



**National Webinar**  
**on**  
**"Climate change and Biodiversity"**  
**14 October, 2025**



**ORGANIZED BY**  
Shri Rajiv Gandhi Government College  
Banda, District Sagar (M.P.)



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# National Webinar on "Climate change and Biodiversity"

October 14, 2025

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Proceeding National Webinar: 2025

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"Climate change and Biodiversity"

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978-81-974473-5-8

Published online/offline by:

Ramkripal Richhariya and Sons Publication, Chhatarpur, Madhya Pradesh.

Organized by:

Shri Rajiv Gandhi Government College Banda, District Sagar, MP

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दिनांक : 28-10-2025

### संदेश



हर्ष का विषय है कि श्री राजीव गांधी शासकीय महाविद्यालय बण्डा, जिला सागर द्वारा जलवायु परिवर्तन एवं जैव विविधता विषय पर दिनांक 14.10.2025 को एक दिवसीय राष्ट्रीय वेबिनार का आयोजन किया गया। जिसमें देश के विभिन्न विशेषज्ञों ने मंचासीन होकर अपने विचारों का आदान प्रदान किया।

राष्ट्रीय वेबिनार आयोजन तथा विचार मंथन से प्राप्त अनूत रुपी सार को शोध संक्षेपिका के रूप में प्रकाशन हेतु प्राचार्य, आयोजन समिति तथा समस्त महाविद्यालय परिवार को शुभकामनाएँ।

  
(डॉ. नीरज दुबे)

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**शुभकामना संदेश**

हर्ष का विषय है कि श्री राजीव गांधी शासकीय महाविद्यालय बण्डा जिला सागर द्वारा राष्ट्रीय वेबिनार का आयोजन दिनांक 14 अक्टूबर 2025 को "जलवायु परिवर्तन एवं जैव विविधता" विषय पर उच्च शिक्षा म.प्र. शासन द्वारा प्रायोजित तथा आंतरिक गुणवत्ता आश्वासन प्रकोष्ठ विभाग एवं एनवायरमेंट एण्ड सोशल वेलफेयर सोसायटी खजुराहों के सहयोग से किया गया।

इस अवसर पर महाविद्यालय द्वारा "शोध पत्रिका" का प्रकाशन किया जा रहा है जो शोध के लिये उल्लेखनीय कार्य है।

"शोध पत्रिका" प्रकाशन पर आयोजन मंडल समस्त महाविद्यालय परिवार एवं संपादक मंडल को हार्दिक शुभकामनायें।

  
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## KEYNOTE

**CLIMATE CHANGE AND CROPS PRODUCTION**

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Food security through crops production under the adverse climatic conditions is a big global challenge. Among the climate factors (light, temperature, precipitation, humidity, wind and atmospheric gases) only temperature is in the main focus to sustaining the life on the earth, in recent scenario of the climate change. Climate change refers to a broad range of a global phenomenon created predominantly by burning of fossil fuels which add heat trapping gases to earth's atmosphere that increases temperature of the earth, All the living beings need food to sustain the life, and conditions to live. Every species must be in harmony with their internal as well as external conditions to live in their changing environment. Otherwise, they will be expelled out from their habitat. Increasing temperature trends across the entire earth's atmosphere since the early 20<sup>th</sup> century, and noticeable since the late 1970s. Since 1880, global temperature increased about .8 °C. The climate change is a natural phenomenon, but intergovernmental panel on climate change (IPCC) reported human influence has been the dominant cause of global warming and climate change within the recent decades. The main green house gas CO<sub>2</sub> is the main cause of global warming along the other gases such as methane, watervapour, nitrous oxide, chlorofluorocarbons, and ozone. A great loss in the crops production has been noticed. Due to the extreme weather changes resulting heat waves on land and ocean, severe floods, droughts, extreme wildfires, etc. will reduce the food production globally, in future. All the above events increasing abiotic stress conditions on the earth surface, day by day. The stress conditions affect morphological, anatomical, and physiological changes in the plants. At the severe conditions loss of food production and biodiversity may be resulted on a large scale basis. In a report of International chamber of commerce (ICC) the global economic loss will be more than 2 trillion dollar over the past decades due to the climate related extremes weather events, shows big loss in the economy. Also, 1.6 billion people in between 2014 – 2023 have affected due to the extreme weather changes. It has been observed by researcher that, at every degree celcius of global warming on an average will drag down the world's ability to produce food by 120 calories per person per day (4.4% of current daily consumption). To reduce the climatic change problems, all the mitigation strategies should be followed given by international agreements policies. As food security is concerned, multidirectional strategies should be adapted. Research activities may play significant role in the development of resilient strains, temperature and stress tolerant crops may be helpful to global food security.

## BIOLOGICAL COLLECTIONS FOR UNDERSTANDING THE EFFECTS OF CLIMATE ON THE BIODIVERSITY

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### Abstract:

Biological collections, both as dry and wet specimens of flora and fauna, are preserved in the Natural History Museums. Currently, they serve as a medium for interpretation through physical, digital and virtual modes. These collections are displayed in dioramas decorated with painted backgrounds, models of plants in their natural environments. Usually, museums are seen as informal education centres to disseminate knowledge about specimens through various interpretation methods. In the era of climate change, numerous research projects are currently underway. Ecological changes have become a point of discussion in modern biology. There are several research projects that correlate the modern biodiversity with its ancient counterpart. Museum specimens are important repositories for ecological studies. It is only biological specimens that may serve as a source of research to conduct a comparative analysis of data collected from ancient specimens with their modern counterpart. The extent of air pollution in a particular geographical area during the ancient past can be studied by examining specimens collected from that area. Their feather and other body parts are a useful source of study.

**Keywords:** Biological collections, specimens, natural history museum, interpretation, ecological change.

### INTRODUCTION:

The modern geological epoch, that is Anthropocene, is recognised as an era of human impact on the earth's biodiversity, biogeochemical cycles, as well as ecosystems (Lewis and Maslin, 2015). During this period, there is a major global change, major drivers of the global changes being climate change, invasive species, habitat conversion, human exploitation and land conversion (Millennium Ecosystem Assessment-2005). The data collected through the field study is limited across space, time and clades. Because one cannot travel back to the past to collect the data, a researcher has to rely on the present data only. In this case, the museum collections are the best resources for the collection of data of the ancient past (Lavies, 2013, & Heberling, 2017). The data will give detailed information on changes in floral and faunal morphology (McLean BS et al., 2015), species decline (Margules Astin, 1994) and shift in life history events (Daru et al, 2018).

### NATURAL HISTORY COLLECTIONS:

The biological collection preserved at any Natural History Museum is known as the Natural History collection or biological collection, and it contains important data sets for nutrients (MacLauchlan et.al., 2010), pollution (Weis et.al., 1999), physiological processes (Miller et. al., 2009), disease (Antonivics et al., 2003, pollinator interactions (Miller et.al, 2015 & Byers, 2017) and herbivore interactions (Beauvais et. al., 2017). They are preserved in the form of dry and wet specimens of plants and animals. In the Indian subcontinent, certain biological collections are quite important from the point of view of biological research. Among them, Bombay Natural History Society, Mumbai, Chhatrapati Shivaji

Maharaj Museum, Mumbai, Indian Museum, Kolkata, Govt. Museum Madras, Chennai and State Museum Lucknow are a few to mention.

#### **DIGITIZATION OF MUSEUM DATA:**

Several museums around the world are now taking the initiative of digitising their data, and it is available online for further research and innovations. It is quite helpful for researchers in remote areas who are unable to travel or trace the items preserved in a particular museum. For example, the National Museum of Natural History, Paris, France, has digitised approximately 90% of its vascular plant data, which comprises 5.4 million specimens. A researcher can search for these specimens on the official website of the museum. There are certain institutions, like the National Science Foundation (NSF) funded Integrated Digitised Biocollections (iDigBio: <https://www.idigbio.org/portal/>) that have compiled millions of data representing innumerable species of flora and fauna. These digitised data give an immense opportunity to conduct a study on ancient biodiversity. The tropical regions had comparatively fewer opportunities to collect the specimens than their European and American counterparts. Certain countries, like Brazil, have started compiling data from their collection preserved in different museums outside the country. They are collecting it in the form of digital data, and it can be retrieved for studying the ancient biodiversity of Brazil in the Ancient past, comparable to the biodiversity of flora and fauna preserved in wild regions (Zappi et.al., 2015). Such initiatives can be taken by Indian institutions regarding the collection of data on the species preserved in different museums around the world.

#### **METHOD AND METHODOLOGIES:**

In the present scenario, the world is facing many challenges and climate change is one of them. Across the world, several studies are underway to study the impact of climate change. Museums as a repository of biological collections may serve as an important laboratory for climate change research. In this small study, the focus is on the relevance of biological collections preserved in various Natural History Museums. The study will attempt to document ancient biodiversity by studying various taxa in museum collections. The research is based on studying morphological as well as cytological changes caused by climatic changes. The author has focused on different biological collections preserved in various natural history collections. Though the museums are informal institutions by their origin but through the passage of time, it has proved that nowadays they have transformed into research centres conducting various studies on cytology, morphology, comparative anatomy, phenology and various other branches of biology. The ecological study based on biological collection is rather very rare, but it has its own importance in assessing the role played by climate change over the period of time. Under this study, the information collected about the biological collections will be used to describe the importance of museum specimens and their role in the analysis of climate change in the ancient past.

#### **RESEARCH METHODOLOGY:**

The research methodology for analysing the biological collections for understanding the effects of climate on the biodiversity involves a review-based approach in different museums across the world.

##### **b) Data Collection**

**Primary Data:** The primary data is based on a biological collection of the State Museum, Lucknow.

Secondary Data: A review of relevant literature, including government reports, research articles, National Science Foundation project reports, and the Royal Society Publishing Reports, etc.

### **MUSEUM SPECIMENS FOR GLOBAL CHANGE RESEARCH:**

Initially, the museum specimens were collected as a precious repository by the elite class and were not available for research and learning. However, in modern times, the scenario has changed entirely, and these museum collections are now an important source for research and future studies, open to all. On average, there are approximately 1.5 million data points preserved worldwide. These species are the most authentic record for ancient biodiversity and a reference for taxonomists. Surprisingly, there are many newly discovered species present in the collection of the museum. Interestingly, they might not have been seen in a particular area for a long time and declared extinct (Kemp, 2015). Museum specimens are the best repositories to be used as ecological data to study the phenology and distribution of the species. Long-term data collection in the wild gives us comparative data for phenological study and distribution patterns. But it has a limitation to a few years or centuries. But the museum data collection has an edge over it. It gives a data set of approximately 200 to 300-year-old preserved specimens in various collections. It will help in studying phenological variations over the years and across climatic space, viz, temperature and precipitation. Based on the field slips attached to the specimens, we get the information about the provenance of the species, and it gives a comparable data set for the comparative geographical distribution of a particular species. Analysis of these data reveals the ancient distribution of the species, and comparing with the modern distribution throws light on the impact of climatic change (Freeley, 2012). It gives an insight into the shifting distribution and community composition of a particular species (DeCandido, 2004).

The phenological studies, like changes in beak shape and size of a particular species, in case of non-availability of a particular non-berry species, give an insight into the climatic change of a particular area. Stable isotope analysis of plant and animal tissue provides important data on species' ecologies and life histories, a next-to-impossible task for field biologists (McLean, 2015). Apart from species conservation, extracting aDNA from these species has allowed reconstruction of phylogenetic relationships, which will ultimately give information about the hybridisation generating barcode of life, bottleneck species, introgression, range contraction and range expansion, etc. (Wandeler et.al., 2007). Whole-genome sequencing is an important source for identifying mutations in a particular species. Apart from this, using high-resolution molecular techniques, we can extract fungi and other pathogens from the soft tissues of the preserved specimens (Yoshida, 2013).

The preserved specimens are a valuable source of study for understanding environmental changes and biological evolution over time. A thorough analysis of a preserved specimen gives an overview of the emergence and expansion pattern of pathogens causing the extinction of a particular species. For example, the preserved specimen analysis of amphibians explains that the extinction driver of amphibians, the *chytrid* fungus, was spread across the world.

Likewise, the presence of atmospheric black carbon soot on the feathers of the bird in the biological collection has led to the formulation of the pollution control policies in the US.

### **RESULT AND CONCLUSION:**

Various human activities in the Anthropocene age have resulted in changes in Biodiversity, Biogeochemical cycles, ecosystems, and climate change. Several research projects are underway to find ways to reduce their intensity. Invasive species, habitat conversion, human exploitation, and Conversion of Land are a few prominent drivers.

Climate change is a major threat to biodiversity in the wild. Field biologists are conducting studies on phenology, morphology, and distribution patterns, but it has limitations of space and time. The biological collections are important repositories to combat this problem. Both dry and wet specimens of flora and fauna, preserved in the Natural History Museums, serve as a medium for interpretation through physical, digital and virtual modes

These collections are preserved way back 200-300 years and serve as an important source of information related to aDNA analysis, nutritional content, prey-predator relationship, and fungal infection. There are several specimens of a single species, which allows conducting a study on phenology, taxonomy and other comparative aspects of the specimens. There are many species which preserved in museums but are not found in the wild. Morphological study of the specimens gives an idea of the carbon-soot deposit on the feathers, explaining the pollution in a particular space and time. The heavy metal deposits in the bone and tissues are also a marker of the pollution. A thorough study of these specimens gives an idea of mutation and decline in population due to climatic changes over a period of time. It is only biological specimens that may serve as a source of research to conduct a comparative analysis of data collected from ancient specimens with their modern counterpart.

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## THE ROLE OF BIODIVERSITY IN ENHANCING CLIMATIC RESILIENCE OF ERI SILKWORM AND HOST PLANT ECOSYSTEMS

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### Abstract:

Eri silk production (*Samia ricini* Donovan) represents a unique sericulture system deeply intertwined with biodiversity conservation and climate adaptation, particularly in the northeastern regions of India where it forms an integral component of traditional agroforestry landscapes. This chapter examines the critical role of biodiversity in enhancing the climatic resilience of eri silkworm and host plant ecosystems, focusing on the complex ecological interactions that buffer against climate variability and enable adaptive responses to long-term environmental change. Through systematic analysis of biodiversity at genetic, species, and ecosystem levels, we demonstrate how biological diversity acts as a fundamental insurance mechanism against climatic stresses. The chapter synthesizes evidence from ecological theory, empirical field studies, and traditional ecological knowledge to elucidate three primary mechanisms: insurance effects and functional redundancy, adaptive capacity through genetic variation, and ecosystem service provisioning. We propose integrated biodiversity-based adaptation strategies encompassing conservation of genetic resources, promotion of host plant diversity, enhancement of agroecosystem complexity, and integration of traditional knowledge systems. Eri sericulture emerges as a model system demonstrating how agricultural production can be sustained through climate change by leveraging biodiversity that underpins ecosystem function.

**Keywords:** Eri-culture, Eri-silkworm, Biodiversity, Host plant, Climate adaptation, Agroforestry.

### 1. INTRODUCTION

The eri silkworm (*Samia ricini* Donovan), also known as the castor silkworm, represents one of the most commercially important non-mulberry silk producers in tropical and subtropical regions. Unlike the domesticated mulberry silkworm (*Bombyx mori*), eri silk production maintains closer connections with natural ecosystems and biodiversity, making it particularly relevant for understanding climate-biodiversity-agriculture interactions (Sarmah et al., 2010). The system is primarily practiced in northeastern India, particularly Assam, where it forms an integral component of rural livelihoods and traditional agroforestry systems. Climate change presents unprecedented challenges to sericulture globally, with altered temperature regimes, precipitation patterns, and increased frequency of extreme weather events threatening production stability (Kusuma et al., 2024). The eri silk ecosystem faces particular vulnerability due to its dependence on specific host plants and environmental conditions. However, the inherent biodiversity within these systems spanning genetic, species, and ecosystem levels offers potential adaptive mechanisms that can enhance resilience.

Biodiversity serves multiple functions in ecosystem resilience: it provides functional redundancy, enables adaptive responses through genetic variation, maintains ecosystem processes across environmental gradients, and creates insurance effects against disturbances (Oliver et al., 2015). This chapter explores mechanisms through which biodiversity enhances

climatic resilience in eri silkworm and host plant ecosystems, examining current biodiversity states, climate change threats, and management strategies that leverage biodiversity for adaptation.

## 2. BIODIVERSITY COMPONENTS IN ERI SILK ECOSYSTEMS

### 2.1 Genetic Diversity of Eri Silkworms

Genetic diversity within eri silkworm populations represents the foundation for adaptive capacity under changing climatic conditions. Unlike the highly domesticated *B. mori*, eri silkworms maintain substantial genetic variation, with multiple ecotypes adapted to different geographical and climatic zones (Pradeep *et al.*, 2011). This genetic diversity manifests in traits critical for climate adaptation, including thermal tolerance, developmental plasticity, disease resistance, and feeding efficiency across varying host plant qualities. Studies have identified significant genetic variation in eri silkworm populations across northeastern India, with distinct genetic clusters corresponding to different agro-climatic zones (Vijayan *et al.*, 2009).

These populations exhibit differential responses to temperature stress, with some ecotypes demonstrating superior survival and cocoon production under heat stress conditions. Wongsorn *et al.*, 2015 concluded that morphological traits, the ability of genotypes to produce different phenotypes under varying environmental conditions represents another critical dimension. Eri silkworms demonstrate considerable plasticity in developmental rates, body size, and cocoon characteristics in response to temperature and humidity variations enabling population persistence across environmental fluctuations.

### 2.2 Host Plant Diversity

The diversity of host plants available to eri silkworms constitutes a crucial component of ecosystem resilience. While castor (*Ricinus communis*) remains the primary host plant, eri silkworms can feed on multiple species including cassava (*Manihot esculenta*), Kesseru, Tapioca, Borpat, papaya (*Carica papaya*), and *Evodia flaxinifolia* (fig.1) (Gogoi *et al.*, 2024).

Castor	Kesseru	Borpat
Tapioca	Papaya	Manihot

**Fig. 1. Host plants of Eri-Silkworm (*Samia ricini* Donovan)**

This polyphagous nature contrasts sharply with the obligate monophagy of mulberry silkworms and provides significant advantages for climate adaptation. Different host plants exhibit varying responses to climatic stresses. Castor demonstrates considerable drought tolerance but is sensitive to waterlogging, while cassava shows opposite characteristics (Bellotti et al., 2012). The availability of multiple host plant species creates temporal and spatial insurance against host plant failure due to climatic extremes. Within-species diversity of host plants also contributes to resilience, with castor landraces showing substantial variation in climatic adaptations (Ganesan *et al.*, 2023). Traditional agroforestry systems in Assam maintain diverse castor varieties alongside other host plants, creating a mosaic of resources that buffer against environmental variability.

### **2.3 Associated Biodiversity in Agroforestry Systems**

Eri silk production typically occurs within complex agroforestry systems that harbor substantial associated biodiversity. These systems integrate host plant cultivation with other tree species, crops, and natural vegetation, creating heterogeneous habitat matrices that support diverse communities of natural enemies, pollinators, and soil organisms. (Borah *et al.*, 2023) Natural enemies of eri silkworm pests provide robust biological control across varying environmental conditions through functional complementarity and compensatory dynamics. Climate change can disrupt pest dynamics, but diverse natural enemy communities buffer against outbreak situations (Snyder et al., 2006). Soil biodiversity plays fundamental roles in nutrient cycling, water retention, and plant health. Arbuscular mycorrhizal fungi enhance plant drought tolerance and nutrient uptake, improving host plant quality for silkworm nutrition (Augé et al., 2015).

## **3. MECHANISMS OF BIODIVERSITY-MEDIATED CLIMATIC RESILIENCE**

### **3.1 Insurance Effects and Functional Redundancy**

The insurance hypothesis posits that biodiversity buffers ecosystem functioning against environmental variability through functional redundancy and complementarity (Yachi and Loreau, 1999). In eri silk ecosystems, multiple species and genotypes perform similar ecological functions but respond differently to environmental conditions. When one component fails under specific climatic stress, others can compensate, maintaining overall system productivity. Functional redundancy operates at multiple levels in eri systems. At the host plant level, the availability of multiple species provides insurance against species-specific climate vulnerabilities. When castor suffers from drought stress, cassava may maintain productivity, ensuring continuous silkworm nutrition. Similarly, genetic diversity within silkworm populations ensures that some genotypes maintain fitness across varying thermal conditions, stabilizing production across seasons and years (Shanafelt *et al.*, 2015). The insurance effect becomes particularly important under increasing climate variability, where extreme events may cause severe but temporary impacts. Diverse systems recover more rapidly from disturbances because surviving components can expand to fill functional roles (Elmqvist et al., 2003).

### **3.2 Adaptive Capacity through Genetic Variation.**

Genetic diversity provides the raw material for evolutionary adaptation to changing environmental conditions. Populations with greater genetic variation possess higher probability of containing genotypes pre-adapted to new conditions or capable of evolving adaptive responses (Jump et al., 2009). For eri silkworms, genetic diversity in thermal tolerance, developmental timing, and stress resistance traits enables population-level adaptation to warming trends and altered seasonal patterns.

Evidence suggests that eri silkworm populations can undergo rapid microevolution in response to selection pressures. Research on temperature adaptation has shown that populations reared under elevated temperatures for multiple generations develop enhanced

heat tolerance while maintaining productivity (Rajput *et al.*, 2023). This adaptive potential depends critically on maintaining genetic variation within breeding populations and avoiding genetic bottlenecks that erode adaptive capacity. Host plants similarly require genetic diversity for climate adaptation. Traditional farming practices that maintain diverse landraces and allow gene flow among populations support this adaptive capacity. (Kaushik *et al.*, 2025).

### 3.3 Ecosystem Services Supporting Resilience

Biodiversity underpins ecosystem services that buffer both silkworms and host plants against climatic stresses. Microclimate regulation represents a critical service enhanced by biodiversity. Complex vegetation structure in diverse agroforestry systems moderates temperature extremes, reduces wind speed, and maintains humidity, creating buffered microclimates that protect both plants and insects from climatic extremes (Lin, 2007). Studies in Assam demonstrate that eri silkworm rearing houses located within diverse agroforestry systems experience lower temperature fluctuations compared to those in open areas.

Water regulation services provided by diverse plant communities and soil biodiversity become increasingly important under changing precipitation patterns. Deep-rooted tree species access water during drought periods while maintaining soil structure that enhances infiltration during heavy rainfall events. Pollination services, though less critical for wind-pollinated castor, remain important for alternative host plants and companion crops, with diverse pollinator communities maintaining function across varying weather conditions (Fründ *et al.*, 2013).

## 4. CLIMATE CHANGE THREATS TO BIODIVERSITY AND RESILIENCE

### 4.1 Direct Climate Impacts

Rising temperatures directly affect eri silkworm physiology, development, and survival. Optimal rearing temperatures for eri silkworms range from 24-28°C, with performance declining at higher temperatures (Sarmah *et al.*, 2010). Projected temperature increases of 2-4°C in northeastern India by 2050 could push conditions beyond optimal ranges during critical periods, reducing survival rates, extending larval duration, and decreasing cocoon quality (Mohammad *et al.*, 2024).

Temperature increases also affect host plants, with castor showing reduced leaf quality and increased secondary compound production under heat stress, potentially reducing nutritional value for silkworms. Altered precipitation patterns create additional stresses. Phenological mismatches represent subtle but significant impacts. If silkworm development and host plant leaf production become temporally desynchronized due to differential responses to temperature changes, nutritional stress may occur during critical larval stages (Das *et al.*, 2021).

### 4.2 Indirect Effects through Biodiversity Loss

Climate change threatens biodiversity through multiple pathways, potentially undermining resilience mechanisms. Range shifts and local extinctions of associated species may disrupt ecological interactions that support system function. Natural enemies may fail to track pest range expansions, leading to pest outbreaks. Similarly, beneficial soil organisms may decline under altered moisture regimes, reducing nutrient cycling and plant health services.

Van *et al.*, 2010 emphasize that Genetic diversity erosion represents a critical but often overlooked climate impact. As farmers respond to immediate climate stresses by adopting recommended high-performing varieties, traditional landraces and ecotypes may be uninhibited, resulting in genetic erosion. Studies document concerning declines in castor landrace diversity in northeastern India, driven partly by climate-related production challenges. Landscape homogenization driven by climate-induced agricultural changes

further threatens biodiversity, eliminating the biodiversity-based insurance mechanisms that provide long-term resilience.5. Biodiversity-Based Adaptation Strategies

### **5.1 CONSERVATION OF GENETIC RESOURCES**

Maintaining genetic diversity in both silkworms and host plants represents a fundamental adaptation strategy. This requires multi-pronged approaches combining ex-situ and in-situ conservation. Germplasm collections should preserve diverse ecotypes from across climatic gradients, prioritizing populations from warm, dry regions that may harbor pre-adapted genotypes for future conditions (Kumaraswamy *et al.*, 2022; Peixoto and Peixoto 2025).

In-situ conservation through support for traditional farming systems that maintain diverse varieties proves equally important. Policies encouraging farmers to continue cultivating multiple castor landraces and alternative host plants preserve adaptive genetic variation while maintaining functional diversity. Participatory breeding programs that engage farmers in selection under diverse conditions can enhance both genetic diversity and local adaptation. (Ceccarelli and Grando, 2007).

### **5.2 Promoting Host Plant Diversity**

Encouraging cultivation of multiple host plant species provides immediate resilience benefits. Extension programs should provide information on alternative hosts and their specific climate tolerances, enabling farmers to make informed decisions about host plant portfolios matched to local climate projections. (Kaushik *et al.*, 2025) studied that the diversified plantings can be arranged spatially (different host species in different areas) or temporally (sequential plantings of species with different climate sensitivities). Temporal diversification proves particularly valuable for managing seasonal climate variability, ensuring host plant availability across varying conditions. Developing integrated host plant management systems that enhance the climate resilience of individual species such as mulching to conserve soil moisture, supplementary irrigation during drought periods, and shade provision during heat waves complements diversity-based strategies (Attri *et al.*, 2024).

### **5.3 Enhancing Agroecosystem Complexity**

Promoting complex agroforestry systems that integrate eri silk production with diverse tree species, crops, and natural vegetation enhances multiple dimensions of resilience. Strategic tree planting can provide shade to moderate temperature extremes, windbreaks to protect plants and rearing structures, and deep-rooted species that access deep water while improving soil structure (Verchot *et al.*, 2007). Habitat management for beneficial organisms strengthens biological control and pollination services. This includes maintaining hedgerows, flower strips, and natural vegetation patches that provide nectar, pollen, and refugia for natural enemies and pollinators. Landscape-level diversity complements farm-scale diversity by maintaining species pools that can recolonize after local disturbances. Conservation of forest patches, wetlands, and natural grasslands within sericulture landscapes preserves regional biodiversity that supports ecosystem resilience.

## **6. TRADITIONAL KNOWLEDGE AND BIODIVERSITY MANAGEMENT**

Indigenous and traditional knowledge systems offer valuable insights for biodiversity-based climate adaptation. Traditional eri silk farmers in Assam have developed sophisticated practices for managing biodiversity across varying environmental conditions, including maintenance of multiple host plant varieties, timing of rearing based on seasonal indicators, and habitat management practices that support natural enemies (Narzary and Boro 2025). Traditional variety selection and seed-saving practices have maintained genetic diversity while adapting varieties to local conditions over generations. These practices embody accumulated wisdom about variety-environment interactions and provide tested approaches

for managing climate variability (Attri *et al.*, 2024). Community-based management institutions traditionally govern resource use and biodiversity conservation in many eri-producing regions. Strengthening such institutions while respecting traditional governance systems provides social infrastructure for implementing biodiversity-based adaptation.

## 7. CONCLUSION:

Biodiversity emerges as a fundamental resource for enhancing climatic resilience in eri silkworm and host plant ecosystems. Operating through insurance effects, adaptive capacity, and ecosystem service provision, biodiversity at genetic, species, and ecosystem levels buffers production against climate variability and provides adaptive potential for responding to long-term changes. However, climate change itself threatens biodiversity through direct impacts and indirect effects, potentially undermining resilience mechanisms precisely when they become most critical.

