07	0.93	0.61	0.65	-0.42	0.68	0.63	0.63	0.57	0.99	1.00

Freshwater ecosystems are dynamic environments where physical, chemical, and biological processes interact continuously. The physico-chemical parameters recorded in the present study indicate seasonal variation typical of tropical freshwater ponds. Similar seasonal trends have been reported from various freshwater bodies across India, emphasizing the influence of climatic conditions and anthropogenic activities on water quality [10][11].

Water temperature is one of the most important environmental factors affecting aquatic ecosystems. In the present study, temperature ranged from 22°C to 35°C (Table 1), showing typical seasonal variation. High summer temperatures increase metabolic activities of aquatic organisms and enhance decomposition processes. Temperature also influences solubility of gases such as oxygen and carbon dioxide in water. Similar seasonal temperature variations have been documented in freshwater ponds and reservoirs across India, where higher summer temperatures are associated with increased biological activity and evaporation-driven concentration of dissolved substances [12][13].

The pH of the pond remained slightly alkaline throughout the study period, ranging between 7.2 and 8.0 (Table 1). Slight alkalinity is common in freshwater ecosystems containing bicarbonates and carbonates. Alkaline conditions are generally favorable for fish production and plankton growth. Stability of pH in the pond suggests good buffering capacity. Comparable findings have been reported in Indian freshwater lakes and ponds, where pH values typically remain within alkaline range due to geological and biological factors [12][14]

Turbidity values ranged from 10 to 52 NTU (Table 1). .Turbidity showed significant seasonal variation, with highest values during monsoon months. Increased turbidity during monsoon is mainly caused by surface runoff carrying suspended particles, clay, organic debris, and nutrients into the pond. High turbidity reduces light penetration and may affect photosynthesis of aquatic plants and phytoplankton. Similar monsoon-induced increases in turbidity have been widely reported in Indian freshwater systems, particularly in ponds and reservoirs located in agricultural landscapes [5][10]

Electrical conductivity varied from 305 to 380 µS/cm, while TDS ranged from 205 to 255 mg/L (Table 1). Electrical conductivity and total dissolved solids showed moderate variation. Higher values observed during summer months may be due to evaporation which concentrates dissolved salts. Conductivity reflects the ionic composition of water and is influenced by geological and anthropogenic factors. Similar monsoon-induced increases in turbidity have been widely reported in Indian freshwater systems, particularly in ponds and reservoirs located in agricultural landscapes [5][10]

Dissolved oxygen is one of the most important parameters determining the health of aquatic ecosystems. In the present study, DO ranged from 5.8 to 8.3 mg/L (Table 1). Higher DO levels recorded during winter months may be attributed to lower temperature and higher oxygen solubility. Conversely, lower DO during summer months may be due to increased

temperature and microbial respiration. Similar seasonal variations in DO have been reported from freshwater lakes and ponds across India [10][14].

Biological oxygen demand (BOD) and chemical oxygen demand (COD) are important indicators of organic pollution in aquatic systems. In the present study, BOD values ranged from 2.0 to 4.1 mg/L, while COD ranged from 11 to 24 mg/L, indicating moderate organic load in the pond. Higher BOD and COD values during summer months may be attributed to increased microbial decomposition of organic matter and reduced dilution due to lower water levels. The strong positive correlation between BOD and COD observed in the study suggests that both parameters are influenced by similar sources of organic matter. Comparable results have been reported in freshwater ponds and reservoirs in India, where moderate BOD and COD values indicate organic enrichment but not severe pollution [2][5].

Total hardness and alkalinity are important parameters that determine the buffering capacity and mineral content of water. In the present study, total hardness ranged from 140 to 175 mg/L, indicating moderately hard water, while alkalinity ranged from 105 to 130 mg/L. These values suggest that the pond water contains sufficient amounts of calcium and magnesium ions, which are essential for aquatic organisms. Moderate hardness and alkalinity are generally considered beneficial for fish production and aquatic productivity. Similar ranges of hardness and alkalinity have been reported in Indian freshwater ecosystems, indicating favorable conditions for aquatic life [13].