Adaptation strategies that prioritize biodiversity conservation and enhancement offer promising approaches for climate-resilient eri sericulture. These include conservation of genetic resources, promotion of host plant diversity, enhancement of agroecosystem complexity, and integration of traditional knowledge. Implementation requires coordinated efforts spanning policy support, research advances, extension services, and community engagement.

The eri silk system, with its integration of production and conservation objectives and its embeddedness in traditional agroforestry systems, provides a model for biodiversity-based adaptation in agricultural systems more broadly. Lessons from eri sericulture can inform adaptation strategies across diverse agricultural contexts facing similar climate challenges. Ultimately, securing the future of eri silk production depends on recognizing and actively managing the biodiversity that underpins its resilience, ensuring that this unique sericulture tradition continues to support livelihoods while conserving biological diversity in a changing climate.

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## INTEGRATING INDIAN KNOWLEDGE SYSTEM FOR SUSTAINABLE BIODIVERSITY CONSERVATION

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### Abstract:

India since ancient times has a strong environmental ethical base. In the past few decades' biodiversity loss has been very sharp and has accelerated due to human activities of industrialization and urbanisation. Climate change is the most seriously observed phenomena due to superfluous race of modernisation by humans. It is important to integrate the Indian Knowledge System (IKS) with modern biodiversity strategies. Organisations UNESCO, IUCN, National Biodiversity Authority (NBA, India) are working together to create an observable difference at a global level while making positive changes at local level. IKS is easy to incorporate and provides working solutions. The typical Indian Knowledge System practiced by tribal and rural communities is also termed as Traditional Ecological Knowledge (TEK). These areas function as In-situ conservation areas and are useful in performing watershed functions, carbon sequestrations and regulation of microclimate. These areas are microcosms of biodiversity and are a huge reservoir of endemic gene pool.

**Keywords:** Biodiversity, Climate change, Indian Knowledge System, Traditional Ecological Knowledge, Tribal Communities, Rural Communities

### INTRODUCTION:

India since ancient times has a strong environmental ethical base rooted in an intricate relationship between nature and our culture. Our knowledge, comprises not only a philosophical or an ethical perspective but also an ecological perspective. Our ecological perspectives deeply integrate the conservation of nature or biodiversity.

We have traditionally safeguarded our environment even long before when ecology was established as a part of study by modern science. Indians were well informed and understood that all life forms are interconnected and a harmony between them and the environment is a duty which should be performed as a sacred ritual.

In the past few decades' biodiversity loss has been very sharp and has accelerated due to human activities of industrialization and urbanisation. Climate change is the most seriously observed phenomena due to superfluous race of modernisation by humans. The damage has increased many folds as observed by many scientific studies and environmentalists. IKS provides quick and efficient solutions which have already been in use in the past. This will help in slowing down and start reversing the damage caused to our climate and biodiversity.

It is important to integrate the Indian Knowledge System (IKS) with modern biodiversity strategies so that science can be combined with culture and help manage what we have lost and preserve what we are left with. Organisations like UNESCO, IUCN, National Biodiversity Authority (NBA, India) are working together to create an observable difference at a global level while making positive changes at local level.

IKS is easy to incorporate and provides working solutions. The conceptual foundations of the Indian Knowledge System as well as its inherent capability to manage biodiversity can be effortlessly integrated for understanding local ecological knowledge and a sustainable use of the resources available, by combining them with scientific interpretations and principles. (Chanyal, 2022)

### **Historical Evidence of Environmental Thought in India**

Indian texts written in ancient times like Vedas, Upnishads, Puranas, Arthashastra provide us with a detailed information about ecology. They all describe interdependence, balance and conservation of all the available biotic as well as abiotic factors.

The Rig Ved focuses on the purity of the natural elements (Prithvi/ Earth, Vayu/ Air, Apah/ Water, Fire. Agni and Aakash/Space) and their preservation. Atharvaveda is full of text which describes restrictions and warnings against polluting the rivers, shedding of trees, destruction of forests. It also details the fragility of the ecosystem and the consequences of the disturbance of balance between man, animal and plant relationships. Arthashastra written by Kautilya describes penalties for destruction and damage to forests and emphasises on appointing officials. Jain and Buddhist philosophies focus on non-violence and teach respect of our living forms. Emperor Ashok had wildlife protection laws and was known for establishing nature reserves. Most of our ethics are related to religious activities whether it is the worship of the natural elements, protection of cattle, farm animals, forests and its inhabitants. Indian tradition has strong environmental ethics and we have always taken biodiversity conservation with serious thought (Harshit, 2025).

### **Indigenous and Traditional Ecological Knowledge (TEK)**

The typical Indian Knowledge System when as practiced by tribal and rural communities in terms of ecology is also termed as Traditional Ecological Knowledge (TEK). This traditional ecological knowledge is intergenerational. TEK is all about practises which can align with agriculture, forestry and water management. Traditional beliefs always play an important role in protecting wild animals and their habitat.

In one such case in Pachmarhi Biosphere Reserve (Madhya Pradesh) the tribal groups have maintained an area of the forest through rotational harvesting and sacred grooves. They have managed 128 plant species which can be utilised not only for food but medicine, rituals and livelihood. These communities are a living repository of the biodiversity of that area. This knowledge has been passed on through generations and are living example where cultural identity has been linked with conservation (Gadgil, 2021 ; Kala, 2022). Another fine example is a tribe in Arunachal Pradesh, the Bugun tribe which is trying to protect a critically endangered bird species *Bugun liocichla*, (ECONE, n.d.).

The most stable kind of IKS based conservation models are the sacred groves or forest patches that have been preserved through centuries. These sacred groves function as In-situ conservation areas. They are useful in performing watershed functions, carbon sequestrations and regulation of microclimate. They are community reserves and their structures are designated under the Wildlife (Protection) Amendment Act, 2002. The groves integrate indigenous practises within the legal framework and maintain a higher species richness and genetic variability than the surrounding areas which are affected by agriculture or urbanisation ([https://en.wikipedia.org/wiki/Sacred\\_groves\\_of\\_India](https://en.wikipedia.org/wiki/Sacred_groves_of_India) n.d.).

A few examples of sacred groves include Devrai, Oran and Sarna situated in Maharashtra, Rajasthan, Eastern India, Meghalaya, Odisha, Jharkhand, Western Ghats and West Bengal etc. We have about more than 100,000 sacred groves across India. These groves serve as cultural keystone ecosystems, are microcosms of biodiversity, secure a lot of threatened flora and fauna and are a huge reservoir of gene pool including endemic species of medicinal plants, as well as animals. Any kind of logging, hunting or damaging activity is prohibited in these groves ensuring ecological stability and long-term survival (Ormsby and Bhagwat, 2010; Ahmed and Dhiman, 2024).

### **Influence of Tribal Biodiversity Conservation**

The tribal communities of India harbour an extensive and unique knowledge of medicinal plants, passed down through generations. The following examples are a strong proof of these ethnic groups being the cultural custodians of biodiversity and their resilience towards the cause of preservation (Ravishankar, 1995; Ravishankar, 1996; Anju and Kumar, 2024; Babar *et al.*, 2024, Ranavagol and Savanur, 2025).

- The Gonds, Kolams, and Koyas of Central India and across Andhra Pradesh manage diverse ecosystems through sustainable harvesting, sacred groves, and rotational agriculture practices. The Gonds use multi-species cropping systems combined with nitrogen-fixing plants that maintain soil fertility and forest resilience. The Kolams maintain strict harvesting calendars that coincide with seasonal flowering and fruiting patterns, preventing overharvesting of forest products. Koyas integrate riverine biodiversity conservation with community fisheries.
- In northeastern India Wancho Tribe of Arunachal Pradesh follows indigenous fallow management by blending shifting cultivation with forest regeneration. They introduce nitrogen-fixing species and regulate secondary forest regeneration to balance soil recovery. These traditional practices reduce deforestation, creates nutrient cycling while preserving pollinators and habitat.
- The Mullu Kuruman Tribe of Tamil Nadu's Nilgiri Biosphere Reserve demonstrates an advanced ethnobotanical system centered on the use of over 100 medicinal plant species and their knowledge spans pharmacognosy, plant taxonomy, and sustainable harvesting. The tribe's plant-based formulations inspire research into anti-inflammatory and antidiabetic compounds, illustrating how IKS can help modern pharmacology.
- Nagaland's Community Conserved Areas (CCAs) connected three Naga villages Sukhai, Kivikhu, and Ghukhuyi Villages. Over 222 bird species and 200 butterfly species have been documented due to ban on hunting and destructive fishing. Integration of CCAs with People's Biodiversity Registers (PBRs) allowed formal recognition of traditional biodiversity governance systems.
- In Mudumalai Tiger Reserve, Tamil Nadu Toda, Irula, and Kurumba tribes have become partners in conservation through eco-tourism initiatives emphasizing traditional herding and forest knowledge.
- Western Ghats Private Conservation Initiatives have privately managed forest restoration projects in partnership with tribal labour. This NGO conservation network sustains endemic tree species and wildlife corridors in degraded plantations.
- A nationwide ethnobotanical survey revealed that over 100 tribal groups across India maintain detailed medicinal plant records. Tribes such as Irulas, Paliyars, Pulayars, and Kadars in Tamil Nadu and Kerala cultivate small herbal gardens contributing to ex-situ plant conservation.
- The Karbi tribe of Assam emphasize renewal of land through rotational farming and seed-sharing festivals.
- Tribal and fisher communities in Andhra Pradesh, Odisha, and Maharashtra have restored over 2,000 hectares of degraded mangrove ecosystems through community-led reforestation projects. These actions mitigate coastal erosion and climate and regenerate spawning grounds for marine biodiversity.

### **Knowledge Preservation and Digital Documentation**

There are challenges in maintaining the Indian knowledge system (IKS) as most of the times it is orally transmitted. Due to modernisation and globalisation, local inhabitants are migrating. So, the maintenance of this wisdom and information passed down from generations is getting challenging.

To address this challenge our government has taken initiatives like the National Mission On Cultural Mapping, Digital India and the National Traditional Knowledge Digital Library (TKDL). Together they are working to preserve the indigenous knowledge in validated form. They are also working to preserve the ethnobotanical, ethnomedicinal and agronomic data.

These digital repositories in combination with People Biodiversity Registers (PBRs) are working as knowledge banks for the community. They promote participation in the form of documentation and also integrate AI tools, open access data frameworks as well as blockchain verifications to protect this knowledge with integrity and also prevent biopiracy.

### **Education and Research Integration**

The National Education Policy (NEP 2020) is having provisions to maintain the Indian Knowledge System in higher education. Our universities are now offering courses which link IKS with Sustainability, Ethnobiology, Global Biodiversity and Governance. Our institutes such as Rashtriya Ayurveda Vidyapeeth, Centre for Indigenous Knowledge Systems and IITs have initiated curriculums which are interdisciplinary and can blend traditional wisdom with modern environmental research. The Department of Science and Technology and the Ministry of AYUSH are trying to bridge local innovations regarding traditional plant breeding and soil conservation methods with national missions.

### **Challenges and Threats**

The coexistence of IKS and modern scientific frameworks does face a lot of challenges and we need to bridge the gaps. The migration of younger generation to cities has weakened community-based knowledge transfer and the erosion of oral traditions is one of the major challenges observed.

Another issue is commercial exploitation of natural resources without Prior Informed Consent (PIC) which threatens the integrity of the area. The resources and their products are being used for bioprospecting and not for maintenance of biodiversity. Legal aspects cannot be overlooked where they overlap between intellectual property laws, biodiversity acts and community rights and legal ambiguity can lead to complexity in enforcement of laws.

Last but not the least the change in the climate has altered rainfall and the species have shifted as per their requirement. This shift leads to reduction in local ecological predictability. Hybrid scientific and indigenous adaptation frameworks can help us better understand the movement of the species and the changes in their characters according to their new adaptation (Negi et al. 2023).

### **Legal and Policy Frameworks**

In India traditional knowledge is legally recognised by the government as the basis of biodiversity governance and accordingly related laws are made. The Biological Diversity Act, 2002, mandates that the benefit sharing and intellectual property rights for local knowledge holders have to be equitable. The Indian government works through People's Biodiversity Registers (PBRs) which document the community level biological and traditional knowledge and prevent bio piracy. Our laws have made judicial developments which recognise climate change as a constitutional right and emphasise that indigenous knowledge should be integrated into the National Policy Framework.

Our National Biodiversity Board (NBA) and the State Biodiversity Board (SBB) collaborate with the Local Biodiversity Management Committees (BMCs) and together they combine scientific legal and community-based approaches where they ensure that the guardians are also the beneficiaries.

At the global level the Convention On Biological Diversity (CBD) and the Nagoya Protocol together advocate that we need to respect traditional knowledge and follow the customary laws with community consent (Kaur et. al. 2025; <https://t20southafrica.org/publications/integrating-indigenous-knowledge-systems-into-global-policy-frameworks/>, n.d.).

### **Creating An Integrated Framework**

To integrate IKS with contemporary biodiversity governance it is important to promote dialogue between traditional healers, farmers and ecologists so that we can bridge the gap between empirical and experiential knowledge.

The local and tribal community needs to be assured that the biodiversity in their region will be utilised non exploitatively and their claim will be strengthened by providing them rights and equitable access so that the knowledge does not lose its originality.

Students should be encouraged to enhance their local ecological knowledge and conservation ethics through biodiversity clubs. They should be educated via digital tools so that they can rapidly progress in integrating this knowledge.

It is also important to align the national strategies under the National Mission on Biodiversity and Human Well Being, 2020 and the IKS division initiatives under the Ministry of Education to promote traditional wisdom backed by scientific support.

### **CONCLUSION:**

The Indian knowledge system is not a remnant of the past but has sustained oral traditions via generations. It is not only our rich cultural heritage but also a dynamic living wisdom which offers valuable frameworks for conservation of biodiversity and sustainable development.

In this globalisation era, homogenization, threatens are ecological and cultural diversity. To maintain our identity, we need to focus on IKS which emphasises on local ecology. It is important to realize that our well-being is reciprocal to Earth's well-being. The ecological practises which have been our tradition need to be protected by legal framework and modern sustainable science. The sacred groves, the tribal agroforestry and the traditional medicine all collectively illustrate our biodiverse ethnic background which has been preserved since ancient times.

It is imperative to integrate our traditional ecological knowledge with modern methods and protect it via policies, education, digital infrastructure so that we can prepare a future which goes hand in hand in bridging science, spirituality, technology and tradition. It is very important to revisit our indigenous patterns and frameworks to look for viable options for a sustainable development.

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## NATURAL PRODUCT-BASED GREEN CHEMISTRY: A STEP TOWARD VIKASIT BHARAT

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### Abstract

Green Chemistry, also known as sustainable chemistry, represents an innovative scientific approach that emphasizes the design of chemical products and processes which reduce or eliminate the use and generation of hazardous substances. It seeks harmony between technological advancement and ecological balance. In the context of *Viksit Bharat*—a vision for a developed, self-reliant, and environmentally conscious India—Green Chemistry emerges as a transformative tool for achieving sustainable growth. By prioritizing renewable resources, atom economy, and waste prevention, it fosters cleaner production and responsible consumption.

This paper focuses on the role of natural product-based Green Chemistry in replacing harmful synthetic chemicals with eco-friendly alternatives derived from herbal and biological sources. Natural extracts, essential oils, plant-based catalysts, and biopolymers offer sustainable substitutes in industries such as pharmaceuticals, agriculture, textiles, and water purification. These natural compounds are biodegradable, less toxic, and compatible with the principles of circular economy and environmental protection.

Moreover, the integration of India's traditional knowledge—Ayurveda, ethnobotany, and indigenous resource management—into modern scientific research promotes innovation rooted in heritage. Such an approach not only reduces chemical hazards but also strengthens rural economies through the cultivation of medicinal and aromatic plants. The adoption of herbal-based chemistry contributes directly to India's goals of *Atmanirbhar Bharat* (self-reliant India) and *Viksit Bharat* by promoting sustainable industrial practices, employment generation, and ecological conservation.

In conclusion, natural product-based Green Chemistry offers a comprehensive model for sustainable development by bridging science, society, and sustainability. It is a decisive step toward building a cleaner, greener, and self-reliant India where economic progress coexists with environmental integrity.

**Keywords:** Green Chemistry, Natural Products, Sustainable Development, Herbal Alternatives, Viksit Bharat

### INTRODUCTION

India's vision of *Viksit Bharat* (Developed India) is not limited to economic advancement—it envisions a nation where progress is inclusive, environmentally responsible, and sustainable. True development lies in achieving harmony between industrial growth, social welfare, and ecological balance. In this context, the integration of science and sustainability becomes crucial. As India continues to urbanize and industrialize rapidly, it faces mounting challenges of pollution, chemical waste, and resource depletion. Traditional chemical industries, though vital for national growth, rely extensively on hazardous substances such as toxic solvents, synthetic reagents, and non-biodegradable materials. These contribute to environmental degradation, water contamination, and long-term health hazards. Green Chemistry, often referred to as *sustainable chemistry*, provides a powerful solution to these challenges. It is a forward-looking scientific approach that seeks to design chemical

products and processes that minimize environmental impact and maximize efficiency. Rather than controlling pollution after it occurs, Green Chemistry emphasizes prevention at the molecular level. By focusing on renewable resources, safer solvents, and energy-efficient reactions, it represents a paradigm shift from conventional chemistry toward sustainability.

One of the most promising dimensions of this field is natural product-based Green Chemistry, which involves utilizing renewable biological materials—such as plants, herbs, essential oils, and agricultural residues—as sustainable substitutes for synthetic chemicals. These natural resources are biodegradable, non-toxic, and easily available in India's diverse ecosystems. Their application spans across multiple sectors—pharmaceuticals, agriculture, textiles, cosmetics, and environmental remediation. By replacing synthetic reagents with herbal or bio-based alternatives, industries can significantly reduce their ecological footprint while maintaining product quality and efficiency.



This approach aligns seamlessly with India's cultural and scientific heritage. The principles of sustainability, conservation, and responsible use of nature have been embedded in India's traditional systems such as *Ayurveda*, *Siddha*, and *Unani*. For centuries, these systems have utilized natural extracts and herbal compounds for healing, preservation, and daily living—long before the concept of Green Chemistry emerged. Reviving and integrating such indigenous knowledge with modern scientific techniques can strengthen India's global position in sustainable innovation.

Furthermore, this transition holds immense potential for rural and economic development. The cultivation of medicinal and aromatic plants for industrial use can provide livelihood opportunities for farmers and local entrepreneurs. This promotes the concept of *Atmanirbhar Bharat* (Self-Reliant India), where indigenous resources and innovations drive national progress. By encouraging industries to adopt eco-friendly processes and supporting local production of natural raw materials, India can reduce dependence on imported chemicals and build a resilient, sustainable economy.

Green Chemistry is thus more than a scientific discipline—it is an ethical and developmental framework that supports the vision of *Viksit Bharat*. It calls for collaboration between scientists, policymakers, educators, and industries to create a sustainable ecosystem of innovation. By merging ancient wisdom with modern science, India has the potential to lead a global green revolution in chemistry—demonstrating that economic development and environmental preservation are not opposing goals but complementary pathways toward a prosperous, sustainable future.

### **Concept of Green Chemist of Green Chemistry**

Green Chemistry, a concept introduced by Paul Anastas and John Warner in the 1990s, represents a revolutionary approach to chemical science that emphasizes sustainability, safety, and efficiency. It is guided by twelve fundamental principles designed to minimize or eliminate the generation of hazardous substances throughout the entire chemical life cycle—from design and synthesis to use and disposal. These principles advocate the prevention of waste at its source rather than its treatment after formation, the use of less hazardous synthesis methods, and the design of safer chemicals and products that reduce risks to human health and the environment. They also emphasize the use of renewable feedstocks instead of depletable resources, energy-efficient processes that operate under mild conditions, and the use of catalysts in place of stoichiometric reagents to enhance atom economy. Moreover, the principle of designing for degradation ensures that chemical products break down into harmless substances after use. Natural products inherently fulfill many of these criteria, as they are renewable, biodegradable, and multifunctional, often possessing inherent chemical properties that reduce the need for synthetic additives. Thus, natural product-based Green Chemistry seamlessly bridges traditional ecological wisdom with modern scientific innovation, offering a pathway toward truly sustainable chemical practices.

### **Role of Natural Products in Green Chemistry**

Natural products are chemical compounds obtained from plants, animals, or microorganisms, and their application in Green Chemistry has attracted significant attention due to their low toxicity, high efficiency, and inherent biodegradability. These bio-resources serve as versatile and sustainable alternatives to conventional synthetic chemicals. For instance, essential oils function effectively as natural solvents and antimicrobial agents; plant extracts act as reducing and capping agents in the green synthesis of nanoparticles; bio-based polymers derived from starch, cellulose, or chitosan offer eco-friendly substitutes for conventional plastics; and herbal dyes provide non-toxic, biodegradable replacements for synthetic colorants in the textile and cosmetic industries. The incorporation of such natural materials into industrial and academic chemistry not only reduces environmental pollution and resource depletion but also promotes circular economy principles by ensuring that materials can be regenerated and reused sustainably. In this way, natural product-based Green Chemistry contributes to cleaner production systems, minimizes ecological footprints, and strengthens the global movement toward sustainable scientific innovation.

### **Herbal Alternatives to Synthetic Chemicals Natural Dyes and Pigments**

Synthetic dyes, though vibrant and inexpensive, contribute significantly to water pollution, toxicity, and ecological imbalance due to their non-biodegradable nature. In contrast, natural dyes derived from plants such as turmeric, indigo, madder, and henna are eco-friendly, safe, and biodegradable. These dyes possess antimicrobial and antioxidant properties, making them suitable not only for textiles but also for cosmetics, handicrafts, and food coloring. Their extraction and use support rural artisans and small-scale industries while minimizing environmental hazards. The revival of traditional dyeing practices through Green Chemistry ensures sustainable production that preserves both cultural heritage and ecological integrity.

### **Herbal Extracts as Green Catalysts**

In conventional chemistry, catalysts such as mineral acids or heavy metals often produce toxic residues and require complex disposal methods. Herbal extracts, including plant-based acids like citric acid (from citrus fruits) and tartaric acid (from tamarind or grapes), serve as natural catalysts that are renewable, biodegradable, and safe. Enzymes extracted from papaya (papain) and pineapple (bromelain) efficiently catalyze organic reactions under mild conditions, reducing the need for high temperatures or pressures. These green catalysts not only enhance reaction efficiency but also minimize hazardous waste, making them ideal substitutes in pharmaceuticals, food processing, and fine chemical industries.

### **Natural Solvents**

Traditional organic solvents, often derived from petroleum, are volatile and toxic, contributing to air pollution and occupational hazards. Natural solvents, also known as bio-solvents, such as glycerol, ethanol, and limonene (from citrus peels), are renewable and biodegradable alternatives. They possess excellent solvating properties, low volatility, and minimal environmental impact. Their use in extractions, syntheses, and cleaning processes significantly reduces carbon emissions and exposure to harmful vapors. The adoption of these green solvents not only supports safer laboratory and industrial operations but also aligns with sustainable manufacturing principles essential for a cleaner and healthier environment.

### **Herbal Pesticides and Insect Repellents**

The extensive use of synthetic pesticides has led to soil degradation, water contamination, and loss of biodiversity. Herbal pesticides and repellents, derived from plants such as neem, tulsi, and lemongrass, provide safe, biodegradable, and cost-effective alternatives. Neem oil and azadirachtin compounds inhibit insect growth, while tulsi and lemongrass oils act as natural repellents against mosquitoes and pests. These botanical formulations preserve ecological balance, protect beneficial insects, and improve soil fertility. Their large-scale adoption in agriculture supports organic farming practices, ensuring food safety, environmental conservation, and sustainable rural livelihoods in alignment with the goals of *Viksit Bharat*.

### **Integration of Traditional Knowledge and Modern Science**

India's rich tradition of Ayurveda, Siddha, and Unani medicine provides a vast repository of herbal knowledge. Many herbs used in traditional formulations exhibit antimicrobial, antioxidant, or catalytic properties that can be adapted for industrial chemistry. Modern analytical tools—such as chromatography, spectroscopy, and computational modeling—allow chemists to isolate active phytochemicals and study their reaction

mechanisms. Integrating this ancient wisdom with modern chemical research can lead to innovations in pharmaceuticals, materials science, and environmental management.

This synthesis of tradition and technology embodies the true spirit of *Viksit Bharat*—progress rooted in heritage.

### **Applications of Natural Product-Based Green Chemistry in India**

India has achieved significant advancements in implementing natural product-based Green Chemistry across multiple disciplines, contributing to sustainable development and environmental protection. Researchers have pioneered the green synthesis of nanoparticles using extracts from neem, aloe vera, and tea, producing silver, gold, and zinc oxide nanoparticles that find valuable applications in medicine, catalysis, and pollution remediation. In response to the global plastic crisis, biodegradable polymers derived from starch, cellulose, and chitosan are being developed as eco-friendly packaging alternatives, reducing dependency on petroleum-based plastics. The pharmaceutical and cosmetic industries increasingly employ phytochemicals such as curcumin, menthol, and camphor, which provide therapeutic and aromatic properties without causing toxicity or skin irritation.

In agriculture, the use of natural composting agents, biofertilizers, and herbal pest repellents enhances soil fertility, promotes biodiversity, and supports organic farming. Furthermore, moringa seeds and activated carbon from coconut husk are utilized as efficient natural adsorbents for the removal of heavy metals and dyes from contaminated water, offering low-cost and sustainable solutions for water purification. These innovative applications reflect India's potential to harmonize traditional knowledge with modern science, advancing the nation's vision of a cleaner, greener, and self-reliant *Viksit Bharat* through responsible and sustainable chemical practices.

### **Economic and Social Benefits for Viksit Bharat**

Green Chemistry serves as a catalyst for inclusive and sustainable growth, forming a cornerstone of India's vision for *Viksit Bharat*. Its adoption empowers rural communities by providing farmers with new income opportunities through the cultivation of medicinal and aromatic plants, while promoting self-reliance by reducing dependency on imported chemicals. The approach enhances health and safety by minimizing chemical toxicity, creating safer environments for workers and consumers. It also drives employment generation, as industries based on herbal formulations and bio-based materials create jobs in rural and semi-urban regions. Furthermore, education and research benefit as schools and universities incorporating Green Chemistry inspire students to pursue sustainable scientific practices. By embedding these principles into industrial policies and educational curricula, India can foster innovation, economic resilience, and environmental stewardship simultaneously, steering the nation toward a cleaner, safer, and more prosperous future.

### **CHALLENGES AND LIMITATIONS**

Despite its significant potential, the large-scale adoption of natural product-based Green Chemistry faces several challenges. Standardization remains a major issue, as variability in natural raw materials can affect consistency, quality, and reproducibility of chemical processes. Additionally, extraction efficiency and cost and availability pose constraints, since many herbal sources are seasonal or region-specific, limiting continuous industrial supply. Research gaps further hinder progress, as limited funding, infrastructure, and awareness in developing countries slow innovation and practical implementation. Moreover, policy support is still evolving, with regulatory frameworks for certifying green products not yet fully established. Addressing these challenges through government incentives, targeted research collaboration, and public-private partnerships can accelerate the

adoption of herbal and natural alternatives, ensuring that Green Chemistry achieves its environmental, economic, and social objectives while supporting sustainable growth.

### **Policy Framework and Institutional Support**

To effectively align Green Chemistry with the vision of *Viksit Bharat*, India must strengthen its institutional and policy framework. Initiatives such as the National Mission on Green Chemistry and Sustainable Materials can provide coordinated support for research and development in bio-based alternatives. Integrating sustainability, innovation, and indigenous knowledge into the curriculum through NEP 2020 will nurture future scientists with eco-conscious mindsets. Industry-academia collaborations can promote startups and research centers focused on green innovations, while incentives for green manufacturing, including tax benefits and subsidies, encourage industries to adopt environmentally safe processes. Additionally, public awareness campaigns can cultivate consumer preference for eco-certified products. Collectively, these measures can position India as a global leader in sustainable chemical innovation, fostering environmental stewardship, economic growth, and technological self-reliance.

### **CASE STUDIES AND SUCCESS STORIES**

Several initiatives across India illustrate the successful application of natural product-based Green Chemistry and its potential to drive sustainable development. The CSIR-Institute of Himalayan Bioresource Technology (IHBT) has developed herbal dyes and natural preservatives for industrial use, while IIT Guwahati has pioneered the green synthesis of nanoparticles using tea extracts for medical and environmental applications. The Khadi and Village Industries Commission (KVIC) supports small-scale enterprises producing herbal soaps, detergents, and cosmetics, promoting rural entrepreneurship and self-reliance. Additionally, the Forest Research Institute, Dehradun, explores plant-based resins and adhesives for eco-friendly construction materials. Collectively, these case studies demonstrate India's capacity to integrate scientific innovation, environmental sustainability, and socio-economic growth, highlighting a clear pathway toward achieving the vision of *Viksit Bharat*.

### **Educational Integration: Nurturing Future Chemists**

Schools and colleges can become key drivers of Green Chemistry by introducing project-based learning on herbal alternatives. Activities such as preparing herbal cleaners, natural indicators, and eco-friendly dyes can develop scientific curiosity and environmental awareness among students.

Incorporating *Green Chemistry Labs* within the school curriculum aligns with NEP 2020's emphasis on experiential and sustainable education, inspiring students to become innovators for a cleaner and greener *Viksit Bharat*.

### **Future Prospects**

The future of Green Chemistry in India depends on interdisciplinary research that integrates chemistry, biotechnology, agriculture, and environmental sciences. Key areas of focus include the development of bio-based catalysts and polymers, the application of green nanotechnology for pollution control, and the expansion of herbal product industries with both domestic and export potential. Strengthening India's participation in global sustainability collaborations will further enhance scientific innovation and environmental stewardship. Achieving these goals requires a strong commitment to research, entrepreneurship, and supportive policy reforms, ensuring that India's chemical sector grows

sustainably while contributing to economic development, ecological protection, and the vision of *Viksit Bharat*.

**CONCLUSION:**

Natural product-based Green Chemistry represents a harmonious blend of modern science and traditional wisdom. It addresses the pressing global need for eco-friendly technologies while empowering India's journey toward self-reliance and sustainable development. By embracing renewable resources, minimizing pollution, and fostering indigenous innovation, India can set an example for the world.

*Viksit Bharat* is not merely a goal—it is a commitment to progress that values people, planet, and prosperity. Green Chemistry, guided by natural product innovation, is a decisive step in realizing that vision.

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## INDIAN TRADITIONAL KNOWLEDGE AND BIODIVERSITY: A SACRED HERITAGE FOR THE FUTURE

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### Abstract:

India, recognized as one of the seventeen megadiverse countries globally, harbors approximately 8% of the world's biodiversity within 2.4% of Earth's terrestrial area. This remarkable biological wealth is intrinsically linked with millennia-old traditional knowledge systems developed by over 700 indigenous and local communities across diverse ecological zones. This article examines the complex interrelationship between Indian traditional knowledge and biodiversity conservation, exploring how indigenous wisdom has sustained ecological balance while meeting human needs for generations. The study discusses India's four biodiversity hotspots i.e. the Himalayas, Western Ghats, Indo-Burma region, and Sundaland and their overlap with indigenous territories, highlighting the role of traditional communities as de facto custodians of these ecosystems. Special attention is given to sacred groves as unique conservation models, where spiritual beliefs translate into tangible biodiversity protection, harboring rare and endemic species. The article analyzes traditional medical systems (Ayurveda, Siddha, and Unani) that utilize over 7,500 plant species, demonstrating sophisticated ethnobotanical knowledge, while addressing contemporary challenges of biopiracy and intellectual property rights. Agricultural biodiversity forms another critical dimension, with traditional farming practices maintaining thousands of crop varieties adapted to specific ecological conditions, offering valuable genetic resources for climate adaptation. The article examines India's progressive legal framework, including the Biological Diversity Act (2002) and the Protection of Plant Varieties and Farmers' Rights Act (2001), which recognize community rights and ensure benefit-sharing, while acknowledging implementation challenges. Contemporary threats to traditional knowledge including urbanization, generational knowledge loss, climate change, and conflicting conservation policies are critically assessed. The article advocates for integrating traditional ecological knowledge with modern scientific approaches through collaborative research models and community-based conservation strategies.

**Keywords:** Traditional knowledge, biodiversity conservation, indigenous communities, sacred groves, ethnobotany, agricultural biodiversity, biopiracy, sustainable development

### INTRODUCTION:

India stands as one of the world's seventeen megadiverse countries, harboring approximately 8% of global biodiversity within just 2.4% of the Earth's land area (Mittermeier et al., 1997). This extraordinary natural wealth exists in intricate harmony with an equally rich tapestry of traditional knowledge systems that have evolved over millennia. The relationship between Indian traditional knowledge and biodiversity represents not merely a historical curiosity but a living, breathing testament to sustainable resource management and ecological wisdom that holds profound relevance for contemporary environmental challenges (Gadgil et al., 1993).

### The Foundation of Traditional Knowledge

Traditional knowledge in India encompasses the accumulated wisdom, innovations, and practices of indigenous and local communities developed through generations of direct

experience with their natural environment (Berkes, 2012). This knowledge system predates modern scientific classification by thousands of years, embedded deeply within India's cultural, spiritual, and medicinal traditions. From the ancient texts of Ayurveda and the agricultural insights of the Vrikshayurveda to the ecological principles enshrined in sacred groves, Indian traditional knowledge represents a sophisticated understanding of biodiversity conservation and sustainable use.

The Indian subcontinent's diverse geographical features—from the Himalayan heights to coastal mangroves, from arid deserts to tropical rainforests—have given rise to distinct knowledge systems adapted to local ecosystems. Each of India's numerous ethnic groups, numbering over 700 indigenous communities, has developed specialized knowledge about local flora, fauna, and ecological processes (Singh et al., 2015). This diversity of knowledge mirrors the biodiversity it seeks to understand and protect.

### **Biodiversity Hotspots and Traditional Guardians**

India encompasses four global biodiversity hotspots: the Himalayas, the Western Ghats, the Indo-Burma region, and the Sundaland (Myers et al., 2000). These areas contain exceptional concentrations of endemic species facing significant threats. Remarkably, many of these biodiversity-rich regions overlap with areas inhabited by indigenous communities who have served as de facto custodians of these ecosystems for centuries.

The Western Ghats, stretching along India's western coast, exemplifies this convergence. Home to over 7,400 species of flowering plants with nearly 1,800 endemic species, this mountain range has been shaped by traditional agricultural practices, sacred grove protection, and indigenous forest management (Ramesh et al., 1997). Communities here have maintained complex agroforestry systems that preserve biodiversity while meeting human needs, a balance increasingly recognized as essential for conservation success.

Similarly, the northeastern states, part of the Indo-Burma hotspot, showcase remarkable biodiversity alongside extraordinary cultural diversity. The Apatani tribe of Arunachal Pradesh practices an indigenous rice-fish cultivation system that maintains genetic diversity while ensuring food security (Dollo et al., 2009). Their traditional practices have sustained productivity without external input for generations, demonstrating ecological principles that modern agriculture is only beginning to appreciate.

### **Sacred Groves: Living Laboratories of Conservation**

Perhaps no institution better illustrates the intersection of traditional knowledge and biodiversity conservation than India's sacred groves—patches of forest protected through religious and cultural traditions. Estimates suggest India once had over 100,000 such groves, though many have disappeared due to urbanization and changing social values (Malhotra et al., 2001). These sacred spaces, ranging from a few trees to several hectares of pristine forest, are protected through community sanctions rooted in spiritual beliefs.

Sacred groves function as biodiversity repositories, often harboring rare and endangered species. In Kerala's sacred groves, researchers have documented species found nowhere else in the surrounding landscape (Bhagwat and Rutte, 2006; Sachan and Arya 2023). In Maharashtra, the Devrai groves protect water sources while maintaining genetic reservoirs of native species. These groves demonstrate how spiritual values can translate into concrete conservation outcomes, offering models for community-based biodiversity protection.

The traditional knowledge associated with sacred groves extends beyond mere preservation. Communities possess detailed understanding of the ecological relationships within these forests, seasonal variations, and the medicinal or cultural significance of

individual species. This knowledge, transmitted orally through generations, represents an irreplaceable library of ecological information (Gadgil and Vartak, 1976).

### **Traditional Medicine and Bioprospecting**

India's traditional medical systems like Ayurveda, Siddha, and Unani utilize thousands of plant species, representing one of the most sophisticated applications of traditional biodiversity knowledge. The Ayurvedic pharmacopeia alone lists over 1,500 medicinal plants, while total usage across all traditional systems may exceed 7,500 species (Pushpangadan & Dan, 2002, Arya et al. 2024). This represents not only therapeutic knowledge but also deep understanding of plant ecology, sustainable harvesting practices, and conservation.

However, this valuable knowledge has become a double-edged sword in the modern context. The commercial potential of traditional knowledge has attracted bioprospecting the search for valuable genetic and biochemical resources sometimes without proper authorization or benefit-sharing. The famous case of turmeric patents granted to American researchers in the 1990s, eventually revoked after India proved prior traditional use, highlighted the vulnerability of traditional knowledge to misappropriation (Shiva, 1997).

Such incidents spurred India to establish the Traditional Knowledge Digital Library, documenting over 2.4 million pages of traditional knowledge in languages accessible to international patent offices (Gupta, 2011). This initiative aims to prevent biopiracy while preserving traditional knowledge. Yet it also raises complex questions about whether documentation and digitization might inadvertently facilitate exploitation or alter the nature of knowledge traditionally transmitted through oral and experiential means.

### **Agricultural Biodiversity and Traditional Farming**

India's agricultural heritage represents another crucial dimension of traditional biodiversity knowledge. As one of the world's centers of crop domestication, India is home to extraordinary agricultural biodiversity. Farmers have cultivated and preserved thousands of rice varieties, each adapted to specific local conditions flood-resistant varieties for coastal areas, drought-tolerant types for arid regions, and cold-resistant varieties for higher elevations (Brush, 2004, Arya and Sachan 2022).

Traditional farming systems like the Navadanya (nine seeds) practice encourage crop diversity, maintaining genetic reservoirs while providing nutritional variety. Such systems incorporate nitrogen-fixing crops, pest-detering plants, and complementary species in sophisticated polyculture arrangements that maintain soil health and reduce pest pressure without chemical inputs.

The knowledge embedded in these agricultural practices extends to seed selection, storage techniques, soil management, and pest control using natural substances. Farmers possess intricate understanding of microclimates, soil types, and seasonal patterns developed through generations of observation and experimentation (Altieri, 2004, Arya 2019). This knowledge has enabled cultivation in challenging environments from terraced Himalayan slopes to flood-prone deltaic regions demonstrating remarkable adaptive capacity.

### **Challenges and Threats**

Despite its value, Indian traditional knowledge faces mounting pressures. Rapid urbanization draws younger generations away from rural areas and traditional lifestyles, breaking chains of knowledge transmission. Modern education systems often devalue traditional knowledge, creating social incentives to abandon these practices (Agrawal, 2002). Climate change alters the ecological conditions under which traditional knowledge developed, sometimes rendering traditional practices less effective.

The commercialization of biodiversity poses another significant threat. As traditional knowledge attracts commercial interest, there's risk of exploitation without adequate

compensation to knowledge holders. The complexity of establishing ownership over collectively held, orally transmitted knowledge complicates benefit-sharing arrangements. Indigenous communities often lack resources to protect their knowledge through modern legal mechanisms like patents.

Additionally, conservation policies sometimes conflict with traditional practices. Strict preservation models that exclude human activities can undermine communities who have sustainably managed these ecosystems for generations. The transition from community management to state control has occasionally led to degradation rather than protection, as local knowledge and stewardship are displaced (Kothari et al., 2013, Rani and Arya, 2021).

### **Legal Framework and Policy Responses**

India has developed one of the world's most comprehensive legal frameworks for protecting traditional knowledge and biodiversity. The Biological Diversity Act of 2002 establishes a three-tier structure of National, State, and local Biodiversity Management Committees, explicitly recognizing the role of local communities in biodiversity conservation and ensuring equitable benefit-sharing from bioresource utilization (Venkatesan, 2009).

The Protection of Plant Varieties and Farmers' Rights Act of 2001 acknowledges farmers' contributions to agricultural biodiversity conservation and their rights to save, use, exchange, and sell farm-saved seeds. This legislation represents pioneering recognition of farmers as innovators and knowledge holders rather than mere producers.

However, implementation challenges persist. Many communities remain unaware of their rights under these laws. Bureaucratic complexities hinder benefit-sharing arrangements. Conflicts arise between intellectual property rights frameworks designed for individual inventors and collective knowledge systems. These tensions reflect broader challenges in reconciling traditional knowledge systems with modern legal and economic structures.

### **Integrating Traditional and Scientific Knowledge**

The future of biodiversity conservation in India likely depends on successfully integrating traditional knowledge with modern scientific approaches. Research increasingly validates traditional practices, revealing sophisticated ecological understanding in what dismissive observers once considered mere superstition or primitive practice. Studies demonstrate that sacred groves maintain higher biodiversity than surrounding areas, traditional water management systems enhance groundwater recharge, and traditional crop varieties possess genetic traits valuable for climate adaptation (Ramakrishnan, 2007, Goel et al. 2023).

Collaborative research models that engage knowledge holders as partners rather than subjects show promise. Such approaches respect the intellectual contributions of traditional communities while bringing scientific rigor to documentation and validation. Joint management of protected areas, combining scientific monitoring with traditional stewardship practices, has produced encouraging results in several locations.

Educational initiatives that incorporate traditional knowledge alongside modern science can help preserve this heritage while making it relevant to younger generations. Some schools in tribal areas now teach traditional ecological knowledge as part of the curriculum, validating local wisdom while equipping students with both traditional and modern knowledge systems.

### **The Path Forward**

As India confronts environmental challenges from climate change to habitat loss, traditional knowledge offers crucial insights for building resilience. Traditional water harvesting techniques, sustainable forestry practices, and climate-adapted crop varieties

represent ready-made solutions developed over centuries of experimentation. The challenge lies in adapting these practices to contemporary contexts while preserving their essential wisdom.

Empowering indigenous and local communities as primary stakeholders in conservation efforts rather than excluding them represents a critical shift. Community-based conservation models that recognize traditional rights and knowledge can achieve both biodiversity protection and social justice goals. Ensuring equitable benefit-sharing from biodiversity commercialization provides economic incentives for conservation while acknowledging the contributions of knowledge holders.

Documentation efforts must balance preservation needs with respect for traditional knowledge systems. While recording knowledge for patent prevention serves important protective functions, it should not replace living traditions or facilitate exploitation. Digital platforms might enable knowledge sharing among communities while restricting external access.

India's traditional knowledge and biodiversity represent intertwined heritages, each supporting and shaping the other. As the world seeks sustainable pathways forward, this ancient wisdom offers invaluable guidance, reminding us that humans can be not just destroyers of nature but its knowledgeable stewards. The challenge for contemporary India lies in honoring this heritage while adapting it to meet twenty-first-century needs—a task requiring creativity, respect, and commitment to both ecological and cultural preservation.

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## CLIMATE CHANGE: REASONS, EFFECTS, AND CHALLENGES

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### Abstract:

Climate change is one of the most pressing issues of the 21st century, affecting every aspect of human life and the natural environment. It refers to significant and long-term changes in global temperatures, weather patterns, and precipitation levels. While natural processes such as volcanic eruptions and variations in solar radiation have historically contributed to shifts in the Earth's climate, the current pace and intensity of change are largely driven by human activities.

**Keywords:** Climate change, Industrial Revolution, Greenhouse Gas

### INTRODUCTION:

The Industrial Revolution marked a turning point, as the massive use of fossil fuels, deforestation, and rapid urbanization accelerated greenhouse gas emissions, resulting in a steady rise in global temperatures. According to the Intergovernmental Panel on Climate Change (IPCC), the average global temperature has increased by approximately 1.2°C since pre-industrial times. This may seem small, but even slight variations in temperature can trigger severe environmental, social, and economic consequences. The following discussion provides an in-depth exploration of the reasons, effects, and challenges associated with climate change, emphasizing the need for global cooperation, policy reforms, and lifestyle transformations to mitigate its far-reaching impacts.

### I. REASONS FOR CLIMATE CHANGE:

**1. Greenhouse Gas Emissions-** The primary reason behind climate change is the accumulation of greenhouse gases (GHGs) in the atmosphere. Gases such as carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), and fluorinated gases trap heat and prevent it from escaping into space—a process known as the greenhouse effect. While this natural process keeps the Earth warm enough to sustain life, excessive human-induced emissions have intensified it, leading to global warming.

- Carbon Dioxide: The largest contributor, released mainly from burning coal, oil, and natural gas for energy and transportation. Industrial activities and cement production further add to atmospheric CO<sub>2</sub> levels.
- Methane: Released from agriculture (especially rice paddies), livestock digestion, landfills, and fossil fuel extraction. Methane is over 25 times more potent than CO<sub>2</sub> in trapping heat.
- Nitrous Oxide: Emitted through agricultural fertilizers, industrial activities, and waste management processes.
- Fluorinated Gases: Synthetic gases used in refrigeration, air conditioning, and manufacturing, though emitted in smaller quantities, have extremely high global warming potential.

**2. Deforestation and Land Use Changes-** Forests act as carbon sinks, absorbing CO<sub>2</sub> during photosynthesis. However, deforestation for agriculture, logging, and urban expansion drastically reduces this capacity. The loss of forest cover not only releases stored carbon but also disrupts regional rainfall patterns and soil fertility. Slash-and-burn agriculture, particularly in tropical regions like the Amazon and Southeast Asia, has become a significant driver of global emissions.

**3. Industrialization and Urbanization-** The rise of industrial economies has led to extensive energy consumption and waste generation. Factories, power plants, and transportation systems emit massive amounts of greenhouse gases. Moreover, urban heat islands—areas where cities are significantly warmer than surrounding rural areas—intensify local climate variations, increasing the demand for energy (e.g., air conditioning) and further fueling the cycle.

**4. Agricultural Practices-** Agriculture contributes substantially to climate change through methane emissions from livestock, nitrous oxide from fertilizers, and deforestation for croplands. Unsustainable irrigation and tilling practices also degrade soil, reducing its carbon sequestration ability.

**5. Waste Management and Pollution-** Inadequate waste disposal and landfill management release methane, while plastic pollution affects oceanic ecosystems that otherwise absorb CO<sub>2</sub>. Industrial and chemical wastes pollute water and air, amplifying the greenhouse effect.

**6. Natural Causes (Minor Contribution)-** While human activity dominates current climate change, natural processes like volcanic eruptions, oceanic circulation changes, and solar radiation fluctuations have historically influenced Earth's climate. However, these factors cannot explain the rapid warming observed over the last century.

## II. EFFECTS OF CLIMATE CHANGE:

**1. Rising Global Temperatures-** The most direct effect of climate change is the increase in global average temperature. This warming influences every natural system, from the melting of glaciers to changes in species distribution. The last decade has been the hottest on record, with extreme heat waves becoming more frequent and intense. Higher temperatures also lead to greater evaporation rates, causing droughts in some regions and heavy rainfall in others.

**2. Melting Glaciers and Rising Sea Levels-** The accelerated melting of polar ice caps and glaciers contributes to rising sea levels. This poses a significant threat to coastal areas, small island nations, and low-lying cities such as Mumbai, Dhaka, and Jakarta. According to the IPCC, global sea levels could rise by more than one meter by the end of the century, displacing millions of people and destroying habitats.

**3. Extreme Weather Events-** Climate change intensifies the frequency and severity of natural disasters—such as hurricanes, cyclones, floods, droughts, and wildfires. For instance, warmer ocean temperatures fuel stronger tropical storms, while prolonged dry periods increase wildfire risks. Countries like Australia, Greece, and the U.S. have faced record-breaking wildfires in recent years.

**4. Disruption of Ecosystems and Biodiversity Loss-** Altered temperature and rainfall patterns disrupt ecosystems and threaten species survival. Coral reefs, for example, are bleaching due to warmer oceans. Polar bears and penguins face habitat loss as ice melts, while shifting climate zones push many terrestrial species to migrate or face extinction. Biodiversity loss undermines ecosystem resilience and affects food chains, agriculture, and medicine.

**5. Impact on Agriculture and Food Security-** Climate change alters growing seasons, reduces crop yields, and increases pest infestations. Droughts and unpredictable rainfall make farming less reliable, especially in developing nations dependent on rain-fed agriculture. Rising temperatures also affect livestock health and productivity, threatening global food supply chains.

**6. Water Scarcity-** Glacial meltwater and irregular rainfall patterns have reduced the availability of freshwater resources. Many regions, especially in Africa and Asia, are facing acute water shortages. The competition for limited water supplies could lead to conflicts and migration crises.

**7. Human Health Impacts-** Climate change poses severe health challenges—heat stress, vector-borne diseases (like malaria and dengue), respiratory issues from air pollution, and malnutrition due to food scarcity. Warmer temperatures expand the habitats of disease-carrying insects, while extreme weather events disrupt healthcare systems.

**8. Economic and Social Inequality-** The economic impact of climate change is profound, particularly for developing nations that lack resources for adaptation. Poor communities are more vulnerable to disasters, food insecurity, and displacement. Climate change thus exacerbates existing inequalities, creating a cycle of poverty and vulnerability.

**9. Ocean Acidification-** Increased CO<sub>2</sub> absorption by oceans leads to acidification, which harms marine life such as corals, shellfish, and plankton. Since these organisms form the foundation of the marine food web, acidification threatens the entire ocean ecosystem and the livelihoods of millions dependent on fisheries.

### III. CHALLENGES OF CLIMATE CHANGE:

**1. Mitigation vs. Adaptation-** Mitigation involves reducing emissions, while adaptation focuses on coping with the inevitable impacts. Balancing these two approaches is a global challenge, as developing nations often prioritize economic growth over emission cuts. Effective policies must combine renewable energy transitions, reforestation, and resilience-building measures.

**2. Political and Economic Barriers-** Climate change solutions require international cooperation, but differing national interests hinder progress. Developed nations, historically responsible for the majority of emissions, face pressure to support developing countries through finance and technology transfer. However, economic competition and political polarization often delay collective action.

**3. Technological and Infrastructural Limitations-** Transitioning from fossil fuels to renewable energy demands massive infrastructure investment. Many countries lack access to affordable clean technologies or the resources to modernize their energy systems. Additionally, some renewable sources are intermittent and require storage innovations to ensure reliability.

**4. Environmental Refugees and Migration-** As sea levels rise and extreme weather worsens, millions of people are forced to migrate. Climate refugees face uncertain futures, and host nations struggle with social and economic integration challenges. This adds a humanitarian dimension to the climate crisis.

**5. Lack of Awareness and Behavioral Change-** Individual actions collectively influence global outcomes, yet awareness about sustainable living remains limited. Consumerism, wasteful energy use, and unsustainable diets contribute to emissions. Educational programs and grassroots initiatives are essential for promoting climate responsibility.

**6. Loss of Indigenous Knowledge-** Traditional ecological knowledge held by indigenous communities offers valuable insights into sustainable living. However, modernization and displacement are eroding this wisdom. Preserving indigenous practices can enhance climate resilience and biodiversity conservation.

**7. Financing Climate Action-** The estimated cost of achieving the Paris Agreement goals is trillions of dollars annually. Developing countries depend on climate finance commitments from wealthier nations, but funding gaps and bureaucratic hurdles slow progress. The challenge is ensuring that resources are equitably distributed and effectively utilized.

**8. Governance and Accountability-** Transparent and accountable governance is crucial for implementing climate policies. Corruption, weak institutions, and lack of data hinder progress in many regions. International agreements like COP summits aim to address these gaps, but enforcement remains inconsistent.

#### **IV. GLOBAL AND LOCAL EFFORTS TO COMBAT CLIMATE CHANGE:**

##### **1. International Agreements**

- Paris Agreement (2015): A landmark global treaty where nations pledged to limit temperature rise to below 2°C, preferably 1.5°C, by reducing emissions and supporting sustainable development.
- Kyoto Protocol (1997): The first binding international agreement targeting emission reductions by industrialized countries.
- UN Sustainable Development Goals (SDG 13): Calls for urgent action to combat climate change and its impacts.

**2. Renewable Energy Transition** - Solar, wind, hydro, and geothermal power are key alternatives to fossil fuels. Countries like Germany, China, and India are investing heavily in renewable energy infrastructure. The shift not only reduces emissions but also creates green jobs and promotes energy security.

**3. Reforestation and Conservation**- Large-scale afforestation projects, like India's Green India Mission and the UN's Trillion Tree Campaign, aim to restore degraded lands and enhance carbon sinks. Protecting existing forests and biodiversity hotspots remains equally critical.

**4. Technological Innovations**- Emerging technologies such as carbon capture and storage (CCS), electric vehicles, smart grids, and sustainable agriculture hold promise for emission reduction. Research into hydrogen fuel and bioenergy could revolutionize clean energy.

**5. Climate Education and Public Participation**- Awareness campaigns, environmental education, and youth-led movements like Fridays for Future have amplified global attention on climate issues. Individual actions—reducing waste, conserving energy, and adopting sustainable diets—play a vital role in collective change.

#### **V. THE WAY FORWARD:**

To confront climate change effectively, a multi-dimensional approach is essential:

- Strengthening global governance through binding commitments and transparent monitoring.
- Investing in research and innovation to develop affordable, clean technologies.
- Encouraging sustainable lifestyles that minimize waste and overconsumption.
- Empowering vulnerable communities through climate adaptation funds and capacity building.
- Integrating climate action into education, so that future generations grow up with environmental awareness.

The battle against climate change is not just scientific—it is moral, political, and economic. Every individual, institution, and government must recognize their shared responsibility in preserving the planet for future generations.

#### **CONCLUSION:**

Climate change is not a distant threat—it is a present reality shaping our world today. The reasons behind it are deeply rooted in industrial progress, deforestation, and unsustainable human practices. Its effects are visible across continents, from melting glaciers and rising seas to heatwaves and biodiversity loss. The challenges it poses—social, economic, and political—demand urgent, unified global action. While the problem is complex, solutions exist. Transitioning to renewable energy, protecting ecosystems, promoting sustainable development, and enhancing international cooperation are key steps forward. Climate change is ultimately a test of humanity's collective will and wisdom. The choices made today will determine whether future generations inherit a thriving planet or one scarred by neglect.

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## EDUCATING FOR ECOLOGY: A SCHOOL'S JOURNEY IN BIRD BIODIVERSITY CONSERVATION

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### Abstract:

Birds are vital indicators of environmental health and play a significant role in maintaining ecological balance through pollination, seed dispersal, and pest control. However, rapid urbanization, deforestation, pollution, and climate change have caused an alarming decline in avian diversity across India. Recognizing the urgent need for conservation at the grassroots level, *Swami Vivekanand Public School, Harda* launched a comprehensive institutional initiative to conserve bird biodiversity through environmental education, awareness, and community involvement. This study presents the school's structured and multidisciplinary approach that integrates classroom learning with field-based ecological action. The initiative emphasizes experiential learning, project-based research, and student participation in real-world conservation efforts. Key strategies include the formation of a Bird Biodiversity Club, creation of bird-friendly spaces within the campus, installation of feeders and nesting boxes, and plantation of native fruit-bearing trees. In addition, awareness campaigns, exhibitions, and inter-school competitions were organized to sensitize the community. The project also fostered collaboration with the local Forest Department, NGOs, and parents, ensuring collective ownership of conservation efforts. The use of digital tools for species identification and documentation enhanced the scientific accuracy and engagement of students. The outcomes revealed a significant increase in local bird sightings, heightened environmental awareness among students, and the emergence of leadership qualities through participation and responsibility. The initiative aligns with the goals of the National Education Policy (NEP) 2020 and the United Nations Sustainable Development Goals (SDGs), particularly those related to quality education, climate action, and life on land. Ultimately, this school-led model demonstrates how educational institutions can act as catalysts for ecological transformation, nurturing empathy, responsibility, and a lifelong commitment to conserving biodiversity through education, action, and community partnership.