Nutrient parameters such as nitrate and phosphate play a significant role in determining the trophic status of aquatic ecosystems. In the present study, nitrate concentrations ranged from 0.80 to 1.50 mg/L, while phosphate ranged from 0.10 to 0.35 mg/L. Elevated nutrient levels during monsoon months suggest the influence of agricultural runoff and organic matter input from surrounding areas. Nutrient enrichment during rainy season is a common phenomenon in tropical freshwater systems and is often associated with increased primary productivity. However, excessive nutrient input can lead to eutrophication, resulting in algal blooms and oxygen depletion. Similar trends of nutrient enrichment during monsoon have been reported in several freshwater bodies across India [1][10].

Seasonal changes observed in this study are consistent with limnological patterns reported from many tropical freshwater ecosystems. The interaction between climatic factors, nutrient availability, and biological processes determines overall productivity of the pond.

The correlating matrix of present study revealed a strong negative correlation (-0.99) is observed between temperature and dissolved oxygen. This indicates that as water temperature increases during summer months, the solubility of oxygen decreases, leading to lower DO levels. Electrical conductivity and total dissolved solids show a very strong positive correlation (0.97). This relationship occurs because both parameters measure the concentration of dissolved ions in water. BOD and COD show very strong positive correlation (0.96), suggesting that both parameters respond similarly to organic pollution and decomposition processes. A very high positive correlation (0.99) exists between hardness and alkalinity. This indicates that both parameters are influenced by dissolved calcium and magnesium carbonates in the pond water. Turbidity shows strong positive correlation with nitrate (0.88) and phosphate (0.93). This suggests that runoff during monsoon carries suspended particles along with nutrients into the pond. Nitrate and phosphate exhibit very strong correlation (0.99), indicating a common source, most likely agricultural runoff and organic matter input. BOD, COD, EC, and TDS show strong positive correlations, indicating that increased dissolved substances and organic matter contribute to higher oxygen demand. Similar correlation patterns have been reported in Indian freshwater studies, highlighting the interconnected nature of water quality parameters [11].

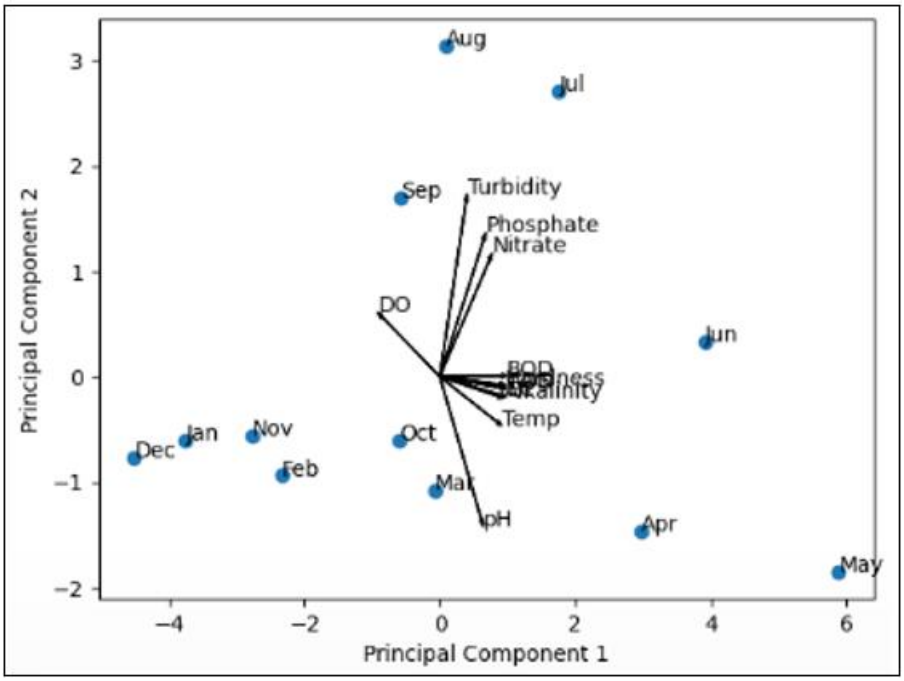
Interpretation of PCA Biplot (Graph 1)