**Keywords:** Bird Conservation, Biodiversity, Environmental Education, Institutional Initiative, Sustainable Practices, Swami Vivekanand Public School, Hardada

### INTRODUCTION

Birds are among the most visible, melodious, and fascinating creatures that share our planet. Their presence enriches the natural world, providing both aesthetic joy and ecological services essential to life on Earth. From pollination and seed dispersal to pest regulation and nutrient cycling, birds contribute profoundly to maintaining environmental balance. They act as natural indicators of the planet's health—when bird populations decline, it signals the degradation of ecosystems. Unfortunately, in recent decades, India has witnessed a concerning reduction in bird diversity due to deforestation, habitat fragmentation, pesticide overuse, pollution, and the effects of climate change. Urbanization and industrialization have led to the loss of nesting areas, scarcity of food, and increased vulnerability to human-induced threats.

The conservation of birds, therefore, is not merely an environmental concern but a moral and ethical obligation for all. Protecting these creatures ensures the preservation of biodiversity, ecological equilibrium, and the sustainability of natural resources for future

generations. Conservation must begin with awareness, and awareness must begin with education. This belief forms the foundation of *Swami Vivekanand Public School, Harda's* institutional initiative toward bird biodiversity conservation.



Schools are not only places for academic instruction but also dynamic spaces for nurturing responsible citizenship and environmental stewardship. They have the power to influence attitudes, shape behaviors, and inspire action. *Swami Vivekanand Public School, Harda* recognized this potential and integrated bird biodiversity conservation into its core educational philosophy. By merging learning with ecological action, the school created a living laboratory where students observe, experience, and contribute to nature's preservation. The school's approach is guided by the principles of *Environmental Education for Sustainable Development (EESD)* and aligns with the *National Education Policy (NEP) 2020*. Both frameworks emphasize the importance of experiential learning—learning by doing—where students gain knowledge through practical engagement with their surroundings. Through this initiative, environmental awareness is not treated as a separate subject but woven across disciplines. Science lessons explain the biological importance of birds; language classes encourage essays and poems about nature; art classes promote creative expression through sketches, posters, and models on conservation themes.

The school's program encourages students to move beyond the classroom and interact directly with the environment. Activities such as field observations, birdwatching, maintaining eco-journals, and creating bird-friendly spaces on campus promote hands-on

understanding. Students are taught to identify local species, study their feeding and nesting habits, and understand their role in the ecosystem. The use of locally available materials to create bird feeders, water pots, and nesting boxes demonstrates sustainable and resourceful practices.

Moreover, the initiative fosters community involvement, recognizing that conservation efforts are most effective when collective. Parents, local residents, and the Forest Department collaborate with the school to plant trees, protect nesting areas, and raise awareness about minimizing pollution and pesticide use.

In essence, *Swami Vivekanand Public School, Hardada* exemplifies how education can transcend traditional boundaries to become a force for ecological transformation. By integrating values of respect, responsibility, and sustainability, the institution not only conserves bird biodiversity but also nurtures young environmentalists—citizens who understand that safeguarding nature is integral to safeguarding life itself.

### **Objectives of the Study**

The primary objectives of the initiative and this study are:

1. To promote awareness about the importance of birds in maintaining ecological balance.
2. To identify and conserve local bird species within the Hardada region.
3. To integrate environmental education into the school curriculum through hands-on activities.
4. To encourage students and teachers to become active participants in biodiversity conservation.
5. To build partnerships between the school, community, and environmental organizations for sustainable ecological practices.

### **METHODOLOGY:**

The school adopted a participatory and interdisciplinary approach that seamlessly blended education, observation, and field action to promote bird biodiversity conservation. The initiative began with a baseline study, where students and teachers identified and documented local bird species through systematic observation. This was followed by curriculum integration, ensuring that environmental themes were embedded within science, social science, and language subjects to build conceptual understanding. Emphasizing project-based learning, students undertook hands-on projects exploring bird habitats, feeding patterns, and migratory behaviors. To spread awareness, the school organized campaigns, rallies, poster-making competitions, exhibitions, and seminars, encouraging creativity and community engagement. Simultaneously, habitat creation efforts within the campus included installing bird feeders, water baths, and nesting boxes, fostering a safe environment for avian life. The program also emphasized community outreach, involving parents, local residents, and environmental organizations in tree plantation and bird conservation drives, thereby extending the impact beyond the school premises. To ensure sustainability and assess progress, a structured monitoring and evaluation system was implemented, with students maintaining observation records to track seasonal changes and the growing diversity of bird species. This comprehensive and collaborative methodology transformed learning into action, instilling ecological responsibility among all stakeholders.

### **Institutional Approach (Integration into Curriculum)**

Swami Vivekanand Public School, Hardada, integrated bird biodiversity conservation into its regular curriculum to foster environmental consciousness among students. Teachers

across disciplines infused ecological themes into their lessons—Science explored food chains, adaptation, and avian physiology; Social Science examined the human impact on ecosystems; and English encouraged essays, poems, and speeches on conservation themes. Art and Craft periods were utilized for making posters and models of bird habitats. This cross-curricular approach made environmental learning contextual, engaging, and meaningful. Students began to connect theoretical knowledge with real-world ecological issues, developing both intellectual understanding and emotional connection toward nature.

### **Bird Biodiversity Club**

The establishment of the *Bird Biodiversity Club* became the cornerstone of the school's conservation initiative. Comprising enthusiastic students from Classes VI to XII, the club met weekly to observe and record bird activity within and beyond the campus. Members maintained field diaries documenting bird species, behavior, feeding patterns, and nesting habits. They created a digital album titled "*Birds of Our Campus*", showcasing photographs and data collected during observations. The club also organized talks by experts, quizzes, and awareness campaigns. Through these activities, students developed scientific observation skills, teamwork, and a strong sense of environmental responsibility and stewardship.

### **Field Visits and Surveys**

To enhance experiential learning, the school organized regular field visits to nearby wetlands, farmlands, and forested areas. Students, guided by teachers and experts from the Forest Department and local NGOs, studied birds in their natural habitats, noting their feeding and migratory behaviors. These surveys were particularly insightful during the migratory season, when species like *Siberian cranes*, *wagtails*, and *starlings* visited the region. Students learned to use binoculars, cameras, and mobile apps for bird identification. These authentic field experiences not only strengthened ecological knowledge but also cultivated patience, observation, and appreciation for the interconnectedness of life in natural ecosystems.

### **Creating Bird-Friendly Spaces**

Under the school's *Green Campus Initiative*, several eco-friendly measures were implemented to make the campus a haven for birds. Bird feeders crafted from recycled bottles were installed on trees, while shaded water bowls provided relief during scorching summers. Native fruit-bearing trees such as *neem*, *jamun*, *guava*, and *amla* were planted to attract and nourish local species. The gardening team minimized pesticide use, maintaining an insect-rich and healthy environment. These efforts transformed the school grounds into a thriving bird-friendly zone. Students took pride in nurturing this living ecosystem, learning that even small, consistent actions can create significant ecological change.

### **Students' Participation**

The most remarkable aspect of the project was active student involvement. Students became researchers, volunteers, and advocates of conservation. They participated in:

- ❖ **Data Collection:** Identifying and recording bird species.
- ❖ **Awareness Campaigns:** Preparing skits, posters, and slogans for "Save the Birds" week.
- ❖ **Eco-Journals:** Writing reflections, poems, and reports about their experiences.
- ❖ **Innovative Projects:** Designing bird feeders using waste materials and documenting their use by birds.
- ❖ **Peer Learning:** Conducting awareness sessions for primary students about the importance of birds.

Through these activities, students developed scientific temper, empathy towards living beings, and leadership qualities.

### **Community and Parental Involvement**

The success of the initiative largely depended on community collaboration. The school encouraged parents to participate in plantation drives and install birdhouses in their homes. Local farmers were sensitized about the harmful effects of chemical fertilizers and pesticides on bird populations. The school also collaborated with the *Forest Department, Harda*, for expert talks and workshops on biodiversity conservation.

Special events such as *World Environment Day*, *World Sparrow Day*, and *Earth Day* were celebrated with public participation, reinforcing a collective sense of ecological responsibility.

### **Use of Technology and Documentation**

Technology played a significant role in enhancing the project's effectiveness. Students used mobile photography and apps like *iNaturalist* and *eBird* for species identification. The data collected was compiled into a digital report, which helped monitor changes in bird populations across seasons. The school created a short documentary titled "*Wings of Harmony*" showcasing the entire journey, which was shared on social media platforms to inspire other institutions.

### **Challenges Faced**

Despite its successes, the initiative faced several challenges that tested the school's commitment to bird biodiversity conservation. Initially, both teachers and students lacked technical expertise in identifying bird species and understanding their behaviors, which required additional training and guidance. Weather conditions, such as extreme heat, heavy rainfall, or seasonal changes, often limited outdoor observations and field activities. Moreover, some community members were initially indifferent or unaware of the importance of conservation, making outreach efforts more demanding. Regular maintenance of bird feeders, water bowls, and planted areas also required consistent effort. Nevertheless, through persistent motivation, teamwork, and strong support from the school management, these challenges were effectively managed, ensuring the long-term sustainability and impact of the project.

### **Outcomes and Impact**

The initiative yielded remarkable results within just two academic years, demonstrating the effectiveness of school-led conservation efforts. There was a noticeable increase in local bird populations, with frequent visits from sparrows, bulbuls, mynas, and parakeets to the campus. Students developed valuable skills in data collection, observation, and documentation, enhancing both their scientific understanding and practical experience. The project also fostered community awareness, inspiring neighboring schools and local residents to adopt bird-friendly practices in their surroundings. Additionally, the school received formal appreciation from the District Forest Office for its contributions to local biodiversity. These outcomes clearly show that when education is combined with proactive engagement and community collaboration, it can produce significant and lasting environmental impact.

### **Alignment with Sustainable Development Goals (SDGs)**

The initiative undertaken by Swami Vivekanand Public School, Harda, aligns closely with several United Nations Sustainable Development Goals (SDGs). Goal 4: Quality Education is addressed by integrating environmental education into the curriculum, fostering

holistic learning and awareness among students. Goal 13: Climate Action is supported through the promotion of sustainable practices, such as tree planting, habitat creation, and reduction of pesticide use, which contribute to climate resilience. Additionally, Goal 15: Life on Land is advanced by protecting terrestrial ecosystems and conserving local biodiversity. By embedding sustainability into education, the school not only nurtures responsible future citizens but also actively contributes to both local and global environmental objectives.

### Lessons Learned

Effective environmental education requires moving beyond textbooks to include hands-on, experiential learning that engages students directly with nature. School campuses can serve as living laboratories, providing opportunities to observe, study, and interact with local biodiversity. Active student involvement in real-world conservation activities helps build character, responsibility, and a sense of stewardship for the environment. Collaborations and partnerships with community members, parents, and government bodies further enhance the impact and sustainability of such initiatives. Even small, consistent actions—like placing water bowls for birds or planting native trees—can create meaningful and lasting ecological benefits, demonstrating that every effort counts.

### RECOMMENDATIONS

1. **Replication Model:** Other schools can replicate this initiative by creating bird-friendly spaces and eco-clubs.
2. **Teacher Training:** Periodic workshops on biodiversity can enhance teachers' capacity.
3. **Interdisciplinary Approach:** Integrate environmental themes across all subjects.
4. **Monitoring System:** Establish a long-term bird monitoring program with student participation.
5. **Recognition Programs:** Schools should reward eco-conscious practices to encourage wider participation.

### CONCLUSION

The journey of *Swami Vivekanand Public School, Hardada* in conserving bird biodiversity exemplifies how education can be a powerful tool for environmental transformation. The school's integrated approach—combining classroom learning, practical action, and community engagement—has created an ecosystem where both birds and students thrive. This initiative not only conserved avian diversity but also nurtured ecological values, empathy, and scientific curiosity among students. As educators, the ultimate goal is to inspire every child to become a protector of nature, realizing Swami Vivekananda's vision of education as the manifestation of the perfection already in man. By educating for ecology, the school has illuminated a path where knowledge, compassion, and action unite to safeguard the planet's precious biodiversity.

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## CLIMATE CHANGE AS A CATALYST FOR BIOLOGICAL STRESS

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### Abstract:

Climate change is a permanent change in weather patterns between the tropical regions and the tropics. It is slowly converting into an international threat. Environmental changes are responsible for climatic dynamics. Environmental stress is associated with increased levels of anxiety, depression, post-traumatic stress disorder (PTSD) and environmental anxiety. Decline in the productivity of vegetation gets transformed into livelihood stress, economic pressure and potential mental health. Ecosystems face stress as soil stabilization; carbon sequestration get disturbed. High temperatures can disrupt the hypothalamic-pituitary-gonadal axis resulting in hormonal imbalance which affect reproduction, growth and metabolism of animals and even human beings. An effect of climatic stress is that endocrine-disrupting chemicals (EDCs), especially pesticides and heavy metals, are made bioavailable and are toxic to life forms.

**Keywords:** Climate, Environmental stress Environmental change, Carbon sequestration, Hypothalamic-Pituitary-Gonadal Axis, Endocrine-disrupting chemicals, Health

### INTRODUCTION

Climate is the atmospheric- ocean land system of a location, or planet (usually in variation, and frequency), of weather-related parameters (temperature, precipitation, wind, humidity, etc.), over time in terms of statistics.

In practice the World Meteorological Organization (WMO) refers to 30 years interval as a normal climate but the term is also used with shorter or longer intervals (months, centuries, geologic time) (Glossary of Climate Change, n.d.). There arises a question of difference between weather and climate and this confuses a lot of people. Weather refers to the state of that atmosphere at a particular place and at a particular time (hourly or daily change).

On the other hand, climate refers to the statistics of weather over extended periods of time: the typical condition, its variability (degree of variability), the existence of extremes. Climate can be formally considered as the distribution of probability of climatic conditions and climate change as variation of distribution.

Climate change is a permanent change in weather patterns between the tropical regions and the tropics. It is an international threat that has started exerting pressure on several industries. The vulnerability of agricultural sector is one of such scenarios which make the world concerned due to the risk of inadequate production and food stocks affected by irreversible weather changes.

### CLIMATE CHANGE AMPLIFIES STRESS ACROSS LIVING SYSTEMS

Various studies done have tried to evaluate the indirect effects of climate change on mental health and conclude that both the short term and long-term climate stressors, including severe weather conditions, displacement, and long-term environmental degradation, play a significant role in leading to psychological distress.

These sources of stress were also associated with increased levels of anxiety, depression, post-traumatic stress disorder (PTSD) and environmental anxiety particularly among victims who were vulnerable. Studies highlight that in humans, mental healthcare intervention is an urgently needed intervention, as the psychological impacts of climate

change need to be overcome for a healthy life. It suggests to focus on related policies and resilience-enhancing measures (Clayton and Crandon, 2024).

Factors that have an impact on the climatic condition include:

- I. Natural
- II. Anthropogenic or Man-made

### I. Natural Factors Causing Stress And Impacting Climate

Natural factors involve disturbance of a period of the day and night, volcanic eruption, hot weather and the earth orbit changes etc. They can be further categorized as:

#### • Photosynthetically Active Light Intensity

Due to changes in climate the light intensity is either high or low and this leads to an abiotic stress among the primary producers. When the light intensity falls below the optimal values, there is a loss in the photosynthetic productivity, loss in biomass and a loss in the carbon absorption and ecosystem stability.

By contrast, excessive light intensity can cause photoinhibition or photodamage of plants and algae, generate reactive oxygen species and cause damage to photosystems, as well as slow down growth.

This stress on primary producers spreads through the food web and leads to imbalance and additional vulnerability. It causes additional disruptions in the ecosystem (Gomez-Bellot *et al.*, 2023).

At the human-level, decline in the productivity of vegetation leads to degradation of forests, affects crop production and the ecosystem properties of soil stabilization and carbon sequestration decline. It then gets transformed into livelihood stress, economic pressure and potential mental-health disorders.

#### • Variations In The Orbit Of The Earth

Geometric variations in the Milankovitch cycles (eccentricity, axial tilt/obliquity, precession) lead to variation in the distribution and the amount of incident solar radiation on geologic-millennial periods.

The changes in the orbit lead to changes in insolation, glacial-interglacial cycles, increase or decrease of ice-caps, changes in carbon cycles reinvestment and large-scale climate restructuring.

These alterations expose the ecosystem to climatic pressure (higher/lower latitudes have longer/shorter seasons, more/less insolation, or abrupt changes), and, therefore, reduce the resistance and resiliency of ecological communities.

Habitable regions, agricultural lands, sources of resources and socio-economic stress (migration, food insecurity, conflict) in human systems are also restructured by these climate restructuring (Ganopolski, 2024).

#### • Volcanic Eruptions And Glaciation Melting

Volcanic eruptions (aerosols, sulphates, ash and gaseous) and glaciation melting (cooling by aerosols, warming by CO<sub>2</sub>) lead to the sudden changes in the insolation or the chemistry of the atmosphere, exposing the ecosystems to stress which include abrupt temperature change and acid deposition.

The melting glaciers which augment the underneath crust pressure leads to volcanic/tectonic activities in the glacier-covered regions thereby establishing a connection between the cryospheric and volcanic stress. Systems previously insulated by the constant cold climates, undergo changes. The species adapted to that sort of environment get affected by glaciers and become casualties of habitat destruction or restructuring.

Human communities undergo hydrological distress, volcanic eruption threat, topography, and related socioeconomic and mental-health pressures (Aubry *et al.*, 2022).

#### • Sea Level Rise and Tsunamis

Organized by:

Shri Rajiv Gandhi Government College Banda, District Sagar, MP

The rise in sea level (SLR) as a result of the warming of the ocean and the melting of ice sheets on land is changing the hydrologic cycles and the ecology of the coastal ecosystems. They are now suffering from saltwater intrusion, wetland loss, habitat fragmentation, and increased erosion.

These processes also increase the chances of extreme water levels which include storm surges and tsunamis. Tsunamis, which are the sea-level excursions caused by seismic activity, landslides or volcanoes produce acute ecological effects. The effect includes massive mortality, habitat loss, resettlement, and redistribution of sediments. Severe impacts are loss of life and forced displacement, the destruction of infrastructures, and the occurrence of severe psychological trauma.

The cumulative impact of regular SLR and frequent destructive waves of tsunamis causes persistent stress on the human communities co-located with the coastline. They have to face loss of livelihoods, psychological impact, pressure to leave and the face a disturbed equilibrium of the seaside ecosystems (Weiss *et al.*, 2022).

## II. **Anthropogenic Factors Causing Stress And Impacting Climate**

Anthropogenic or man-made activities like burning of fossil fuel, poor agricultural practices, deforestation, and land fragmentation into farmlands, urbanization and industrialization are extremely negative in influence for the environment. It is due to these activities that emission of greenhouse gases occurs in the atmosphere.

- **Deforestation**

Forests help to maintain the carbon quantity in soil, mineral cycle as well as water cycle and biodiversity. Cutting of trees or clearing of forests is called deforestation and this disturbs mineral cycle, water cycle and even biodiversity.

Before the native forests were turned into plantations, grasslands, and agricultural land, the bacterial diversity was high, and the fungal communities were more homogenous, with no prevalence of diseases.

Deforestation greatly influenced as well as diminished the soil functional processes regarding carbon storage, cycling of nitrogen and decomposition of the organic matter.

Changes in soil pH and total phosphorus mostly control the responses of microbial communities (bacterial and fungal diversity) to deforestation. In addition, soil fungal diversity and functional activity are highly vulnerable to deforestation particularly in the native warm and moist forest types (Qu *et al.*, 2024).

- **Fragmentation OF Land**

Fragmentation increases ecological stress by preventing species movement, reducing genetic interactions, and furthermore, predisposing populations to local extinction and other disturbed ecosystem processes like nutrient cycling and pollination (Haddad *et al.*, 2015).

An indirect effect of fragmentation on human stress is also that smaller / fragmented natural areas reduce ecosystem services like clean water, pollination, flood buffering etc., which communities depend on. It also increases conflict over scarce resources, and increases uncertainty about rural livelihoods (Brauer and Beheregaray, 2020).

- **Release Of Greenhouse Gases**

This can be attributed to the formation of greenhouse emission (GHG) which in turn results in climatic pressure in the ecosystem leading to warming, disrupted seasons of precipitation and more severe occurrences. These effects decrease the stability of the ecosystem and cause the systems to fall.

The effects of GHG emissions due to climate change trigger chronic and acute stress-heat stress and heat morbidity. They reduce agricultural productivity, cause forced displacement in cases of extreme events, and mental health stresses in humans in the form of anxiety and depression. GHG emissions should be reduced in order to reduce ecological and human stress (Li *et al.*, 2025).

Changes in climate can cause adverse conditions commonly referred to as solastalgia where a person feels homesick because of the changes that occur to the environment in which it originates (Albrecht *et al.*, 2007).

- **Burning Of Fossil Fuel**

The largest source of anthropogenic CO<sub>2</sub> and the largest source of atmospheric pollutants (PM<sub>2.5</sub>, NO<sub>x</sub>, SO<sub>x</sub>, black carbon) is burning of fossil fuels including coal, oil and gas (Perera, 2017). Ecologically, the concentrations of pollutants, along with the warming, which is brought about by climate change, result in massive burdens on the ecosystems including thermal stress, altered phenology and acid deposition (Wang *et al.*, 2023). Combustion air pollution exposes humans to direct physical stress, respiratory and cardiovascular diseases, indirect mental and social stress infection and increases health care costs. Not burning fossil fuels results in co-benefits not only in the form of reduction in greenhouse gas emission leading to reduced climate stress, but also in terms of improved air quality thereby reducing direct health stress (Harlan and Ruddell, 2011).

- **Agricultural Activities Beyond Control**

There are unethical agricultural practices, including, but not limited to, over-tillage, over-application of artificial irrigants, monoculture, and hedgerow selection as well as conversion of native habitat into agricultural use, overgrazing that causes soil erosion, loss of biodiversity and water run-off and poor water tolerance. These in turn, cause immense stress on the ecosystem and reduce commercial business (Gomiero, 2016). These are associated with low harvests, threat of floods, rise in the cost of enterprises (fertilizers, commerce) and food insecurity. Wet atomic gas equipment e.g. N<sub>2</sub>O excess digestate, CH<sub>4</sub> some water management oceans, are also seen to aggravate human stress.

To reduce stress in ecosystem and humans' individual principles like sustainable crops, reduced tillage, nutrient element management, etc. should be implemented (Hassan *et al.*, 2022).

### **Climate Change And Regulation of Hormones**

The endocrine processes of different species are being highly interfered with by the climate change in terms of their hormonal balance. Changes in temperature and rainfall can affect chemical bioavailability, absorption and metabolism with subsequent interference of the hormone receptor besides interference of intracellular signaling pathways. All these transpire to cause delayed sexual maturity, abnormal arousal or menstrual period, low quality gametes and reproductive failure (Vandenberg *et al.*, 2025). Studies have been done in order to evaluate and understand the impact of climate stressors (particularly heat stress) on endocrine parameters (Arneith, 2025). The researchers found out that high temperatures can disrupt the hypothalamic-pituitary-gonadal axis resulting in hormonal imbalance which affect reproduction, growth and metabolism of animals and even human beings. These upheavals appear as either disturbed hormone, disrupted reproductive functions and increased endocrine diseases. Physiological mechanisms mediate climate change in causing endocrine disruption and reproductive dysfunction. The long-term environmental stressors which disturb endocrine activity in organisms, include increased ambient temperatures, reduced precipitation, and extreme weather conditions. They are being gradually identified as the key contributors to reproductive pathology. The key to this cascade is the long-term stimulation of the hypothalamic-pituitary-adrenal (HPA) axis that stimulates the quantity of circulating glucocorticoids namely cortisol or corticosterone. The steroids have a negative feedback effect on the hypothalamus. So, they prevent the release of gonadotropin-releasing hormone (GnRH) and thereby inhibit the release of luteinizing hormone (LH) and follicle-stimulating hormone (FSH) of the pituitary. The overall impact is that it disrupts the normal reproductive cycle. This has profound effects on the fertility and population dynamics.

Another effect of climatic stress is that endocrine-disrupting chemicals (EDCs), especially pesticides and heavy metals, are made bioavailable and are even toxic. They accumulate due to new environmental conditions. This increased chemical load further increases hormonal dysregulation to add to the reproductive effects experienced in the affected species (Bretveld *et al.*, 2006).

## CONCLUSION

To control the impacts of the climate change it requires unanimous actions between the environmental mitigation, adaptation as well as adjustments in the lifestyle of the people. On the national scale, global warming and climate stresses on the ecosystem and human health require the protection of greenhouse gas emissions through the introduction of renewable energy, sustainable transport, and improved land use (Intergovernmental Panel on Climate Change, 2021). At the personal level, it is important to make lifestyle choices which can reduce the personal carbon footprint. These include reducing energy use, reducing meat intake, switching to mass transit, saving water, and minimizing the use of pesticides (Vandenberg *et al.*, 2025). Besides these active health measures like stress management, healthy diet, exercise as well as mental health can be used to make individuals better cope with climate induced stress like heat waves, air pollution and extreme weather conditions. A multi-level solution to both reduce climate impacts and enhance resilience is both social policy and individual lifestyle change.

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## CONSERVING BIODIVERSITY AND EMPLOYING *CLITORIA TERNATEA* FOR HEPATOPROTECTION IN INDIAN KNOWLEDGE SYSTEMS

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### Abstract:

Indian knowledge systems, including classical traditions such as Ayurveda and local health traditions, are deeply rooted in ecological principles that link biodiversity to human well-being. Liver disease is an increasing global health burden, often associated with environmental toxins and metabolic disorders. In this context, we assess the therapeutic potential of *Clitoria ternatea* L. (Fabaceae), commonly known as butterfly pea or Aparajita, a plant with a long and rich ethnobotanical tradition in India for the treatment of various diseases. A critical assessment of *Clitoria ternatea* proves its ethnopharmacological, phytochemical and experimental evidence as a hepatoprotectant. Its mechanism, primarily based on strong anti-inflammatory flavonoids antioxidant and anthocyanins has been studied in preclinical models of hepatic injury. There is a need for policy and research to bridge the gap between traditional knowledge and modern evidence-based medicine, and to promote an integrated approach that advances both health protection and health outcomes.

**Keywords:** Indian Knowledge Systems, Biodiversity, Ethnopharmacology, *Clitoria ternatea*, Hepatoprotection, Anti-Inflammatory, Traditional Knowledge

### INTRODUCTION

The complex relationship between man and nature is at the core of Indian knowledge systems, which include a range of classical texts such as Ayurveda and various local, ethnomedicinal practices (Kalra *et al.*, 2024). These systems are based on the fundamental understanding that human health is inextricably linked to environmental health (Maheshwari, 2024). In this view, biodiversity is not just a collection of species, but a vital, interconnected network that provides basic ecosystem services, including clean air and water, a nourishing diet, and a rich pharmacopeia for human disease (Convention On Biodiversity, 2015).

Degradation of ecosystems and unprecedented loss of biodiversity therefore pose a direct threat to human well-being and compromise access to these life-sustaining resources (Myers *et al.*, 2013). In public health today, liver disease is emerging as a silent epidemic, driven by factors such as viral infection, alcohol abuse, metabolic syndrome and exposure to environmental hepatotoxins. The central role of the liver in detoxification and metabolism makes it uniquely vulnerable to both endogenous and exogenous stresses. While conventional medicines offer treatment, there is growing interest in plant-based therapies which may offer protective or healing benefits with fewer side effects (Patwardhan, 2005).