In the Biplot each point represents a monthly water sample from the pond in the Vidarbha region of Maharashtra. Months that appear close together have similar water quality characteristics, while months far apart have different conditions. Summer months, April, May and June appears to be on positive side of the principal component 1(Mineralization Gradient). This indicates that summer water chemistry is dominated by high mineral concentration and organic activity, mainly due to evaporation and increased microbial decomposition. They are associated with parameters, Temperature, EC, TDS, BOD, COD, Hardness and Alkalinity.

Monsoon months, July, August and September are appears toward upper part of principal component 2 (Nutrient enrichment gradient). They are strongly associated with Turbidity, Nitrate and Phosphate. This suggests nutrient enrichment caused by monsoon runoff, where soil particles and fertilizers from surrounding land enter the pond.

Winter months, November, December and January cluster on negative side of principal component 1. They are associated with higher dissolved oxygen, lower nutrient concentration and lower temperature. Winter therefore represents stable and relatively clean water conditions.

Parameters like EC, TDS, hardness, alkalinity, BOD, COD are pointing in the similar directions, hence have strong positive correlation among them. Whereas Dissolved oxygen (DO) is showing opposite direction has negative correlation with all other parameters. Nitrate and phosphate arrows point toward the monsoon cluster, confirming that nutrient enrichment occurs mainly during rainy months. These findings are consistent with previous studies conducted in Indian freshwater systems, where PCA has been used to identify seasonal gradients and sources of variation in water quality parameters [11].



Graph 1: PCA Biplot of Physico-chemical parameters and months

The ecological status of the pond can be inferred from the observed physico-chemical parameters. The moderate levels of nutrients, BOD, and COD indicate that the pond is moderately productive with slight eutrophic tendencies, particularly during monsoon season. The presence of adequate dissolved oxygen levels throughout the year suggests that the pond is capable of supporting aquatic life, including fish and plankton communities. However, continuous input of nutrients and organic matter may lead to deterioration of water quality in the long term if not properly managed.

Anthropogenic activities such as agricultural runoff, domestic waste disposal, and overexploitation of aquatic resources may contribute to changes in water quality. Studies conducted in various parts of India have highlighted the impact of human activities on freshwater ecosystems, emphasizing the need for proper management and conservation strategies [10][11].

4. Conclusion

The present study highlights the seasonal variation in physico-chemical parameters of Serpar Pond, reflecting typical limnological characteristics of tropical freshwater ecosystems. Temperature played a crucial role in regulating water quality, particularly influencing dissolved oxygen levels, which showed an inverse relationship with temperature. The pond water remained slightly alkaline throughout the study period, indicating good buffering capacity and suitability for aquatic life. Seasonal increases in turbidity, nitrate, and phosphate during the monsoon suggest the influence of surface runoff and nutrient input from surrounding areas. The strong correlations among physico-chemical parameters such as EC, TDS, BOD, COD, hardness, and alkalinity indicate their common dependence on mineral content and organic load. Moderate values of BOD and COD reflect limited organic pollution within permissible limits. Multivariate analysis (PCA) revealed distinct seasonal patterns, identifying summer as a phase of mineral concentration, monsoon as a period of nutrient enrichment, and winter as a phase of improved oxygen conditions. These findings confirm the dynamic nature of the pond ecosystem. Overall, Serpar Pond can be classified as a moderately productive freshwater body with slight eutrophic tendencies during the monsoon season. The water quality is generally suitable for fisheries and irrigation; however, increasing nutrient input may pose ecological risks in the future. Therefore, regular monitoring and sustainable management practices are essential to maintain ecological balance and prevent long-term degradation of the ecosystem.

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