This has renewed scientific interest in the vast repository of medicinal plants that is documented in the traditional knowledge-systems. *Clitoria ternatea* L. (butterfly pea), also known as Aparajita in Sanskrit is widely used in traditional medicine throughout India. The plant is prized for its many properties, including as a tonic for the brain and as a treatment for inflammation and toxicity (Sangekar, 2020). Our goal is to synthesise the ecological wisdom of IKS with the modern scientific knowledge.

### Indian Knowledge Systems and Biodiversity

Indian knowledge systems including the codified principles of Ayurveda as well as the non-codified knowledge base of indigenous and tribal communities are ecologically centred

in their philosophical views. They view the universe as composed of five elemental aspects or Pancha mahabhutas (earth, water, fire, air and space) and there is no distinction between the microcosm (the human body) and the macrocosm (the environment). In this sense, health is viewed as being in a state of balance both internally and externally within the individual and the environment (Khan, 2025).

The biocultural approach to conservation has provided a broad array of conservation approaches based upon traditional cultural and spiritual values. Sacred groves is a section of forest designated as sacred to a particular deity and thus protected by local communities which provide de facto nature reserves and contain significant amounts of biodiversity (Singh et al., 2016). These sacred groves represent the ways in which cultural values support conservation of temperate forests and endemics species such as many medicinal plants.

Similarly, India's traditional farming systems have long been associated with growing crops adapted to specific regional and/or climatic conditions, supporting food security and environmental resiliency (Kalra *et al.*, 2024).

The traditional ecological knowledge documented through the IKS is not static; it is a dynamic system that continues to evolve through interactions with the local ecosystems. The efficacy of traditional medicines depends on the presence of viable and active plant stock. Therefore, the IKS is inherently linked to a conservation imperative. The destruction of natural habitats and the loss of plant diversity will directly threaten the existence of these medicinal systems (Patwardhan, 2005).

### **Ecosystem Health With Special Emphasis On Hepatic Health**

There is a strong and complicated relationship between the loss of biodiversity and human health (WHO, 2020). The diversity of ecosystems supplies many ecosystem services which are essential for maintaining human well-being, including (Paul *et al.*, 2015):

- i) Supply services (food, freshwater, medicine)
- ii) Regulatory services (climate control, water purification, disease control)
- iii) Cultural services (spiritual enhancement, leisure)

Loss of biodiversity diminishes the capacity of these services creating both direct and indirect pathways to poor health outcomes (Marselle *et al.*, 2021). Deforestation alters the local climate and hydrological cycles and thereby reduce agricultural production and the availability of food and can create environments that are conducive to the increased transmission of zoonotic diseases through changes in vector and host habitats (Myers *et al.*, 2013). The liver is especially sensitive to environmental integrity because it is the major detoxifying organ in the body. It is responsible for processing and eliminating harmful substances from the blood. There are several ways how environmental degradation results in an increased toxic load on the liver. Heavy metal and chemical contaminants in drinking water, pesticide residues in the food chain, and air pollutants are examples of environmental stressors that can induce hepatic oxidative stress and inflammation leading to liver failure (Kim *et al.*, 2024). Conversely, a healthy ecosystem has characteristics that promote the health of the liver (Hernandez-Blanco *et al.*, 2022). Biodiverse diets based upon agrobiodiversity provide a wide variety of micronutrients and phytochemicals that have antioxidant and anti-inflammatory properties (Gajender *et al.*, 2023).

In addition to providing nutrients, biodiversity is a source of many medicinal plants that are traditionally used to treat liver disease. These plants have biologically active compounds that can potentially protect the liver from injury, stimulate liver repair and enhance liver metabolism. Therefore, conserving biodiversity is a public health strategy to minimize the adverse effects of hepatotoxicants and for treating liver disease (Pablo *et al.*, 2015).

### **Ethnobotany and Traditional Use of *Clitoria ternatea***

*Clitoria ternatea* belongs to the family Fabaceae and has bright blue or white flowers. It is known by the names 'Aparajita' in some parts of our country and 'Shankhpushpi' in others, for its great fame in traditional medicine (Sangekar, 2020).

Its use goes back to books on Ayurveda under the name Medha Rasayana. It is a herb that improves memory and intelligence and is well known for its nootropic properties for the medicinal substances it contains whose action improves human thinking, learning, and memory used by various communities for the treatment of various conditions (Manimaran, 2023).



*Clitoria ternatea*

Ethnobotanical surveys and traditional texts show that all the roots, seeds, leaves and flowers are used for treatment of ailments (Patel and Mishra, 2023). The roots are considered a powerful nerve tonic and are also used as a laxative and a diuretic. Traditional healers of India use root decoctions for treating whooping cough, asthma and urinary tract infections (Shivgankar *et al.*, 2015).



Paste of its leaves and roots are often applied externally for skin ailments and to relieve swollen joints. Seeds are known for their detoxification and purifying properties and organ preservation. Traditional uses include treatment of digestive disorders, pain in the body and as an antidote to certain animal stings, suggesting a role in the management of internal toxicity and inflammation (Manimaran, 2023).

National and State Biodiversity Boards must formally recognise and integrate indigenous knowledge of traditional medicinal products. Realising its benefits and immense potential policies should provide for the in-situ conservation of wild *C. ternatea* in designated protected areas and for the ex-situ conservation in botanical gardens and gene banks (Singh *et al.*, 2016).

### **Phytochemistry and Mechanisms Relevant to Hepatoprotection**

*Clitoria ternatea* has many chemical compounds that provide it with medicinal value (Sangekar, 2020) including numerous other secondary metabolites, for example, flavonoids, anthocyanins, triterpenes and steroids. The flower petals are blue due to the presence of anthocyanin glycosides; specifically, a class of anthocyanins known as delphinidin derived ternatins (Mohammed and Khan, 2022). Due to their stability, the ternatins are a significant contributor to the high level of antioxidant activity in the plant.

*C. ternatea* is primarily able to protect the liver through inhibition of oxidative stress and inflammation, both of which are among the most common causes of pathological changes in the liver.

- Antioxidant Activity:

The liver is highly sensitive to oxidative damage caused by reactive oxygen species (ROS) produced during the metabolism and detoxification of xenobiotics (Allameh *et al.*, 2023). Phytochemicals in *C. ternatea*, especially flavonoids such as the derivatives of kaempferol and anthocyanins, are potent free radical scavengers (Alkandahri *et al.*, 2023). They can directly neutralise the formation of ROS and also improve the body's endogenous antioxidant defences by increasing the activity of enzymes such as superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GTX). These compounds maintain the structural and functional integrity of hepatocytes by reducing lipid peroxidation and protecting the cell membranes from oxidative damage (Vidana *et al.*, 2021).

- Anti-inflammatory Effect:

Chronic inflammation is a hallmark of most liver diseases. Flavonoids and triterpenoids of *C. ternatea* have been shown to have anti-inflammatory properties. They may inhibit the production of proinflammatory mediators such as cytokines (such as TNF-alpha, IL-6) and CYP2A2 enzymes (Gajender *et al.*, 2023). This helps to reduce tissue damage and to prevent the progression of hepatic impairment to more serious diseases such as fibrosis and cirrhosis.

- Membrane Stability:

In toxic liver injury models, damage to the hepatocyte membrane results in the release of intracellular enzymes such as alanine aminotransferase (ALT) and aspartate aminotransferase (AST) into the blood. Their presence are clinical signs of liver injury. Extracts of *C. ternatea* stabilise these membranes, preventing the leakage of enzymes and maintaining viability of the cells (Nithianantham *et al.*, 2011). The synergistic action of these phytochemicals provides defence against hepatic injury, making *C. ternatea* a strong natural hepatoprotective agent.

### **In vitro, In vivo Evidence Of Hepatoprotective Effects**

- In vitro studies:

In vitro antioxidant tests prove the strong free radical-scavenging ability of extracts from different parts of *C. ternatea*, in particular flowers and leaves. For example, studies measuring the radical scavenging activity of DPPH show that flower extracts have a high antioxidant potential correlated to their high total phenolic and aromatic content (Graziela *et al.*, 2020). These studies confirm the biochemical credibility of the plant's protective effects against cell damage caused by oxidative stress.

- In vivo animal studies:

In vivo studies are the most convincing evidence of the hepatoprotective effects of *C. ternatea* in model animal organisms. These studies typically involve the administration of known hepatotoxins such as paracetamol (acetaminophen) or carbon tetrachloride to rodents followed by treatment with extracts of *C. ternatea* (Jayachitra and Sreelatha, 2011; Nithianantham *et al.*, 2011). Flower extracts also protected against toxicity induced by acetaminophen, restoring glutathione levels and avoiding histopathological changes (Fakurazi *et al.*, 2012). Recent work has shown that it can reduce liver damage in diabetic and dyslipidemic rats by lowering inflammatory markers and hepatic enzymes (Widowati *et al.*, 2024).

### **Research Priorities**

The following recommendations are proposed to achieve the full potential of *Clitoria ternatea* and other medicinal plants:

Development of standardised plant-phytochemical profiles for *C. ternatea* extracts to be used in research as well as in commercially manufactured products. These standardised phytochemical profiles should include the identification of the main bioactive compounds and its metabolites in order to obtain a consistent product from batch to batch in terms of quality, efficacy and safety.

Assessing the efficacy and potential risk of the use of *C. ternatea* as adjunctive therapy in the treatment of non-alcoholic fatty liver disease (NAFLD) and other chronic liver disease.

Research to determine *C. ternatea* toxicity and to develop safe therapeutic doses for this plant.

Research to optimise *C. ternatea* production using agronomic methods, such as organic farming and agroforestry systems to increase yields while preserving biodiversity.

### CONCLUSION:

The convergence of Indian knowledge systems, biodiversity and human health provides a powerful paradigm for sustainable development (Nesshover *et al.*, 2017). The ancient understanding that environmental health and human wellbeing are inseparable is now confirmed by modern environmental and medical science (Hernández-Blanco *et al.*, 2022). *Clitoria ternatea* is a powerful example of this. Its long history of use in traditional Indian medicine has led to scientific investigations which have revealed biologically active compounds with a significant, proven potential to protect the liver. We cannot allow the transformation of traditional knowledge into validated treatments available throughout the world to occur at the cost of losing diversity of life or taking advantage of local populations. Investing in robust clinical research, promoting sustainable agriculture, and enforcing fair benefit-sharing policies will help us tap the therapeutic potential of plants like *C. ternatea*. In doing so, we not only improve human health, but also create strong incentives to preserve the rich biocultural heritage that supports this knowledge. This united approach is the way to a more sustainable future for humans and the planet.

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**DECLINE IN SOIL BIODIVERSITY DUE TO BROAD-SPECTRUM PESTICIDE USE**

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**Abstract:**

Soil animals from tiny nematodes to larger earthworms play an important part in keeping the soil healthy. They help break down waste, improve soil structure, and support helpful microbes that keep nutrients cycling. Growing use of pesticides in farming is harming these small yet vital creatures. Pesticides are meant to kill harmful pest; they often stay in the soil and hurt animals that are not their targets. Pesticides affect soil animals. There are ways to restore soil life by using compost, biochar, and mixed farming life. Soil animals must be protected and it is important to make farming safer and more sustainable to protect biodiversity of soil.

**Keywords:** Nematodes, Earthworms, Pesticides, Compost, Biochar, Sustainable, Biodiversity**INTRODUCTION:**

The soil is a living ecosystem that sustains countless forms of underground life, including earthworms, mites, nematodes, and many others. Together, these organisms contribute to soil fertility by improving aeration, mixing organic matter, and facilitating the recycling of nutrients essential for plant growth. However, this vibrant underground network faces a serious threat from the widespread use of pesticides in agriculture.

Pesticides, including insecticides, fungicides, and herbicides, are designed to target pests, but they inadvertently harm non-target soil organisms as well. These chemicals persist not only in the environment but they also accumulate in soil and within the bodies of organisms, disrupting their physiology and survival (Beaumelle *et al.*, 2023).

Pesticide residues have become a major cause of biodiversity loss in soil ecosystems. They alter soil structure and affect nutrient cycling. They also compromise the sustainability of agricultural systems. These findings are supported by strong scientific researches which rely on biochemical studies, laboratory toxicity tests, and long-term field observations to assess these effects.

**Soil Fauna Role In Soil Health**

Soil fauna includes macrofauna (earthworms, termites), mesofauna (mites, springtails), and microfauna (nematodes, protozoa). They all are categorised based on size and each group plays a unique role in maintaining soil quality. Earthworms the ecosystem engineers, help mix the soil, enhance aeration, and increase water infiltration. Mites and springtails decompose organic matter and promote fungal growth, while nematodes feed on bacteria and fungi, releasing nutrients that plants can easily absorb. When pesticides disrupt or kill these organisms, the entire soil ecosystem becomes unstable. The study by Neher (2001) found that pesticide exposure in earthworms altered the microbial composition in their guts, reducing their ability to decompose organic matter effectively. The diversity and activity of other decomposer organisms also decline under pesticide pressure. Such impacts extend beyond individual species, leading to reduced soil fertility and weakened ecological resilience.

**Behaviour of Different Types Of Pesticides in Soil**

Pesticides are described by their chemical nature and environmental behaviour. Commonly available types of pesticides include organophosphates (e.g., chlorpyrifos),

neonicotinoids (e.g., imidacloprid), carbamates, and pyrethroids. Once applied, these substances interact with soil particles, organic matter, and water.

It has been observed by Bondareva and Fedorova (2021) that Neonicotinoids are highly soluble and can leach into deeper soil layers, thereby reaching organisms residing far below the surface. Organophosphates are more degradable and are neurotoxic. They cause severe biochemical disturbances in soil fauna. Pyrethroids tend to bind strongly to soil particles, posing greater risk to organisms in upper soil layers. Over time, repeated applications cause accumulation and chronic exposure, even when concentrations appear low. The persistence and bioaccumulation of these compounds determine the long-term risk to underground biodiversity and Soil Degradation, Land Scarcity and Food Security and such more Complex Challenges to Sustainability. (Gomiero, 2016).

### **Mechanisms of Pesticide-Induced Toxicity in Soil Fauna**

Pesticides harm soil organisms through a combination of biochemical, physiological, and genetic mechanisms. Many pesticides generate reactive oxygen species (ROS), which cause oxidative stress by damaging proteins, lipids, and DNA. Beaumelle *et al.*, (2023) observed that earthworms exposed to imidacloprid displayed lower antioxidant enzyme activity, indicating a high level of oxidative damage and metabolic imbalance.

Organophosphates and carbamates disrupt normal nerve function by inhibiting the enzyme acetylcholinesterase (AChE), which is essential for transmitting nerve impulses. Keifer *et al.*, (2007) reported that nematodes exposed to pyrethroids, organophosphates and carbamates showed reduced feeding and locomotion thus confirming neurotoxic interference in their behaviour. Soil fauna depend on gut microbes for digestion and detoxification and pesticides alter this delicate balance. Sharma *et al.*, (2023) demonstrated that herbicide exposure changed the gut microbiota of earthworms, reducing their ability to digest organic matter and absorb nutrients effectively.

Prolonged pesticide exposure disrupts reproduction and also damages genetic material. Altered gene expression has been identified related to toxicity and reproduction in soil invertebrates exposed to various pesticides. These molecular changes lead to population decline and long-term ecosystem degradation (Pomacena *et al.*, 2025). Researchers have tried to assess pesticide toxicity also under controlled conditions. Studies have observed significant cellular damage and decreased enzyme activity in earthworms treated with imidacloprid (Nowell *et al.*, 2024). Although tests done in labs do not replicate the natural environment and they also simplify complex ecological interactions, still they provide direct evidence linking pesticides to physiological stress and mortality in soil fauna.

Field-based studies reflect the real-world effects of continuous pesticide use. Frampton *et al.*, (2006) reported higher earthworm density and enzyme activity in organically managed rice fields compared to conventional ones. Konestabo *et al.*, (2022) identified that even after three years ceasing of pesticide application, populations of mesofauna such as springtails remained below pre-exposure levels. Several studies have established the fact that recovery from pesticide contamination can take several years. These findings also prove that soil ecosystems possess limited capacity for self-restoration (Sule *et al.*, (2022).

To understand pesticide effects broadly it is important to connect molecular changes to ecosystem-level outcomes. Chow *et al.*, (2022) found that integrating biomarkers to the investigation is useful to understand the damage. Enzyme activity, movement behaviour, and community composition can be studied to assess soil health. Combining biochemical and ecological indicators provides a complete understanding of how pesticide exposure translates into long-term shifts in biodiversity and ecosystem stability.

### **Restoring Soil Health**

Adding compost or manure enhances microbial diversity and supplies carbon sources that accelerate pesticide degradation. Compost supplementation in contaminated soils

promotes earthworm recovery. It improves reproduction, and also boosts enzyme activity (Kabato *et al.*, 2025). Organic matter also enhances soil structure, reduces pesticide mobility, and provides microhabitats that help fauna survive stress periods. Biochar acts as an absorbent material, trapping pesticides and reducing their bioavailability. Yadav *et al.*, (2024) demonstrated that adding 2% rice husk biochar to chlorpyrifos-polluted soil lowered nematode mortality and increased microbial diversity. Inoculation of soil with beneficial bacteria such as *Pseudomonas* and *Bacillus* species supports pesticide degradation and helps restore soil biological balance. Agricultural diversification through mixed cropping, reduced tillage, and biological pest control can reduce pesticide reliance and improve soil resilience as observed by Virk *et al.*,(2025). Poly-cropping systems maintain higher soil faunal diversity and faster pesticide degradation compared to monocultures. Sustainable practices also stabilise soil communities and reduce vulnerability to future chemical stress. The work of Srivastava *et al.*, (2024) demonstrates that ignoring soil fauna leads to incomplete environmental risk assessments. It is necessary that future policies must include soil-faunal bioassays such as enzyme activity tests, survival studies, and diversity indices as part of pesticide approval processes. Ensuring soil biodiversity protection is vital for achieving sustainable agriculture and long-term food security.

### CONCLUSION:

Soil fauna forms the foundation of healthy soils and sustainable agriculture, yet they remain the hidden casualties of chemical-intensive farming. Research across laboratory, mesocosm, and field levels reliably shows that pesticides are harmful. Pesticides reduce soil fauna abundance, disrupt physiological processes, and alter microbial symbioses. They produce cumulative effects of oxidative stress, neurotoxicity, and genetic damage and lead to long-term biodiversity decline (Keifer and Firestone, 2007). However, restoration of soil is possible. Organic amendments, biochar applications, microbial inoculants, and diversified cropping systems offer effective means to revitalise soil health. Integrating these approaches with firmer regulatory frameworks can help lessen the crisis of underground biodiversity loss. The expanding pesticide use makes it pertinent to protect soil fauna. It is not only a scientific necessity but also an ethical responsibility. Valuing and preserving these unseen organisms, will help safeguard the very foundation of life that sustains agricultural productivity and ecosystem resilience.

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## MANAGING SERICULTURE WASTE: CHALLENGES AND PROMISING SOLUTIONS

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### Abstract:

Sericulture, the practice of cultivating silkworms for silk production, plays a vital economic role in many countries. It produces a lot of trash despite its financial advantages, and improper management of this waste can have detrimental effects on the environment. Reeling remnants from silk extraction procedures, abandoned mulberry leaves, silkworm litter, and pupae are the main sources of waste in sericulture. These byproducts are an untapped resource with a lot of potential, and if they are not treated, they also contribute to environmental contamination. Promoting sustainability in the sericulture sector requires efficient waste management. For example, composting silkworm litter and mulberry leaves can produce nutrient-rich organic manure that can improve soil fertility. Similar to this, silkworm pupae, which are frequently thrown away, can be turned into animal feed or utilized in sectors like cosmetics and pharmaceuticals because of their high protein content. Another by-product that can be recycled into different kinds of biodegradable materials or energy sources is reeling residue. The article explores the various waste products produced throughout the sericulture process, looking at how they affect the environment and emphasizing the possibility of creative waste management strategies. By investigating these strategies, the study hopes to show how sericulture waste may be used efficiently, enhancing the industry's value and promoting environmental sustainability.

**Keywords:** Sericulture, Waste, Sustainable, Management, Environment.

### INTRODUCTION:

Silkworms *Bombyx mori* belongs to Lepidoptera order and family Bombycidae. Silkworm is considered as a valuable economic important insect which fabricates silk thread in the form of cocoon around itself (Hussain *et al.* 2011). They spin a cocoon of fiber that is the source of economic silk. *Bombyx mori* feeds exclusively on the leaves of the mulberry (*Morus* sp.), and is a wonderful model system due to its life cycle, it is inexpensive, and there are no ethical issues involved. Approximately 8 million people in India are involved in sericulture, which involves a great deal of labour and medical care. In order to make sericulture more economically viable, it has become important to review and analyze various factors that improve growth, yield, fiber quality, and larvae's resistance to pathogens. The silkworms are vital economic insects which contributes substantially to the economy and Gross Domestic Production (GDP) of the many countries namely China, India, Thailand etc. (Chen, 2003; Chen and Gu, 2006). Enhancing cocoon quality and productivity is the key factor to achieve maximum GDP through sericulture. In 2016-17 India had witnessed for achieving Rs. 2495.99 Crores, this shows importance of sericulture in India. India is the second largest producer of silk within the world with an annual mulberry silk production of 20478 MT with a region of 2.23 lakh hectares of mulberry during 2016-17 (Anon, 2016). Three primary forms of trash are produced by this industry: excess mulberry twigs, leaves, and fruits; cocoon reeling waste, such as pupae; and bed waste from raising silkworms. The majority of the trash comes from mulberry farms, where it has been observed that about 45% of the leaves that silkworms consume are released as garbage. About 0.067 hectares of farmland can be fertilized using this waste, which is typically 250–300 kg from marginal farmers and can be converted into 2500 kg of agricultural manure (Wenhua, 2001). While

silkworm trash alone can be utilised in the pharmaceutical and biogas production industries, by-products from silkworm farming can be utilised in vermicomposting (Sharma *et al.*, 2022). Low-cost vaccines against a range of infectious diseases can be produced using silkworm larvae as a bioreactor (Datta, 1994). Millions of people rely on sericulture for work and income, making it a vital component of rural economies. However, sericulture produces a lot of trash, just like many other agricultural sectors. In addition to degrading the environment, improper waste management techniques can result in a lost chance to make good use of these byproducts.



Although silk farming is a lucrative industry, the waste products from sericulture can lead to environmental challenges. One significant issue is the disposal of cocoons. While disposing of cocoons may seem like a minor task, silk farmers encounter numerous difficulties in managing it. Additionally, silkworm litter often accumulates on the floors, making cleaning a labor-intensive process. This accumulation increases humidity and temperature, creating an environment favorable for pathogens (Ganesan *et al.*, 2022). Organic materials such as dead larvae, leaf litter, moths, cocoons, and larval excreta can be observed in sericulture waste. Waste from mulberry cultivation in sericulture can be effectively utilized to produce organic manure. Since these waste results in compost with high nutrient content, it should be converted into valuable compost using appropriate technology.

### Importance of Waste Management in Sericulture

Effective waste management in sericulture is essential for three major reasons: protecting the environment, maximizing economic value, and improving social welfare. From an environmental perspective, careless disposal of mulberry residues and silkworm litter can lead to unpleasant odors, microbial infestations, and contamination of soil and water. Economically, these by-products are a rich source of nutrients and organic matter that can be recycled into valuable resources such as organic fertilizers, livestock feed, and biogas — promoting a sustainable circular economy within the industry.

In India, the sericulture sector provides employment to more than eight million people, most of whom live in rural communities where traditional waste handling methods still dominate. By adopting scientific and sustainable utilization practices, this sector can transform what is often seen as waste into a source of profit producing biofertilizers for farming, renewable energy through biogas generation, and nutraceutical compounds extracted

from silkworm pupae. Moreover, efficient waste management directly supports several United Nations Sustainable Development Goals (SDGs), particularly SDG 12, which focuses on responsible production and consumption, and SDG 13, which emphasizes climate action and environmental sustainability.

### **Types of Waste in Sericulture**

#### **A. Mulberry wastes**

Mulberry or other species of the *Morus* genus are the soul food plant of the domesticated silkworm *Bombyx mori*. Mulberry cultivation for silkworm farming is known as Mori culture, and over time, different parts of mulberry are treated as sericowastes and used as sericulture by-products in a variety of ways. There are currently comprehensive pharmacological updates available due to the numerous articles that have occasionally been published regarding the therapeutic significance of the mulberry plant (Nuri *et al.*, 2023). Notable medications have been used to treat conditions like diabetes, stress, heart problems, neurological disorders, etc. In certain clinical situations and in this field of study, mulberry leaves, stems, and roots are still used for their quick mechanism of action. Mulberry fruit is a promising natural tonic because of its high nutritional content, which includes proteins, flavonoids, and anthocyanins. Antioxidant-rich mulberry tea helps lower arterial pressure, or blood pressure, and regulates blood sugar (Arabshahi *et al.*, 2007). Mulberry fruit is known for its laxative properties. As a result, it works wonders for melancholia and dyspepsia and has numerous uses in drugs. In addition to all of these, it's used to make jam and pickles. Mulberry fruits' anti-wrinkle and antioxidant qualities have led to a wide range of applications in the cosmetics industry. Due to their diaphoretic properties, mulberry leaves will effectively inhibit the growth of gram-positive bacteria and yeast on the body of the host (Srivastava *et al.*, 2006). Mulberry stems are used in manufacturing industries because they contain tannin and pigment.

#### **B. Silkworm litter**

Larval molts, leftover mulberry leaves, and silkworm excrement make up silkworm litter. A sizable amount of sericulture by-products are made from this trash. Excreta, also known as frass, are a great input for organic farming since it is high in minerals including potassium, phosphate, and nitrogen. If not adequately degraded, leftover mulberry leaves can lead to unpleasant odors and bug infestations. Another part that is frequently thrown away is larval molts, which are shed throughout silkworm development. When silkworm litter is properly managed, it can be turned into vermicompost or high-quality compost, which helps to increase soil fertility and lessen reliance on chemical fertilizers. It is also being investigated for possible usage as an ingredient in fish or animal feed and in the generation of bioenergy. Poultry can be fed a mixture of silkworm litter and leftover mulberry leaves. Growth hormone that is taken from silkworm waste and are utilized to make high-quality paints, pencil covers, plastic carbon, and commercially available activated carbon (Reddy, 2010). In addition to being useful as raw materials for biogas plants, cow manure and silkworm larvae can also be utilized to extract phytol and carotene, which are then used to create Gan Xue Bao, a novel medication for leukemia and hepatitis (Wani *et al.*, 2020).

#### **C. Silkworm pupae:**

The silkworm pupae, which stay inside the cocoons after the silk strands are removed, are frequently thrown away as garbage. However, due of their high protein and fat content, these pupae have a great deal of potential for usage. Because of their nutritional makeup, they are useful for a number of purposes such as because of their

high protein content; pupae can be turned into feed for aquaculture, poultry, or livestock. Pupae's lipid content can be removed and converted into biodiesel, which provides a sustainable energy source. Pupae proteins may find use in pharmaceuticals and dietary supplements. A lost chance to add value to sericulture is represented by the underutilization of this resource. The industry could increase sustainability and profitability by incorporating pupae processing into waste management plans. Additionally, pupae have naturally produced inhibitors of 1-deoxynojirimycin (DNJ), a strong alpha-glucosidase inhibitor that is also found in their host leaves and has been shown to be effective in reducing blood sugar levels (Tomotake *et al.*, 2010).

#### **D. After reeling**

The waste includes silk filaments, sericin, and defective cocoons produced through the silk reeling process. Remaining fibers that are unsuitable for producing premium silk threads are known as silk fibers. They can be recycled into materials for crafts or insulation and frequently have broken or uneven threads. In order to recover the core silk fibers (fibroin), sericin, a water-soluble protein that makes up a portion of the silk cocoon, is usually eliminated during the silk spinning process. Because of its hydrating and antioxidant qualities, sericin is able to be recovered and utilized in sectors such as food, medicine, and cosmetics rather than being thrown away. These days, sericin protein is emerging as one of the most significant biomolecules due to its possible applications in medicine and cosmetics (Rangi and Jajpura, 2015). Low-quality cocoons are those that are broken, asymmetrical, or otherwise unfit for use in the production of commercial silk. Although they are frequently thrown away, they can be processed to create biofertilizers or animal feed, or they can be utilized to make spun silk. The fact that these residues are mentioned highlights how crucial it is to look into sustainable ways to manage and use them efficiently rather than throwing them away as garbage.

### **Waste Management Strategies**

When it comes to waste management, it is critical to assess the agricultural waste produced during mulberry cultivation and how it can be effectively managed or reused to reduce its negative effects on the environment. Reducing sericulture's environmental impact requires sustainable practices like environmentally friendly dyeing methods and effective wastewater treatment systems. The Indian sericulture sector can preserve its cultural legacy while guaranteeing financial stability and environmental sustainability by adopting these developments (Pooja and Mariyappanavar, 2024).

#### **A. Biogas Production**

The need to protect the environment and the atmosphere from the negative impacts of using non-renewable energy sources has raised awareness of the need for renewable energy sources, such as biomass (Wani *et al.*, 2020). Utilizing environmentally friendly raw materials from ecosystems and their waste is part of using renewable energy (Hastik *et al.*, 2015). In addition to the economical benefit of producing biogas, the manure is also far more uniform. Mulberry silkworm pupae that have been defatted have previously been studied as a feedstock for the production of biogas. Waste is primarily prepared by insect technology as food scraps combined with excrement. It guarantees an ideal environment for the growth and efficient metabolic activity of the bacteria that contribute to the process, making it a high-quality substrate for the production of biogas using the anaerobic fermentation process (Viswanath & Nand, 1994). Utilizing biogas has several advantages, such as

being economically viable, requiring the least amount of money to produce energy, being environmentally benign, and having limitless potential. Through the production of energy and bio-manure, the use of biogas has addressed the problem of energy resources in a "zero-waste" way. While a very high organic loading rate suppresses bacterial activity, a higher organic loading rate improves process efficiency (Mao et al., 2015).

**B. Vermicompost**

Vermicomposting is the process of using earthworms to turn garbage into vermicompost (Lee *et al.*, 2018). The mulberry cultivation can be made sustainable and low-cost via recycling all the natural residues of sericultural beginning as compost and vermicompost. Although, the reaction of vegetation to chemical fertilizers is immediately, the function of natural manure in increasing the yield can't be under envisioned. Vermicompost is an eco-friendly era and has a top notch scope within the recycling of sericultural residue. While anaerobic compost in pits takes four to five months, vermicompost technology uses earthworms and composts any organic waste that is finished 50 to 60 days after the earthworms are added. Dealing with the stuff is not tough. It contains rich plant nutrition made up of micronutrients as well as helpful microbes (Wani et al., 2020). Vermicomposting involves loading organic waste, such as silkworm litter, bed waste, and field weeds, among other materials, into an open pit or trench, filling it with enough water and cow dung or biogas production slurry, and letting it lie for 25 to 30 days to partially decompose. This is used as earthworm beginning feed. The semi-decomposing cloth's temperature will increase to 50–60 °C throughout this procedure. The temperature can be lowered by turning the material up and down one or two times, after which it will return to normal.

**C. Pupae Utilisation**

Insects known as silkworm pupae are good for human health because of their high nutritional content and—more significantly—the range of pharmacological actions they can have when ingested (Zhou *et al.*, 2022). Domestic silkworm pupae's biological roles have been gradually discovered and validated, particularly their positive impact on human health. According to studies, silkworm pupae have beneficial benefits on blood pressure reduction, blood glucose and lipid regulation, liver protection, immunological boosting, antiapoptosis, antitumor, and antibacterial properties. Protein is the most abundant substance in silkworm pupae, followed by oil. With 26.2% oil content, Eri silkworm pupae have the highest amount of oil among the four species (Longvah *et al.*, 2011). In addition to being high in oils, silkworm pupae also have high concentrations of unsaturated fatty acids, particularly polyunsaturated fatty acids that are highly nutritious as a source of edible oil (Longvah *et al.*, 2012).

**D. Sericin Utilisation**

The silk gland insect *B. mori* produces and secretes sericin, a naturally occurring polymer. 25–30% of the cocoon weight is made up of sericin, a water-soluble glycoprotein that has 18 amino acids, strong polar side groups (the hydroxyl, carboxyl, and amino groups), and a high concentration of serine, a aspartic acid, and glycine, which makes it a hydrophilic protein. The functional characteristics of sericin are influenced by its physicochemical characteristics, which mostly rely on the silkworm lineages and the sericin isolation technique. This makes sericin a potentially biocompatible substance for use in biological applications (Kunz *et al.*, 2016). In vitro and in vivo studies of biological compatibility and antioxidant properties have shown that sericin is immunologically inert, have established its safety, and have opened up a wide range of biomedical applications, including the food and cosmetics industries, as

a supplement in culture media, cryogenic preservation, wound healing, antitumor effect, various metabolic responses in organic systems, and suggest its use in tissue engineering and as a drug delivery vehicle (Snehal, 2008; Zhang *et al.*, 2006). When sericin is added to cosmetic formulations like creams and shampoos, the results include increased hydration, elasticity, less irritating cleansing, antiaging as well as antiwrinkle properties (Singh, 2014).

### Conclusion:

Waste management in sericulture offers a special chance to turn a problem into strength. The industry may lessen its impact on the environment and increase sericulture's economic competitiveness by implementing sustainable methods. To do this, cooperation between farmers, the researchers, and policymakers is crucial. Future studies should concentrate on creating affordable technologies and studying novel uses for byproducts of sericulture. The sector may increase its overall economic viability and provide stakeholders with more revenue streams by turning sericulture waste into assets like fertilizer, animal feed, or bioenergy. Solutions for waste byproducts and new, affordable technologies are needed. For instance, creating effective methods to extract vital nutrients and proteins from pupae or investigating new applications for silk reeling residues.

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**BIODIVERSITY CHALLENGES IN HUMAN AND ENVIRONMENTAL CONTEXTS**

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**Abstract:**

Biological diversity refers to the variety of plants, animals and microorganisms that exist. The status of our biodiversity has always been dynamic. Over millions of years, under natural conditions, some species have increased in variety or numbers and others have been reduced or lost. Some people wonder why we should be worried about conserving biodiversity now, in particular, when the world has gone on more or less as it is for so long. But natural habitats everywhere are being assaulted as never before and as habitats are lost we are also losing various types of plants and animals. No one would have thought, even a few years ago, that the common house sparrow of Britain could be endangered, but now it is. There are concerns that man-made changes to our environment are leading to too many of our species being lost and our biodiversity becoming seriously depleted.

One of the reasons biodiversity is important is because it helps to keep the environment in a natural balance. An ecosystem which is species-rich is more resilient and adaptable to external stress than one in which the range of species is limited. In a system where species are limited, the loss or temporary reduction of any one could disrupt a complex food chain with serious effects on other species in that same system. Once biodiversity is sufficient, if one nutrient cycling path is affected another pathway can function and the ecosystem - and the biological species it supports-can survive. Elsewhere, tropical rainforests, in particular, have provided many beneficial products, from natural medicines to biological control agents for agriculture. Water is one of the most vital factors in the existence of the living organism on this planet.

Asia is the world's continent, encompassing an area of 17,139,000 square miles (44,390,000 square kilometers), almost 30% of the world's land area. Because Asia covers such an enormous area and contains so many countries and island including India. India 20.5937° N, 78.9629° E has the total area of 3,287,263 sq km land: 2,973,193 sq km water: 314,070 sq km is situated in the south part of Asia, bordering the Arabian Sea and the Bay of Bengal, between Burma and Pakistan.

Biodiversity may also define as "Biodiversity are an integral part of the ecosystem and have an importance in eco-balance for animal welfare" a new definition suggested in the present situation. We need to preserve as many individual species as we can and we also need to preserve as many different types of ecosystem as we can, because each one serves a different and important function with environmental challenges.

**Keywords:** biodiversity conservation, environment, ecosystem, global warming, climate change, natural disasters.

**DEFINITIONS OF BIODIVERSITY**

"Biological diversity" or "biodiversity" is still a relatively new concept which is not found in dictionaries published before mid-1980s (Dudley, 1992). The term "biodiversity" entered the scientific language as a result of a US National Academy of Sciences' publication of the same name (Wilson, 1988). The term biodiversity is derived from the contraction of biological diversity (Walter G. Rosen, 1985). However it draws together concepts that had preoccupied ecologists and geneticists for some time prior to that date. There have been a

number of international conventions concerned with specific aspects of biodiversity — for example, the Convention on Wetlands of International Importance, especially Waterfowl Habitat (known as the Ramsar Convention, 1971), the Convention to Regulate International Trade in Endangered Species of Fauna and Flora (Washington, 1973), the Convention of Migratory Species of Wild Animals (Bonn, 1980), and the non-binding International Undertaking on Plant Genetic Resources. There have also been conventions concerning biodiversity in particular regions, for example the Convention on European Wildlife and Natural Habitats (Bern, 1979), the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere (Washington, 1940) and the African Convention on Conservation of Nature and Natural Resources (Algiers, 1968).

As the names of these conventions imply, the issues involved concerned species and landscape conservation. None of them were focused on biodiversity on a global scale, and on the full and integrated set of definitions of the word (which are discussed below). Nor did they explicitly consider the implications of conservation for development and human welfare, except in passing. By 1987, there was growing scientific evidence of the erosion of biodiversity on a global scale. This also resonated with emerging problems with the control of genetic information, which emerged with the rapid development of biotechnology. Since the beginning of the 1990s the conservation of biodiversity had also become one of the central goals of international conservation organizations such as the World Wide Fund For Nature (WWF), International Union for Conservation of Nature (IUCN) and the United Nations Environment Programme (UNEP) (WWF, 1993). Much of the scientific and commercial interest originated in the United States, and this country was the first to pressure for a global convention. Nonetheless, it addressed the wider issues of all biodiversity protection on a global scale, and is used as a framework for the discussion by the present paper. Biodiversity may also define as “Biodiversity are an integral part of the ecosystem and have an importance in eco-balance for animal welfare” a new definition suggested in the present situation.

## **INTRODUCTION:**

In the last 50 years life has change rapidly world over. The loss of biodiversity as a result of anthropogenic activities has become a central preoccupation among natural scientists, and many social scientists as well. Although we do not know the exact scale of the problem, in particular the extent to which human beings have been responsible for the loss of biodiversity as compared to the natural evolution, the process of species extinction, green house effects and critical changes in the earth’s biochemical cycle are now increasingly emphasized. The concept of human welfare is equally tangled. In general terms, it relates to the provision of improved conditions of living. Human welfare is linked with the preservation of biodiversity in varieties of ways. Biodiversity forms the basis of a global-life support system. Human beings have fulfilled many of their needs by taking advantage of the existence of many genes, species, as well as a “balanced” ecosystem. For instance, many plant species have formed the basis of food, fibre, medicines and many other useful items. There are also many aesthetic and ethical values of plant and animal species.

This paper considers the complex relationships between biodiversity and human welfare. It shows how biodiversity and human welfare are perceived differently by a wide range of actors. These contested meanings constitute the problematique of biodiversity, an understanding of which has profound implications for conservation policy-making. The authors examine, in particular, how biodiversity has been seen by different groups of people and how they interact in the arena of biodiversity. It not only looks at the level of dependence that different sections of the rural poor have on biodiversity either as use values or for petty commodity production, but it also examines such groups as policy makers at the national and international levels, state functionaries, entrepreneurs, corporations and timber traders which

have frequently more influence on the discourses surrounding the protection and use of biodiversity. To illustrate this, the paper includes detailed case studies involving India, a treasure trove of biodiversity and wildlife.

The paper suggests that State, national and international conservation policy and practice are undergoing rapid transformation from the previous predominately nature preservation orientation to sustainable use of natural resource for livelihoods. Many groups of policy makers and scholars at the international level perceive a synergy between biodiversity conservation and human welfare. However, few concrete policies and strategies have so far been developed to implement these ideas in practice. There have been formidable political problems in the way of negotiating biodiversity conservation at the national and international level. There has also been serious questioning of the capability and will of many states to implement conservation policies on the ground. At the local level, conservation efforts have led to the definition and appropriation of the biodiversity resources by outside forces, and this in turn has generated conflicts over these resources. The paper argues that while the contemporary debate about biodiversity appears to represent elements of a new moral dimension about “human-nature” relationships, it is also a testimony to familiar political-economic divisions. These involve divisions between international, national and local interests; between science and politics; official and folk; and power relations at the local level deriving from differences of class, ethnicity and gender.

The conclusion of the paper is that there are strong pragmatic and political grounds for paying detailed attention of the impact of biodiversity erosion and conservation upon human welfare against environmental challenges particularly in cases where conservation efforts may possibly affect local people directly. The political grounds are that other considerations such as the abuse of human rights and the accentuation of inequalities are related to environmental degradation, and so conservation efforts must be seen to address these issues too, and not to exacerbate them.

### **LEVELS OF BIODIVERSITY:**

The biodiversity found on our earth today is the result of 3.5 billion years of evolution. It now has international recognition as a result of the Biodiversity Convention signed under the auspices of the United Nations Conference on Environment and Development (UNCED) in Rio in June 1992, and it has since become an increasingly prominent public policy issue, as governments seek to ratify the Convention. The term biodiversity involves a complexity of meanings and levels. As used in the Convention, the term has the following definition (IUCN, 1994).

**Biological diversity** means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems. Thus biodiversity is the variability of life in all forms levels, and combinations. It is not the sum of ecosystems, species and genetic material, but rather represents the variability within and among them (IUCN, 1994). Biologists usually consider it from three different perspectives:

**Genetic diversity:** refers variation of genes within a species which results in different varieties of breeds within the species.

**Species diversity:** refers to the variety of species within the region.

**Ecosystem diversity:** refers variety of ecosystems within an area.

It can be seen that these three perspectives form a hierarchy and are basically different ways at looking at the same thing (IUCN, 1990). All biodiversity is the result of natural selection working on the consequences of genetic variation (Lee, 1993). Much important diversity is invisible such as microscopic life-forms in soil (Beard, 1991) or not obvious such

as variation within a single species. The scientific understanding of biodiversity is still at an early stage. The initial scientific focus was on estimating the diversity of life forms and the scale and rapidity of their decline (Wilson, 1988). Although an estimated 1.7 million species have been described to date, we do not know the true number of species on Earth, even to the nearest order of magnitude. While counts for small groups, such as birds, are relatively well known, the biggest question mark lies over the number of insects and micro-organisms (WCMC, 1992). India is one of the mega biodiversity countries in the world and occupies the ninth position in terms of freshwater mega biodiversity (Mittermeier *et al.*, 1997).

#### **TYPES OF BIODIVERSITY:**

- Floral biodiversity
- Faunal biodiversity
- Agro biodiversity
- Horticulture biodiversity
- Forest biodiversity
- Domesticated biodiversity
- Aquatic biodiversity
- Microbial diversity

#### **WHY IS BIODIVERSITY IMPORTANT ?**

At least 40 % of the world's economy and 80 % of the needs of the poor are derived from biological resources. In addition, the richer the diversity of life, the greater the opportunity for medical discoveries, economic development, and adaptive responses to such new challenges as climate change.

**Biodiversity offers many natural services such as** Ecosystem services, Water conservation, Soils formation and protection, Nutrient storage and recycling, Pollution breakdown and absorption, Contribution to climate stability, Maintenance of ecosystems, Recovery from unpredictable events, Biological resources, such as Food, Medicinal resources and pharmaceutical drugs, Wood products, Ornamental plants, Breeding stocks, population reservoirs, Future resources, Diversity in genes, species and ecosystems, Social benefits, such as Research, education and monitoring, Recreation and tourism, Cultural values, Building materials, Fuel, Paper product, Fiber (clothing, textile), Industrial product (waxes, rubber, oils), Regulating global process such as atmosphere, climate and soil conservation, Pollination and seed dispersal, Control of agricultural pests, Genetic library

#### **VALUE OF BIODIVERSITY:**

Values have to be relevant to human beings, and implicitly values of a resource such as biodiversity, when they are realized, are a way of understanding human welfare. However, at the outset it is worth mentioning that the reasons for conserving biodiversity relate not only to human welfare and that there are other non-anthropocentric reasons for conservation. Five general reasons have been given to explain the importance of maintaining biodiversity (Inskipp, 1992).

- (i) **Ethical reasons:** the belief that every life form warrants respect independent of its worth to people and human welfare.
- (ii) **Maintaining ecosystems:** a myriad of life forms are essential for keeping air clean; stabilizing weather; disposing of wastes; recycling nutrients; creating soils; controlling diseases; pollination, etc.
- (iii) **Material and economic benefits to people:** biodiversity contributes to agriculture; fisheries; medicines; industry, etc.

(iv) **Maintaining evolutionary processes:** biodiversity is the raw material of further evolution. If the genetic resource base is drastically reduced, the result is likely to be a depletion of evolution's capacities for speciation and adaptation persisting far into the future.

(v) **Aesthetics:** many species inspire beauty and awe. Conservation literature is full of statements about the connection between biodiversity and human well-being in terms of these subjective criteria.

These general reasons for conserving biodiversity may be expressed in terms of the values which they represent, as described below.

#### **Health Security**

- 30 % of drugs obtained from plants;
- 80 % of world's population depends upon natural medicines;
- Of 150 top prescription drugs 118 originate from natural sources. Eg. Vincristine, Vinblastin (sada bahar), Taxol (taxes bacata), Reserpin (sarpandha), Guggul.

#### **Food Security**

- Development of high yielding varieties World famous rice variety IR-36 developed from *Oryza nivara* in India;
- Development of disease resistant varieties e.g. Grassy Stunt disease resistant variety development from *Oryza nivara* in India;
- Out of 3000 edible crops, only 150 are commercialized;
- 4 major food crops- Rice, Wheat, Maize and Potato.

#### **INTERNATIONAL BIODIVERSITY GEOGRAPHICAL DISTRIBUTION:**

Worldwide distribution of biodiversity in various geographic regions are divided in six regions viz. Palaearctic regions, Nearctic region, Ethiopian region, Oriental region, Neotropical region, and Australian region. The main objective of Zoogeography is the systematic study of Geo-zoo-biodiversity. Need to discuss in details with new strategy suggested.

#### **INDIA A TREASURE TROVE OF BIODIVERSITY:**

Asia is the world's continent, encompassing an area of 17,139,000 square miles (44,390,000 square kilometers), almost 30% of the world's land area. Asia covers such an enormous area and contains so many countries and island including India. India 20.5937° N, 78.9629° E has the total area of 3,287,263 sq km land: 2,973,193 sq km water: 314,070 sq km is situated in the south part of Asia, bordering the Arabian Sea and the Bay of Bengal, between Burma and Pakistan. Water is one of the most vital factors in the existence of the living organism on this planet. The risk that China and India will be facing severe water shortages due to a perfect storm of economic growth, global warming, climate change, and demands of fast growing populations by mid century may be facing a "high risk of severe water stress".

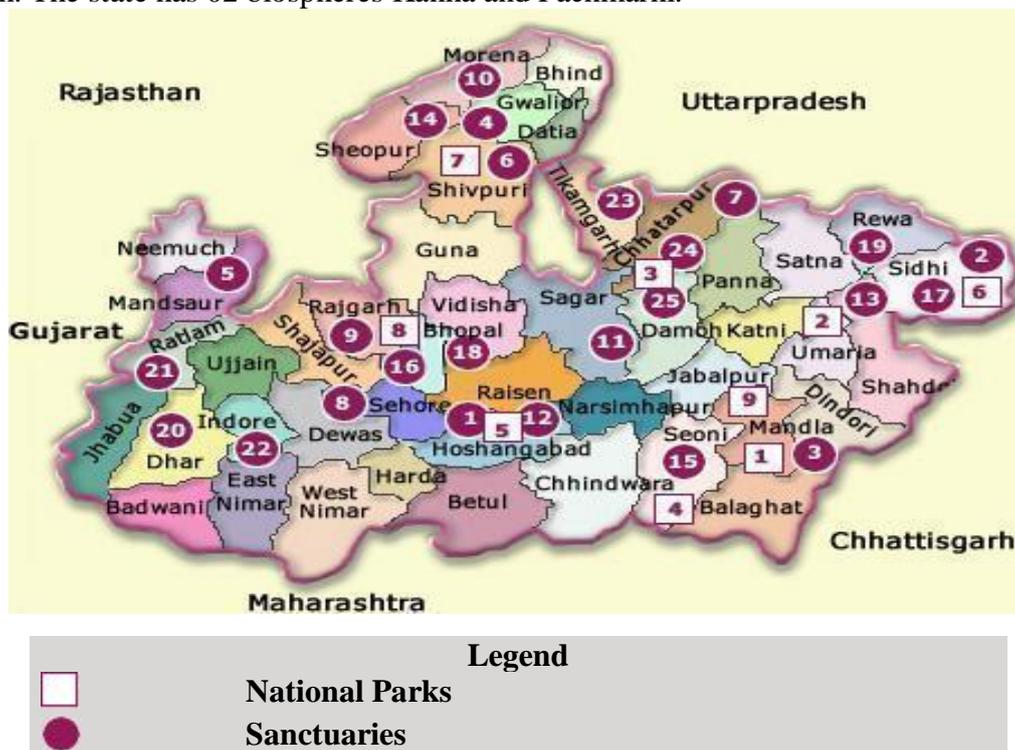
- With 2.5 % of the land area, India accounts for 7-8 % of the globally recorded species.
- India is one of the 8 Mega diverse countries of the world.
- India ranks among top ten species-rich nation and shows high endemism.
- Over 46,000 species of plants; 91,000 species of animals recorded in the country.
- 89 National parks in India extending over nearly 37,530.76 square km area i. e., they are covering nearly 1.14% part of the total geographical area of the country.
- There are about 489 sanctuaries in India with the total area about 1,17,042.04 square km I e., they are covering nearly 4.7% part of the total geographical region of the country.
- Biosphere Reserves was initiated from the conservation point of view for human welfare Man and Biosphere programme of UNESCO in 1971. At present there are 13

biosphere reserve in India. Nilgiri biosphere was firstly declared as reserve area in 1986.

- 04 Hotspot of biodiversity (Eastern Himalaya; Indo-Burma; Western Ghats and Sundaland)
- One of the world's 8 Vavilovian centers of origin (with 167 species of agriculture crops and 320 species of their relatives known to have originated here).

### BIODIVERSITY IN MADHYA PRADESH:

Madhya Pradesh is situated on the cross junction of the 02 Hot spots of Biodiversity i.e. Eastern Himalayas and the Western Ghats. The state has 9 National park Bandhavgarh National Park, Kanha National Park, Satpura National Park, Sanjay National Park, Madhav National Park, Van Vihar National Park, Mandla Plant Fossils National Park, Panna National Park, and Pench National Park (Wild Life Forest Department, Madhya Pradesh) and 25 Sanctuaries Bori, Bagdara, Phen, Ghatigaon, Gandhisagar, Karera, Ken Ghariyal, Kheoni, Narsingharh, North Chambal, Nauradehi, Pachmari, Panpatha, Kuno, Pench, Ratapani, Sanjay Dubri, Singhori, Son Ghariyal, Sardarpur, Sailana, Ralamandal, Orchha, Gangau and Veerangana Durgawati showing following figure spread over an area of 5680 sq. km region which is about 1.3 % of total geographical region and 3.4% of total forest region in Madhya Pradesh. The state has 02 biospheres Kanha and Pachmarhi.



**Figure: National park and Sanctuary of Madhya Pradesh India**

There are 5000 Plant species including 1000 medicinal plants, 500 Birds species and 180 fish species reported by various scientists. 73 bird species present in Chhatarpur district of Madhya Pradesh (Dubey, 2014); 32 fish species recorded in Chhatarpur district of Madhya Pradesh (Dubey et al., 2012); 24 species of reptiles reported (Dubey and Khare, 2013) and Diversity of lentic freshwater Catfish (Dubey, 2012) reported in our previous study.

Madhya Pradesh is the largest producer of Oilseeds and Pulses. A rich diversity of minor millets: Kodo, Kutki, Sawan etc. Malwi, Nimari, Gaolao and Kenkatha are the native breeds of cattle. "Bhadhawari" is a native buffalo breed with highest fat content in milk.

“Jaminapari” Native breed of goat. “Kadakhnath” is a native breed of poultry famous for its black meat found in Jhabua District of Madhya Pradesh.

### **THREATS TO BIODIVERSITY:**

The proximate or direct causes of biodiversity loss are well documented. These include mechanisms such as habitat loss and fragmentation, over-exploitation of plant and animal species, introduced species, pollution, climate change, and agro-economic processes. This process began with the emergence of settled agriculture and more sophisticated hunting and herding techniques. Until approximately 10,000 years ago, only natural processes of extinction had occurred, but were added to by spatially isolated cases of the extinction of wild animals which competed with humans, usually at sites of intensive settlement. It is estimated that in the present greatly accelerated phase of extinctions, current rates of extinction may be between 1000 and 10,000 times the historical rate (Wilson, 1988).

- Reducing Forest Cover
- Unsustainable Harvesting
- Invasive Alien Species
- Pollution Pressure and contamination
- Poaching, Forest Fires, Grazing, Timber, Fuel Wood Mining
- Mono Cropping
- Climate change
- Global warming

### **ENDANGERED AND THREATENED SPECIES:**

IUCN and Natural Resources prepare The Red Data Book containing the name of those animals whose future is in danger. This book is being revised time to time so as to get the correct knowledge of the present status of the species. Europe, Mediterranean, Africa, Asia, Arabian Peninsula and Americas.

The IUCN Red List of Threatened Species™ provides taxonomic, conservation status and distribution information on plants, fungi and animals that have been globally evaluated using the IUCN Red List Categories and Criteria. This system is designed to determine the relative risk of extinction, and the main purpose of the IUCN Red List is to catalogue and highlight those plants and animals that are facing a higher risk of global extinction (i.e. those listed as Critically Endangered, Endangered and Vulnerable). The IUCN Red List also includes information on plants, fungi and animals that are categorized as Extinct or Extinct in the Wild; on taxa that cannot be evaluated because of insufficient information (i.e., are Data Deficient); and on plants, fungi and animals that are either close to meeting the threatened thresholds or that would be threatened were it not for an ongoing taxon-specific conservation programme (i.e., are Near Threatened).

### **CONSERVATION ISSUE:**

Once this short list of heavily utilized species is established, the forces for specialization become firmly established in which capital goods are applied to the production of these species and these species alone. “Sunk costs” such as technologies, along with adapted social and economic structures (e.g. irrigated paddy production), are important considerations acting against the diversification and extension of the short list of existing species (Swanson, 1992c). The result is that it becomes attractive to increase the quantities of these established specialized species, rather than to invest in the new technologies and socio-economic and political structures that would be necessary in order to begin to exploit other species not on the short list of the twenty or so which produce the great majority of the world’s food (Plotkin, 1988). As specialization of agriculture deepens and diffuses, the rates

of conversion to specialized species and the associated conversion of wild habitats to settled agriculture or livestock production increases greatly.

According to some observers, conservation of biodiversity is merely a sophisticated expression of a well established pre-occupation with the conservation of a small number of extinction-prone animal species and their habitats. Despite the rhetoric, conservation policy is still aimed at key species (Dudley, 1992). However, Pimbert (1993) acknowledges that most of the species important for the maintenance of ecological processes are located in human-managed ecosystems such as agricultural and forestry land, which therefore lie outside protected areas, with greater species diversity. For example, in West Germany only 35-40 percent of the total of 30,000 species is found in protected areas; the remaining species live in human-managed ecosystems (Pimbert, 1993). There is a strong case for conservation organizations to pay more attention to human-managed ecosystems to fulfill the goals of biodiversity conservation, rather than to concentrate efforts and data collection on unconverted habitats.

The notion of “welfare” is also subject to multiple interpretations, and can be identified in the current context as ways in which different values of biodiversity are appropriated by different actors. Thus, there is a growing recognition of the need to accommodate qualitative and indigenous concepts of the values of biodiversity with a particular emphasis on the ways in which these appropriated values are distributed. Also, the range of measures of welfare has been steadily extended, as illustrated by the increasing sophistication of the Human Development Index (HDI), published annually by UNDP. For example, in 1993 UNDP introduced the idea that the participation and empowerment of individuals and groups to shape their own lives are important dimensions of welfare. Many of the methodological and scientific references which mention the connections between biodiversity and human welfare have done so in very general terms. The discourse usually focuses on the benefits of biodiversity to “mankind” over long time periods and on a global scale. Attempts are made to identify the value of biodiversity conservation, to demonstrate its constituent parts, and then go on to capture those values in decision-making criteria. It is, of course, in the latter that the question of how these benefits affect humans impinges upon our concern of human welfare. We believe there is an urgent need to analyze the social complexities of these generalized arguments. This is done first by identifying the different values of biodiversity in principle, and then by specifying who appropriates each of these values which contribute to their welfare.

#### **STRATEGIES FOR BIODIVERSITY CONSERVATION:**

- **International Organization:** International Union for the Conservation of Nature and Natural Resources, Switzerland 1948, World Wild Life Fund, Switzerland 1961. Conservation of Biological Diversity-1992-Rio De Janeiro, Brazil – A landmark treaty. 193 signatory countries till date. The Paris Agreement, reached Dec. 12, 2015, is a pragmatic deal that holds countries accountable and builds ambition over time. Core elements of the agreement include commitments on emissions, adaptation, finance and transparency, and steps to promote carbon trading. The real and rising risks of climate change, and the opportunities of a clean energy economy not only drove the Paris Agreement, but will keep encouraging stronger action and investment
- **National organization:** Government - Zoological Survey of India, Kolkata 1916; Indian Board of Wild Life, 1949; Wildlife Institute of India, Dehradun 1982. Non Government Organization - Bombay Natural History Society, Mumbai 1883. Wild Life Preservation Society of India, Dehradun 1958. Environment and Social Welfare Society, Khajuraho 2000. The National Biodiversity Authority (NBA) was established in 2003. As a follow up of Conservation of Biological Diversity (CBD) the Biological

Diversity Act was promulgated by India in 2002 followed by Biological Diversity Rules in 2004.

- **State Government:** Began setting up a network of *in-situ* conservation area under the provision of the Wildlife Protection Act, 1972 was declared in 1973. Govt. of India & WWF launched Project Tiger in 1973. The Biological Diversity Act, 2002. CBD, Sustainable use of its components, and Fair and equitable sharing of the benefit arising out of the use of biological resource, knowledge and for matters connected therewith or incidental there to.

**Conclusion:** “Biodiversity are an integral part of the ecosystem and have an importance in eco-balance for animal welfare”. We need to conserve many individual species because each one serves a different and important function with eco-balance and human welfare. Once any species extent it cannot be generate again.

#### ACKNOWLEDGEMENTS:

Author thankful to Managing Director, Godavari Academy of Science & Technology, Chhatarpur Madhya Pradesh India for provide laboratory facilities. Author is thankful to Managing Director and Technical Staff, Fisheries Demonstration Centre, Godavari Estate, Nahdora-Khajuraho-471625 India for their valuable support.

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## CLIMATE CHANGE AND CORBON FOOT PRINT- A BRIEF REVIEW

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### Abstract:

As it is well known the climate change, a long-term shift in global weather patterns, is caused by human activities that increase greenhouse gases. The basic cause of this issue is due to the industrial revolution, human economic & social activities and the global development of society. In general, it has been heavily dependent on the exploitation of natural resources. The use of fossil fuels, deforestation, the drainage of wetlands, the transformation of coastal marine ecosystems, unsustainable land use, and many other unbalanced processes of human activity have led to an increase both in the anthropogenic emissions of climate-active gases and in their concentration in the atmosphere. In the present review article, I have studied in brief about Corbon Foot Print (CFP) here in this review. The concept of carbon footprint arose during the process of measuring greenhouse gases (GHG) emissions, to help gauge the impact of GHG emissions on global climate change more accurately. CFP is an accounting for carbon emissions has become particularly important. In this article we have discussed in brief CFP fundamentally.

### INTRODUCTION:

Carbon accounting, the first step in carbon management and emission reduction, includes a series of activities related to carbon emissions such as measurement, calculation, verification, reporting, and so on [1,2]. It is believed that over the past ~150 years these phenomena have contributed to an increase in the global average temperature in the near-surface layer of the atmosphere by ~1 °C. Currently, the most pressing tasks facing states and scientific and civil societies are to reduce anthropogenic CO<sub>2</sub> emissions and to limit the global air temperature increase. In this regard, there is an urgent need to change existing production systems in order to reduce greenhouse gas emissions and to sequester them. In this review, it is briefly reviewed and consider up-to-date scientific approaches and innovative technologies, which may help in developing roadmaps to reduce the emissions of climate-active gases, control rising temperatures, decarbonize economies, and promote the sustainable development of society in general. Climate change has brought about global crises, such as extreme weather, melting glaciers, rising sea levels, reduced food production, and the spread of epidemics, posing severe challenges to human survival and development. These phenomena are exacerbated mainly by the carbon emissions generated by human activities [3-5]. Many climate experts believe that global temperatures will continue to increase over the next 100 years [3]. Hence, the Intergovernmental Panel on Climate Change (IPCC) considers the reduction of greenhouse gas (GHG) emissions important to mitigate climate change.

The term carbon footprint originates from the concept of ecological footprint, which was first proposed by Canadian scientist William Rees in the 1990s. The ecological footprint quantifies the pressure and resource consumption of human activities on the ecosystem by converting the resources consumed and waste generated by a certain population into the required biologically productive land area [6]. The currently recognized definition of carbon footprint is the total amount of GHGs directly and indirectly emitted by the studied product, activity, or service throughout its life cycle, expressed in CO<sub>2</sub> equivalents. GHGs are categorized into six types specified in the Kyoto Protocol: CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs, PFCs, and SF<sub>6</sub> [5]. As research progressed, the definition of the carbon footprint has incorporated concepts such as implicit carbon, carbon flow, and virtual carbon. Carbon footprint

accounting is the technological foundation for achieving green production, promoting low-carbon consumption, and economic development. It is also an important prerequisite for breaking down green trade barriers and achieving international exchange and mutual recognition of carbon footprint labels. The proposed carbon footprint reveals the impact of human behaviour on climate change from a unique perspective, thus providing an effective tool for the scientific measurement of carbon emissions. It has been accepted by governments, organizations, and institutions in various countries and has gradually penetrated various research fields.

### **IMPORTANCE OF CARBON FOOTPRINT (CFP)**

The carbon footprint is a key indicator of human footprint in climate change. Recently in the last years global greenhouse gas emissions were around 35 billion tonnes of CO<sub>2</sub>. In order to limit global warming to below 2°C, the global per capita carbon footprint should fall below 2 tons CO<sub>2</sub> per year by 2050. This is a significant reduction from the current averages of 16 tons per capita globally. Knowing your carbon footprint enables you to take concrete actions to minimize environmental damage by determining the primary sources of emissions. It also helps efforts to combat climate change and reduce worldwide emissions [2-4].

### **COMPONENTS OF A CARBON FOOTPRINT**

A carbon footprint includes emissions from:

- Energy use: Electricity use, heating and cooling homes and offices.
- Transportation: Motor vehicle driving, air travel, public transport, and shipping.
- Food and consumption: Production, processing, and transport of food
- Waste: Generation and disposal of waste materials.
- Land use and farming: Cropping and deforestation.

### **CALCULATION OF CFP**

A carbon footprint is estimated by measuring not only CO<sub>2</sub> emissions but also emissions of other greenhouse gases such as methane – which is 25 times more potent than carbon – and nitrous oxide. The effects of each of these gases are summed and represented as a single value in metric tons of carbon dioxide (MT CO<sub>2</sub>e) [9]. There are two commonly used methods of carbon footprint estimation, life cycle assessment and input-output analysis [4]. Life cycle assessment takes into account all processes in the product's life cycle, from production to disposal of the product. It involves summing up as many of the emissions pathways as possible. With this approach, there is a high possibility of missing out some pathways and since it is a manual process; it could take days to calculator per product and therefore not suitable for large scale use.

The second method known as input-output analysis involves using carbon intensities, which are measured in kilograms of CO<sub>2</sub> per amount spent on the products, to assign a footprint to a product based on its price. Because the process is fully automated, it is much faster and can handle large amounts of data. The main limitation of this method is that it cannot manage product-specific data, such as low carbon sources.

Assuming that a family consumes 500 kWh of electricity per month and an emission factor of 0.5 kg CO<sub>2</sub> emission per kWh, monthly emissions from electricity would be 250 kg CO<sub>2</sub> emission.

### **Strategies to Reduce Carbon Footprint**

1. Lowering a carbon footprint requires lifestyle modification and systemic transformation, such as:
2. **Energy efficiency:** Energy-efficient appliances, insulation upgrades.  
**Renewable energy:** Solar, wind, or other alternative energy sources.

3. **Sustainable mobility:** Public transport, cycling, walking, electric vehicles.
4. **Dietary changes:** Reduced meat and dairy, locally sourced food.

Conserving waste is about not using single-use products, recycling, and composting.

## CONCLUSION

The carbon footprint is a valuable tool for measuring the contribution to climate change by an individual, organisations, products and services, and more. For example, by computing the industrial carbon footprint, an industry can better understand its major sources of emissions and find ways to minimise them. Such as assist you in understanding the key emissions sources in your organisation. It enables you to dive deep into your company's activities and identify the most important challenges as well as opportunities. It enables you to become more conscious of your consumption and contribute to making more responsible decisions [5]. At the individual level, to efficiently contribute to climate change mitigation, you do so by monitoring and measuring your individual carbon footprint. Some people produce much more carbon dioxide than others; the average carbon footprint for an individual in the United States is sixteen tons, which is one of the largest in the world. The average carbon footprint on a global scale is closer to four tons [7-8]. To have the best chance of keeping global warming to 1.5 degrees Celsius, carbon footprints must be measured at multiple levels, including national, organisational, and individual.

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## जलवायु परिवर्तन का आर्थिक विकास पर प्रभाव

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### सारांश

जलवायु परिवर्तन 21वीं सदी की सबसे गंभीर वैश्विक चुनौतियों में से एक है। यह केवल एक पर्यावरणीय समस्या नहीं, बल्कि सामाजिक, आर्थिक, स्वास्थ्य और वैश्विक राजनीतिक स्थिरता से भी गहराई से जुड़ी हुई है। औद्योगिक क्रांति के बाद मानव गतिविधियों जैसे जीवाश्म ईंधनों का अत्यधिक उपयोग, वनों की कटाई, शहरीकरण ने वायुमंडल में ग्रीनहाउस गैसों की मात्रा में वृद्धि किया है, जिससे पृथ्वी के तापमान में वृद्धि हो रही है। जलवायु परिवर्तन एक वैश्विक और बहुआयामी संकट है जो सभी देशों, वर्गों और पीढ़ियों को प्रभावित करता है। इसका समाधान केवल सरकारों की जिम्मेदारी नहीं, बल्कि प्रत्येक व्यक्ति, समुदाय और संस्था को भी इसमें भागीदारी निभानी होगी। स्थायी विकास, हरित तकनीक और जवाबदेही ही इस संकट से निपटने के प्रभावी उपाय हैं।

जलवायु परिवर्तन को नियंत्रित करने के लिए प्रभावी नीति उपायों की आवश्यकता है। इसके लिए सरकारों, अंतर्राष्ट्रीय संगठनों और नागरिकों के बीच सहयोग और प्रयासों का समन्वय आवश्यक है। विषाक्त गैसों के उत्सर्जन में कमी, अनुकूलन उपायों का कार्यान्वयन और जलवायु परिवर्तन के प्रभावों से निपटने के लिए प्रभावी नीति बनाए बिना, इस संकट का समाधान संभव नहीं है। समय रहते इन नीतियों को लागू करना और जलवायु परिवर्तन के प्रति जागरूकता जरूरी है, ताकि आने वाली पीढ़ियों के लिए एक सुरक्षित, स्थिर और अनुकूल पर्यावरण की उपलब्धता सुनिश्चित किया जा सके। जलवायु परिवर्तन केवल पर्यावरणीय समस्या नहीं है, बल्कि यह एक गंभीर आर्थिक चुनौती भी है। इससे होने वाले नुकसान का अनुमान लगाना और उससे बचाव के उपायों को लागू करना आवश्यक है। विकासशील देशों को जलवायु परिवर्तन के प्रभावों से बचाने के लिए आर्थिक नीतियाँ तैयार करनी होंगी और वैश्विक स्तर पर एकीकृत प्रयासों की आवश्यकता होगी। यदि समय रहते आवश्यक कदम नहीं उठाए गए, तो जलवायु परिवर्तन का प्रभाव हमारे आर्थिक विकास को अवरुद्ध कर सकता है और सामाजिक असमानता को बढ़ा सकता है।

**मुख्य शब्द—** जलवायु परिवर्तन, आर्थिक विकास, पर्यावरण प्रदूषण, पोषणीय विकास, मानव स्वास्थ्य ।

### 1. प्रस्तावना

पृथ्वी की जलवायु निरंतर रूप से बदलती और विकसित होती रहती है। जिसमें कुछ परिवर्तन प्राकृतिक रूप से होते रहते हैं। किंतु कुछ परिवर्तन मानवीय गतिविधियों के कारण संपन्न होते हैं, जैसे वनों का विनाश, उद्योग एवं परिवहन के साधनों से निकलने वाले उत्सर्जन आदि जिसके कारण वातावरण में विषाक्त गैसों और एरोसॉल जमा हो जाते हैं। इन गैसों को ग्रीन हाउस गैस कहा जाता है। यह गैसें पृथ्वी पर सूर्य के गर्मी के प्रभाव को रोक लेती हैं और जमीन के पास हवा के तापमान को बढ़ा देती हैं। भारत में जलवायु परिवर्तन के प्रभाव के मूल्यांकन के लिए वैज्ञानिकों का एक पैनल तैयार किया गया है, जो जलवायु परिवर्तन कार्यक्रमों के माध्यम से इस क्षेत्र में अध्ययन एवं अनुसंधान कार्यों को बढ़ावा देते हैं।

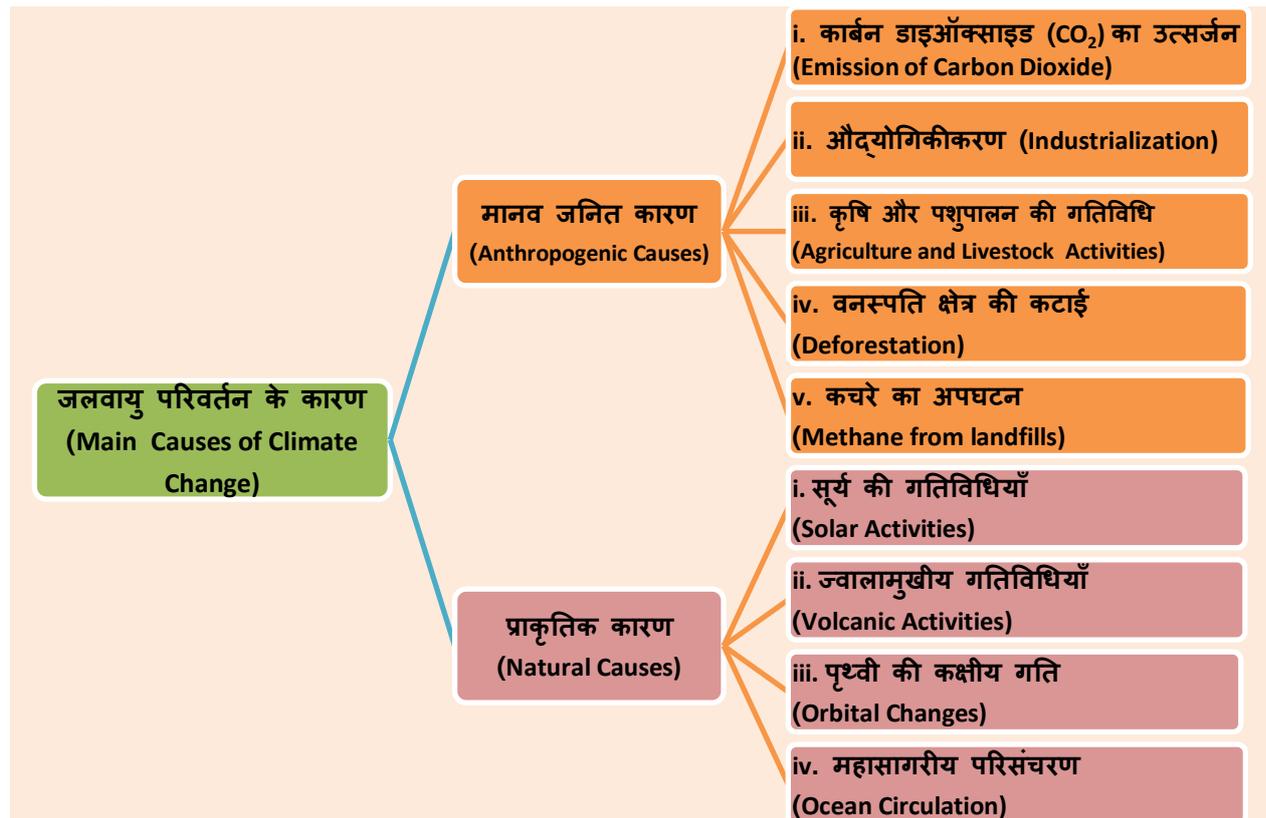
“जलवायु परिवर्तन का अर्थ है दीर्घकालिक अवधि में पृथ्वी की जलवायु में होने वाले महत्वपूर्ण बदलाव से होता है। इसमें तापमान, वर्षा, तूफानों की तीव्रता और समुद्र स्तर में परिवर्तन आदि शामिल हैं।”

जलवायु परिवर्तन, पृथ्वी के औसत तापमान में वृद्धि और उसके परिणामस्वरूप होने वाली पर्यावरणीय, सामाजिक, और आर्थिक परिवर्तनों को संदर्भित करता है। जलवायु परिवर्तन पर अर्थशास्त्र का अध्ययन यह समझने का प्रयास करता है कि कैसे जलवायु परिवर्तन और उससे जुड़ी नीतियाँ, आर्थिक गतिविधियों और संसाधनों पर प्रभाव डालती हैं और इसके निवारण या अनुकूलन के उपायों के लिए

कौन से आर्थिक दृष्टिकोण उपयुक्त हैं। इस शोधपत्र में जलवायु परिवर्तन के आर्थिक विकास पर पड़ने वाले प्रभाव के विभिन्न पहलुओं को समझने का प्रयास किया गया है।

## 2. जलवायु परिवर्तन के प्रमुख कारण

जलवायु परिवर्तन का अभिप्राय पृथ्वी के मौसम पैटर्न में दीर्घकालिक बदलाव से लगाया जाता है। इस प्रक्रिया का कारण प्राकृतिक घटनाएँ और मानव गतिविधियाँ दोनों हो सकती हैं। हालाँकि, वर्तमान समय में जलवायु परिवर्तन, मुख्य रूप से मानव गतिविधियों के कारण हो रहा है। जिनसे ग्रीनहाउस गैसों (जैसे कि कार्बन डाइऑक्साइड, मीथेन) का उत्सर्जन बढ़ रहा है, जो पृथ्वी के तापमान को बढ़ा रहे हैं। जलवायु परिवर्तन के प्रमुख कारकों का अध्ययन निम्न भागों में बाटकर किया जा सकता है



### (A) मानव जनित कारण

जलवायु परिवर्तन का मुख्य कारण मानव गतिविधियाँ ही हैं। आर्थिक विकास के इस दौड़ में लोगों का एक दूसरे से आगे निकलने की अभिलाषा, पर्यावरण के प्रति जागरूकता का अभाव और पर्यावरण के प्रति अनुत्तरदायित्व की भावना जैसे कारक इसमें मुख्य भूमिका का निर्वहन कर रहे हैं। जलवायु परिवर्तन के लिए उत्तरदायी कुछ प्रमुख मानवीय कारक निम्नलिखित हैं—

#### (i) कार्बन डाइऑक्साइड का उत्सर्जन

कार्बन डाइऑक्साइड सबसे प्रमुख ग्रीनहाउस गैस है जो जलवायु परिवर्तन को प्रभावित करती है। यह गैस, जीवाश्म ईंधन जैसे कोयला, पेट्रोलियम तेल और गैस जलाने से उत्सर्जित होती है, जोकि ऊर्जा के उत्पादन, उद्योगों से निकालने वाले अपशिष्ट पदार्थों, परिवहन के साधनों से निकालने वाले धुओं और वनस्पति क्षेत्र में हो रही कटाई के कारण होती है। जिससे ग्रीनहाउस गैसों का उत्सर्जन बढ़ रहा है परिणाम स्वरूप जलवायु परिवर्तन की घटना भी बढ़ रही है।

#### (ii) औद्योगिकीकरण

औद्योगिकीकरण ने प्रदूषण और ग्रीनहाउस गैसों के उत्सर्जन को बढ़ाया है। बड़े पैमाने पर कारखानों, वाहनों और निर्माण गतिविधियाँ वातावरण में कार्बन डाइऑक्साइड और अन्य हानिकारक गैसों की मात्रा को बढ़ाती हैं। जोकि जलवायु परिवर्तन के लिए प्रमुख रूप से उत्तरदायी मानवीय कारक हैं।

**(iii) कृषि और पशुपालन की गतिविधियाँ**

कृषि क्षेत्र में रासायनिक उर्वरकों और कीटनाशकों का उपयोग, साथ ही भूमि उपयोग परिवर्तन (जैसे जंगलों की कटाई) जलवायु परिवर्तन में योगदान देते हैं। इसके अलावा, पशुपालन से मीथेन गैस का उत्सर्जन होता है, जो कार्बन डाइऑक्साइड से भी अधिक प्रभावशाली ग्रीनहाउस गैस है। यह जलवायु परिवर्तन को बढ़ावा देने वाली मानवीय गतिविधि है।

**(iv) वनस्पति क्षेत्र की कटाई**

वनों की कटाई के कारण वातावरण से कार्बन डाइऑक्साइड का अवशोषण कम हो जाता है, जिससे ग्रीनहाउस गैसों की सांद्रता बढ़ जाती है। इसके परिणामस्वरूप पृथ्वी का तापमान बढ़ता है और उस क्षेत्र की जलवायु परिवर्तित हो जाती है।

**(v) कचरे का अपघटन**

जब घरेलू, औद्योगिक और कृषि कचरा (खासकर जैविक कचरा जैसे खाना, पत्ते, कागज आदि) लैंडफिल में जमा होता है, तो वह ऑक्सीजन की कमी में ऐनएरोबिक अपघटन के माध्यम से सड़ता है। इस प्रक्रिया में मुख्यतः दो गैसों निकलती हैं— मीथेन और कार्बन डाइऑक्साइड। मीथेन एक ग्रीनहाउस गैस है जोकि कार्बन डाइऑक्साइड की तुलना में लगभग 34 गुना अधिक ग्लोबल वार्मिंग पोटेंशियल की क्षमता रखती है। मीथेन गैस की वृद्धि से पृथ्वी का तापमान बढ़ता है और यह वर्षा का पैटर्न बदल देता है। सूखा और बाढ़ जैसी घटनाओं में वृद्धि होती है। यह आर्कटिक बर्फ पिघलने और समुद्र स्तर बढ़ाने में योगदान करता है।

**(B) प्राकृतिक कारण**

जलवायु परिवर्तन केवल मानव गतिविधियों के कारण नहीं हो रहा है, बल्कि कुछ प्राकृतिक कारक जैसे सूर्य की गतिविधियाँ, ज्वालामुखी, पृथ्वी की कक्षीय गतिविधियाँ, महासागरीय परिसंचरण आदि भी जलवायु परिवर्तन में महत्वपूर्ण भूमिका निभाते हैं। जिनका संक्षिप्त विवरण निम्न प्रकार है—

**(i) सूर्य की गतिविधियाँ**

सूर्य की विकिरण में परिवर्तन होने से जलवायु परिवर्तन होता है। सूर्य के क्षेत्रीय प्रभावों के कारण पृथ्वी के तापमान में बदलाव हो सकता है। सूर्य के चारों ओर के क्षेत्रों की गतिविधियों में बदलाव पृथ्वी की जलवायु को प्रभावित कर सकते हैं। सूर्य की ऊर्जा उत्सर्जन में लगभग 11 वर्ष पर प्राकृतिक रूप से उतार चढ़ाव होता है। जब सूर्य अधिक ऊर्जा उत्सर्जित करता है, तब पृथ्वी गर्म हो जाती है और जब कम विकिरण निकलता है तो सूर्य ठंडी हो जाती है। यह जलवायु परिवर्तन का सबसे पुराना और महत्वपूर्ण प्राकृतिक कारक है।

**(ii) ज्वालामुखीय गतिविधियाँ**

ज्वालामुखी विस्फोट से सम्बन्धित क्षेत्र में बड़ी मात्रा में सल्फर डाइऑक्साइड, कार्बन डाइऑक्साइड और अन्य ग्रीनहाउस गैसों की मात्रा वातावरण में बढ़ जाती है, जिससे पृथ्वी का तापमान भी बढ़ जाता है, जोकि जलवायु परिवर्तन का कारण बनाता है।

**(iii) पृथ्वी की कक्षीय गति**

पृथ्वी अपनी धुरी पर झुकी हुई सूर्य के चारों तरफ अपनी कक्षा में गति करती है। इसमें धीरे-धीरे बदलाव आते हैं जिसे मिलैकोविच चक्र कहा जाता है यह तीन प्रकार का हो सकता है— दीर्घवृत्तीय कक्षा में परिवर्तन, धुरी झुकाव में परिवर्तन और धुरी के घूमने की दिशा में परिवर्तन। इन परिवर्तनों से हिम युग और गर्म काल जैसे दीर्घकालिक जलवायु परिवर्तन होते हैं। पृथ्वी की परिक्रमा और झुकाव में बदलाव से जलवायु परिवर्तन होता है।

**(iv) महासागरीय परिसंचरण**

महासागरीय धाराओं में परिवर्तन होने से जलवायु परिवर्तन होता है। महासागरों की गति और जलवायु प्रणालियाँ पृथ्वी के जलवायु में बदलाव ला सकती हैं। विशेष रूप से, "एल नीनो" और "ला नीना" जैसे घटनाएँ महासागरीय परिसंचरण को प्रभावित करती हैं, जिससे वैश्विक तापमान में उतार-चढ़ाव आता है।

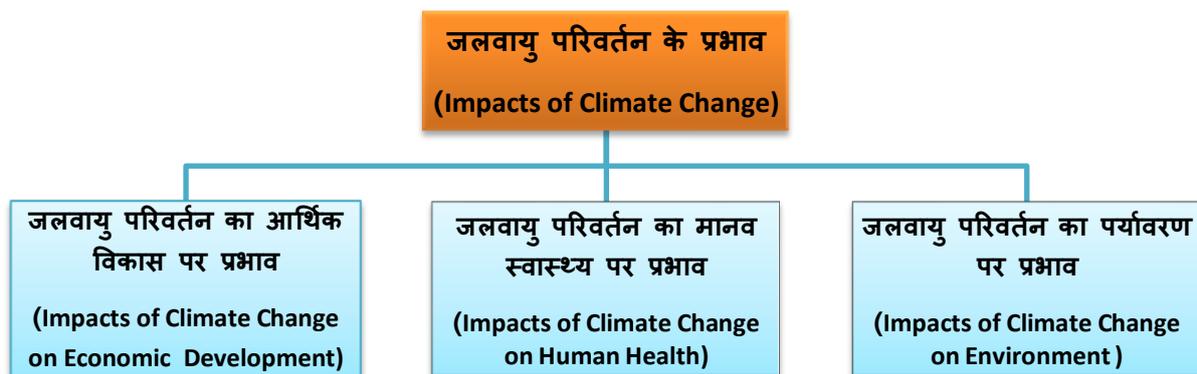
जलवायु परिवर्तन के कारणों में मानव गतिविधियाँ और प्राकृतिक घटनाएँ दोनों शामिल हैं। हालांकि मानव जनित कारणों का प्रभाव अधिक है, और इन कारणों को नियंत्रित करना जलवायु

परिवर्तन को धीमा करने और पर्यावरण को संरक्षित करने के लिए आवश्यक है। जलवायु परिवर्तन को रोकने के लिए वैश्विक स्तर पर नीति निर्माण, पोषणीय विकास और प्राकृतिक संसाधनों का विवेकपूर्ण उपयोग आवश्यक है।

### 3. जलवायु परिवर्तन के प्रभाव

जलवायु परिवर्तन का मानव जीवन पर व्यापक प्रभाव पड़ता है। जिसके समग्र प्रभाव का अध्ययन निम्न शीर्षकों के अन्तर्गत किया जा सकता है

- 1- जलवायु परिवर्तन का आर्थिक विकास पर प्रभाव
- 2- जलवायु परिवर्तन का मानव स्वास्थ्य पर प्रभाव
- 3- जलवायु परिवर्तन का पर्यावरण पर प्रभाव



#### 3.1. जलवायु परिवर्तन का आर्थिक प्रभाव

जलवायु परिवर्तन एक वैश्विक संकट है, जो न केवल पर्यावरणीय समस्याओं को जन्म देता है, बल्कि आर्थिक दृष्टिकोण से भी गंभीर परिणाम उत्पन्न करता है। जलवायु परिवर्तन के कारण होने वाली प्राकृतिक घटनाओं और पर्यावरणीय परिवर्तनों का प्रत्यक्ष और अप्रत्यक्ष रूप से आर्थिक गतिविधियों पर गहरा प्रभाव पड़ता है। इस भाग में जलवायु परिवर्तन के आर्थिक प्रभावों की विभिन्न अवस्थाओं पर चर्चा की जाएगी।

##### (i) कृषि और खाद्य उत्पादन पर प्रभाव

जलवायु परिवर्तन का सबसे बड़ा प्रभाव कृषि क्षेत्र पर पड़ता है, क्योंकि यह फसलों की पैदावार, सिंचाई की उपलब्धता और मौसम के पैटर्न को प्रभावित करता है। तापमान में वृद्धि से उच्च तापमान के कारण कुछ फसलें, जैसे गेहूं, चावल, और मक्का, अपनी सामान्य पैदावार से कम उपज सकती हैं। यह खाद्य सुरक्षा संकट उत्पन्न कर सकता है, खासकर विकासशील देशों में, जहाँ कृषि पर निर्भरता अधिक होती है। मौसम परिवर्तन के कारण अत्यधिक वर्षा, सूखा, और मौसम में असमय बदलाव कृषि में अस्थिरता उत्पन्न करता है। उदाहरण के तौर पर, अधिक वर्षा से बाढ़ आ सकती है, जबकि सूखा फसलों की नष्ट होने का कारण बन सकता है। इन प्रभावों से कृषि उत्पादन में गिरावट और खाद्य कीमतों में वृद्धि हो सकती है। जलवायु परिवर्तन से पानी की उपलब्धता में कमी हो सकती है, जिससे सिंचाई के लिए पानी की कमी होगी और इससे कृषि उत्पादकता पर नकारात्मक प्रभाव पड़ेगा।

##### (ii) ऊर्जा क्षेत्र पर प्रभाव

जलवायु परिवर्तन ऊर्जा उत्पादन और खपत को प्रभावित करता है। बढ़ते तापमान के कारण वायु और शीतलन उपकरणों का उपयोग अधिक बढ़ सकता है, जिससे बिजली की मांग में वृद्धि हो सकती है। जलवायु परिवर्तन के कारण जलवायु संसाधन जैसे जल, पवन और सौर ऊर्जा पर निर्भरता बढ़ सकती है, जबकि पारंपरिक ऊर्जा स्रोतों जैसे कोयला और तेल पर दबाव आ सकता है। इससे ऊर्जा उत्पादन लागत में वृद्धि हो सकती है। अत्यधिक तापमान और प्राकृतिक आपदाओं के कारण

बिजली संयंत्रों और ऊर्जा उत्पादन सुविधाओं को नुकसान हो सकता है, जिससे ऊर्जा उत्पादन में बाधाएँ उत्पन्न होती हैं।

### (iii) आर्थिक असमानताएँ

जलवायु परिवर्तन से सबसे अधिक प्रभाव उन देशों और समुदायों पर पड़ता है जो पहले से ही आर्थिक रूप से कमजोर हैं। विकासशील देशों में संसाधनों की कमी और गरीबी के कारण जलवायु परिवर्तन के प्रभाव से बचाव मुश्किल हो सकता है। इन देशों को जलवायु परिवर्तन के कारण होने वाले प्राकृतिक आपदाओं, स्वास्थ्य संकटों, और कृषि संकटों का सामना करना पड़ता है। विकसित देशों और विकासशील देशों के बीच असमानताओं में वृद्धि होती है। गरीब और हाशिए पर स्थित समुदायों को जलवायु परिवर्तन के कारण अधिक नुकसान हो सकता है, जैसे कि बाढ़, सूखा और स्वास्थ्य समस्याएँ। इसके कारण उनके पास पुनर्निर्माण या अनुकूलन के लिए आवश्यक संसाधन नहीं होते हैं।

### (iv) वैश्विक व्यापार में असंतुलन

जलवायु परिवर्तन वैश्विक व्यापार को भी प्रभावित कर सकता है। जलवायु परिवर्तन के कारण बाढ़, सूखा और तूफान जैसी घटनाएँ आपूर्ति श्रृंखलाओं को बाधित कर सकती हैं, जिससे उत्पादन में देरी और सामान की उपलब्धता में कमी हो सकती है। कृषि उत्पादन में गिरावट और प्राकृतिक संसाधनों के नुकसान से निर्यात की दर घटा सकती है, जिससे वैश्विक बाजार में व्यापारिक असंतुलन उत्पन्न हो सकता है। जलवायु परिवर्तन का आर्थिक प्रभाव अत्यधिक व्यापक और गहरा है। इसका प्रभाव कृषि, स्वास्थ्य, ऊर्जा, और व्यापार जैसे प्रमुख क्षेत्रों पर पड़ता है। इस वैश्विक संकट से निपटने के लिए दीर्घकालिक और प्रभावी नीति उपायों की आवश्यकता है, जिसमें जलवायु वित्त, नवीकरणीय ऊर्जा में निवेश और वैश्विक सहयोग को बढ़ावा देना शामिल है। आर्थिक दृष्टिकोण से जलवायु परिवर्तन के प्रभावों को समझना और इसके निवारण के लिए सही कदम उठाना आवश्यक है, जिससे भविष्य में इसकी गंभीरता को कम किया जा सके।

### 3.2. जलवायु परिवर्तन का मानव स्वास्थ्य पर प्रभाव

जलवायु परिवर्तन के कारण स्वास्थ्य पर प्रत्यक्ष और अप्रत्यक्ष प्रभाव पड़ता है। बढ़ते तापमान के कारण गर्मी की लहरें अधिक तीव्र हो सकती हैं, जिससे गर्मी से संबंधित बीमारियों, जैसे हीट स्ट्रोक और डिहाइड्रेशन के मामलों में वृद्धि हो जाती है। तापमान में वृद्धि के कारण मलेरिया, डेंगू और अन्य बीमारियाँ फैल रही हैं। जलवायु परिवर्तन के कारण तापमान और जलवायु में बदलाव से पानी से उत्पन्न होने वाली बीमारियाँ जैसे हैजा और डायरिया फैल सकता है। उष्णकटिबंधीय और उपोष्णकटिबंधीय क्षेत्रों में बाढ़ और पानी की कमी की समस्या बढ़ सकती है। जलवायु परिवर्तन से वायु प्रदूषण और धूलकणों की वृद्धि हो सकती है, जो श्वसन तंत्र से जुड़ी बीमारियाँ, जैसे अस्थमा और फेफड़ों की बीमारियों को बढ़ा सकती है। स्वास्थ्य संकट से सार्वजनिक स्वास्थ्य सेवाओं पर दबाव बढ़ता है, जिससे स्वास्थ्य देखभाल लागत में वृद्धि होती है और श्रमिकों की उत्पादकता प्रभावित होती है। कृषि उत्पादन में गिरावट के कारण खाद्य सुरक्षा पर नकारात्मक प्रभाव पड़ता है। पानी के स्रोतों के सूखने से पेयजल की कमी की समस्या उत्पन्न हो रही करती है।

### 3.3. जलवायु परिवर्तन का पर्यावरण पर प्रभाव

जलवायु परिवर्तन के कारण बाढ़, तूफान और समुद्र स्तर में वृद्धि जैसी घटनाएँ बुनियादी ढांचे को नष्ट कर सकती हैं। जलवायु परिवर्तन के कारण होने वाली आपदाओं से बुनियादी ढांचे की मरम्मत और पुनर्निर्माण पर उच्च लागत आती है। जलवायु परिवर्तन के कारण ऊर्जा उत्पादन और आपूर्ति नेटवर्क पर भी प्रभाव पड़ सकता है, जिससे आर्थिक गतिविधियाँ प्रभावित होती हैं।

#### (i) प्राकृतिक आपदाओं में वृद्धि

जलवायु परिवर्तन से प्राकृतिक आपदाओं का खतरा बढ़ रहा है। चक्रवात, बाढ़, सूखा, और गर्मी की लहरों की तीव्रता बढ़ रही है। जो अर्थव्यवस्था को सीधे प्रभावित करती हैं। तूफान और चक्रवात की आवृत्ति और तीव्रता जलवायु परिवर्तन के कारण बढ़ रही है, जिससे न केवल संपत्ति का नुकसान होता है, बल्कि जीवन रक्षक कार्यों और पुनर्निर्माण कार्यों पर भारी खर्च आता है।

#### (ii) वर्षा पैटर्न में बदलाव

जलवायु परिवर्तन से बाढ़ और सूखे की घटनाएँ बढ़ सकती हैं, जो कृषि, जल आपूर्ति और ऊर्जा उत्पादन जैसे प्रमुख क्षेत्रों को प्रभावित करता है। इन प्राकृतिक आपदाओं के कारण वित्तीय नुकसान

होता है, जो पुनर्निर्माण कार्य, राहत और चिकित्सा सहायता और बुनियादी ढांचा के पुनः निर्माण के लिए सरकारी खर्च को बढ़ाता है।

### (iii) समुद्र के जल स्तर में वृद्धि

जलवायु परिवर्तन से समुद्र स्तर में वृद्धि हो रही है, जिससे तटीय क्षेत्रों में जलभराव एवं बाढ़ का खतरा बढ़ रहा है। इसके परिणामस्वरूप भारी बुनियादी ढांचा क्षति, जल स्रोतों का प्रदूषण और जनहानि हो सकती है। जिससे लोगों के सुरक्षित विस्थापन की समस्या उत्पन्न हो रही है।

### (iv) जैव विविधता का नुकसान

जलवायु परिवर्तन के कारण कई प्रजातियाँ संकट में पहुँच गयी हैं और कई प्रजातियाँ विलुप्ति के कगार पर हैं। क्योंकि जलवायु में परिवर्तन होने से क्षेत्र विशेष का मौसम भी परिवर्तित हो जाता है। इस प्रकार विभिन्न जीवों और पक्षियों का रहन-सहन और प्रजनन कार्य प्रभावित होता है। जिससे अंततः जैव विविधता का ह्रास होता है।

### (v) तापमान में वृद्धि

जलवायु परिवर्तन होने से वैश्विक स्तर पर तापमान में वृद्धि हो जाती है जिससे ग्लेशियरों में संरक्षित जल पिघल कर मैदानी इलाकों में आ जाता है। गर्मी में वृद्धि के कारण लोगों को विभिन्न प्रकार की त्वचा संबंधी समस्याओं तथा कैंसर के खतरों का सामना करना पड़ता है।

### (vi) अम्लीय वर्षा

जलवायु परिवर्तन के परिणाम स्वरूप पर्यावरण प्रदूषण जनित अम्ल वर्षा होती है जिसका पेड़-पौधों, जीव जंतुओं के साथ-साथ विभिन्न बिल्डिंगों, मकान और धातु से बनी चीजों पर तथा मानव स्वास्थ्य पर नकारात्मक प्रभाव पड़ता है।

### (vii) ओजोन परत का क्षरण

ओजोन परत सूर्य की पराबैंगनी किरणों से पृथ्वी की सुरक्षा करता है। जलवायु परिवर्तन होने से ओजोन परत का क्षरण हो जाता है। जिससे त्वचा से संबंधित रोग में वृद्धि होती है। फसलों की उत्पादकता कम हो जाती है। ओजोन परत के क्षण से स्थलीय और जलीय परिक्षेत्र के आवासीय परिवेश प्रभावित होते हैं। विश्व बैंक के एक आकलन के अनुसार ओजोन परत चरण से प्रतिवर्ष लगभग तीन लाख लोग त्वचा कैंसर के शिकार हो रहे हैं, और मोतियाबिंद के मामले में लगभग 17 मिलियन वृद्धि होती है।

## 4. जलवायु परिवर्तन को नियंत्रित करने के उपाय

### (i) ग्रीनहाउस गैस उत्सर्जन में कमी

जलवायु परिवर्तन से निपटने के लिए सबसे महत्वपूर्ण कदम ग्रीनहाउस गैसों के उत्सर्जन में कमी करना है। सरकारों को नवीकरणीय ऊर्जा स्रोतों (जैसे सौर, पवन, जल और बायोमास) को बढ़ावा देने के लिए नीति अपनानी चाहिए। इन ऊर्जा स्रोतों का उपयोग जीवाश्म ईंधनों के उपयोग को करके कार्बन उत्सर्जन को घटाता है। ऊर्जा के कुशल उपयोग को बढ़ावा देने के लिए ऊर्जा दक्षता से जुड़े मानक और योजनाएँ लागू करनी चाहिए। जैसे ऊर्जा बचत उपकरणों को प्रोत्साहित करना, उद्योगों में ऊर्जा बचत तकनीकों का उपयोग और घरों में ऊर्जा दक्षता बढ़ाने वाले उपायों को लागू करना चाहिए। इलेक्ट्रिक और हाइब्रिड वाहनों को प्रोत्साहन देकर भी ग्रीनहाउस गैस उत्सर्जन में कमी की जा सकती है।

### (ii) वनीकरण और वृक्षारोपण

जलवायु परिवर्तन के प्रभाव से बचने लिए यह आवश्यक है कि बड़े पैमाने पर वृक्षारोपण और वनों की सुरक्षा किया जाए। वनों की कटाई को पूर्णतया प्रतिबंधित किया जाना चाहिए। साथ ही साथ व्यक्तिगत उपयोग के लिए भी पेड़ काटने के लिए इस शर्त पर छूट दी जानी चाहिए कि एक पेड़ काटने के बदले, एक नया पेड़ लगाया जाए पेड़ लगाया जाये। अधिकांश क्षेत्रों पर वृक्षारोपण होने से जलवायु परिवर्तन के प्रभाव को काम किया जा सकता है।

### (iii) पोषणीय कृषि

कृषि के क्षेत्र में पोषणीय कृषि प्रणाली के माध्यम से जलवायु परिवर्तन के प्रभाव को कम किया जा सकता है। कृषि में रासायनिक उर्वरकों और कीटनाशकों के प्रयोग को कम करके जैविक उर्वरकों और

जैविक रूप से तैयार कीटनाशकों का प्रयोग किया जाना चाहिए। इसके अतिरिक्त जल प्रबंधन तकनीकी का कुशल उपयोग करके जलवायु परिवर्तन के प्रभाव को शिथिल किया जा सकता है।

#### (iv) कार्बन टैक्स

कार्बन टैक्स एक आर्थिक नीतिगत उपकरण है, जिसके तहत ग्रीनहाउस गैसों के उत्सर्जन पर टैक्स लगाया जाता है। यह प्रदूषण करने वाले उद्योगों और व्यक्तियों को उत्सर्जन को कम करने के लिए प्रेरित करता है। जिसे ग्रीनहाउस गैसों के उत्सर्जन को नियंत्रित करने के लिए लागू किया जाता है। यह टैक्स उन उद्योगों या गतिविधियों पर लगाया जाता है जो ग्रीनहाउस गैसों का उत्सर्जन करती हैं। इसका उद्देश्य उत्सर्जन को कम करने के लिए कंपनियों और व्यक्तियों को प्रोत्साहित करना है। इसका एक प्रमुख लाभ यह है कि यह उत्सर्जन को कम करने के लिए बाजार आधारित समाधान उत्पन्न करता है।

#### (v) व्यापार योग्य उत्सर्जन परमिट्स

यह एक प्रणाली है जिसमें सरकार एक निश्चित सीमा (कैप) तक उत्सर्जन को सीमित करती है और कंपनियों को उत्सर्जन परमिट देती है। जिससे वह उद्योग या क्षेत्र को एक सीमा तक ग्रीनहाउस गैसों का उत्सर्जन करने की अनुमति होती है। कंपनियाँ उन परमिट्स को आपस में व्यापार कर सकती हैं। इसका उद्देश्य उत्सर्जन को किफायती ढंग से नियंत्रित करना और कंपनियों को उत्सर्जन घटाने के लिए प्रोत्साहित करना है।

#### (vi) पर्यावरणीय विनियमन और मानक

सरकारें जलवायु परिवर्तन पर नियंत्रण रखने के लिए कड़े पर्यावरणीय विनियमन और मानक निर्धारित कर सकती हैं, जैसे प्रदूषण की सीमाएँ, ऊर्जा दक्षता मानक, और हरित प्रौद्योगिकियों के लिए प्रोत्साहन आदि जिससे जलवायु परिवर्तन के खतरों से बचा जा सकता है।

#### (vii) वन्य जीवन संरक्षण और जैव विविधता

वन्य जीवन और जैव विविधता को संरक्षण देने के लिए नीति उपायों की आवश्यकता है। वन वृक्षों के रूप में कार्बन डाइऑक्साइड को अवशोषित करते हैं, इसलिए वनस्पति क्षेत्र की रक्षा करना और वृक्षारोपण को बढ़ावा देना आवश्यक है। जलवायु परिवर्तन के कारण जैव विविधता में कमी आ सकती है। इस समस्या को हल करने के लिए वन्य जीवों और पारिस्थितिकीय तंत्र की रक्षा अर्थात् जैव विविधता संरक्षण करना आवश्यक है।

(viii) शिक्षा और जन जागरूकता जलवायु परिवर्तन से निपटने के लिए नागरिकों और समाज के सभी स्तरों में शिक्षा और जागरूकता फैलाना अत्यंत महत्वपूर्ण है। शिक्षा प्रणाली में जलवायु परिवर्तन का समावेश होने से बच्चों और युवाओं में जलवायु परिवर्तन के मुद्दे पर समझ और समाधान की जागरूकता विकसित होगी। सार्वजनिक जागरूकता अभियान के माध्यम से जलवायु परिवर्तन के बारे में लोगों को सूचित करना और उन्हें सतत जीवनशैली अपनाने के लिए प्रेरित करना, जैसे कि ऊर्जा की बचत, कचरे का निपटान और पर्यावरणीय दृष्टिकोण से जिम्मेदार नागरिकों का विकास होगा।

#### (ix) जलवायु न्याय (Climate Justice)

जलवायु परिवर्तन से सबसे अधिक प्रभावित होने वाले देशों को न्यायपूर्ण तरीके से समर्थन प्रदान करना चाहिए। विशेष रूप से, विकासशील देशों को जलवायु परिवर्तन के प्रभावों से निपटने के लिए वित्तीय और तकनीकी सहायता प्रदान करनी चाहिए।

जलवायु परिवर्तन का अर्थशास्त्र विभिन्न आर्थिक, सामाजिक और पर्यावरणीय दृष्टिकोणों से जलवायु परिवर्तन के प्रभावों को समझने और नियंत्रण उपायों को लागू करने का एक महत्वपूर्ण क्षेत्र है। इसके समाधान के लिए नीतियों, वित्तीय उपायों और अंतर्राष्ट्रीय सहयोग की आवश्यकता है। यदि हम जलवायु परिवर्तन के दुष्प्रभावों से बचना चाहते हैं, तो हमें अधिक प्रभावी और दीर्घकालिक उपायों को लागू करना होगा। जलवायु परिवर्तन एक वैश्विक समस्या है, जो न केवल पर्यावरण, बल्कि आर्थिक और सामाजिक विकास को भी प्रभावित कर रही है। इसे रोकने के लिए वैश्विक सहयोग, तकनीकी नवाचार, और व्यक्तिगत प्रयासों की आवश्यकता है।

“जलवायु परिवर्तन से निपटना हमारी प्राथमिकता होनी चाहिए, क्योंकि एक स्वस्थ पर्यावरण ही मानवता के उज्ज्वल भविष्य का आधार है।”

## 5. जलवायु परिवर्तन को रोकने के लिए राष्ट्रीय कार्य योजना

भारत सरकार जलवायु परिवर्तन के प्रभाव से निपटने के लिए अपने आर्थिक एवं सामाजिक विकास कार्यक्रमों के माध्यम से महत्वपूर्ण घरेलू रणनीति तैयार किया है। जलवायु परिवर्तन पर राष्ट्रीय कार्य योजना को विशिष्ट क्षेत्रों में नोडल मंत्रालयों के अधीन क्रियान्वित किया जा रहा है। जिसमें सौर ऊर्जा, ऊर्जा क्षमता का विकास, पोषणीय कृषि, टिकाऊ आवास, हिमालयी परितंत्र संरक्षण, हरित भारत और जलवायु परिवर्तन राजनीतिक ज्ञान के क्षेत्र में राष्ट्रीय स्तर पर कुल आठ जलवायु परिवर्तन पर राष्ट्रीय कार्य योजना केन्द्र क्षेत्रीय स्तर पर कार्यरत हैं।

भारत में पर्यावरण वन एवं जलवायु परिवर्तन मंत्रालय जनवरी 2014 से जलवायु परिवर्तन कार्य कार्यक्रम नाम की योजना का क्रियान्वयन कर रहा है। जिसका प्रमुख उद्देश्य वैज्ञानिक और नीतिगत कार्यक्रमों के लिए उचित संस्थागत संरचना स्थापित करना है। यह पोषणीय विकास के संदर्भ में जलवायु परिवर्तन से संबंधित योजनाओं का क्रियान्वयन करते हुए देश में जलवायु परिवर्तन के मूल्यांकन हेतु वैज्ञानिकों एवं विश्लेषकों की क्षमता निर्मित करता है। जिसके माध्यम से ब्लैक कार्बन के प्रभाव की निगरानी एवं मूल्यांकन के द्वारा जलवायु परिवर्तन में ब्लैक कार्बन के प्रभाव को काम किया जा सकता है।

## 6. जलवायु परिवर्तन के लिए वैश्विक समाधान

जलवायु परिवर्तन एक वैश्विक समस्या है जो पृथ्वी के सभी हिस्सों को प्रभावित कर रही है। इसके प्रभावों से निपटने के लिए केवल राष्ट्रीय स्तर पर कार्य नहीं किया जा सकता, बल्कि एकजुट वैश्विक प्रयासों की आवश्यकता है। विभिन्न देशों के बीच सहयोग और साझा समाधान, जैसे कि कार्बन उत्सर्जन में कमी, नवीकरणीय ऊर्जा का उपयोग, और जलवायु अनुकूलन उपाय, इस चुनौती से निपटने में महत्वपूर्ण भूमिका निभाते हैं।

### (i) पेरिस समझौता

जलवायु परिवर्तन पर वैश्विक स्तर पर सबसे महत्वपूर्ण अंतर्राष्ट्रीय समझौता फ्रांस की राजधानी पेरिस में वर्ष 2015 में सम्पन्न हुआ। जिसमें विश्व के प्रमुख देशों के प्रतिनिधियों ने वैश्विक जलवायु परिवर्तन के मुद्दे पर चर्चा करने के लिए उपस्थित हुए थे। जिसका प्रमुख उद्देश्य वैश्विक तापमान वृद्धि को 2°C तक सीमित करना, सभी देशों के द्वारा अपने सीमा में जलवायु परिवर्तन के लिए उत्तरदायी कारकों के लिए कठोर रणनीति तैयार करना तथा जलवायु वित्त आदि पर चर्चा करना था। इस समझौते के तहत सभी देशों ने सहमति व्यक्त किया है कि वे 2°C से अधिक तापमान वृद्धि को रोकने के लिए कदम उठाएंगे और प्रयास करेंगे कि यह वृद्धि 1.5°C तक सीमित रहे। प्रत्येक देश को अपने जलवायु परिवर्तन के खिलाफ संघर्ष के लिए लक्ष्य तय करने होंगे और हर पांच साल में इन लक्ष्यों की समीक्षा करनी होगी। विकसित देशों को विकासशील देशों को जलवायु परिवर्तन से निपटने के लिए वित्तीय सहायता (जलवायु वित्त) प्रदान करनी होगी।

### (ii) नवीकरणीय ऊर्जा संक्रमण

जलवायु परिवर्तन से निपटने के लिए जीवाश्म ईंधनों से नवीकरणीय ऊर्जा स्रोतों की ओर संक्रमण आवश्यक है। इसके लिए सौर और पवन ऊर्जा जैसे अक्षय ऊर्जा स्रोतों का उपयोग बढ़ाने के लिए सरकारों को नीतियाँ बनाना होगा तथा सौर पैनल और पवन टर्बाइन स्थापित करने के लिए वित्तीय प्रोत्साहन प्रदान किया जा सकता है। विकासशील देशों में स्वच्छ ऊर्जा प्रौद्योगिकियों की उपलब्धता बढ़ाने के लिए तकनीकी सहायता और निवेश की आवश्यकता है।

### (iii) कार्बन उत्सर्जन में कमी

ग्लोबल कार्बन उत्सर्जन को कम करने के लिए कई उपायों की आवश्यकता है। कार्बन टैक्स और उत्सर्जन व्यापार प्रणाली के द्वारा उद्योगों को प्रदूषण कम करने के लिए प्रेरित किया जा सकता है। औद्योगिक प्रक्रियाओं, निर्माण क्षेत्र और परिवहन में ऊर्जा दक्षता बढ़ाना, कार्बन उत्सर्जन में कमी लाने के लिए महत्वपूर्ण कदम है। परिवहन क्षेत्र में सुधार, इलेक्ट्रिक वाहन को बढ़ावा देना, सार्वजनिक परिवहन का उपयोग बढ़ाना और कार्बन उत्सर्जन वाले वाहनों का उत्सर्जन घटाना वैश्विक प्रयासों का हिस्सा होना चाहिए।

**(iv) जलवायु वित्त**

जलवायु परिवर्तन के समाधान के लिए आवश्यक निवेश में कमी का सामना करने के लिए अंतर्राष्ट्रीय जलवायु वित्त महत्वपूर्ण है। जलवायु परिवर्तन से निपटने और इसके प्रभावों से बचाव के लिए वित्तीय उपायों की आवश्यकता होती है। विकासशील देशों को जलवायु परिवर्तन के प्रभावों से निपटने और अनुकूलन के उपायों को लागू करने के लिए वित्तीय सहायता की आवश्यकता होती है। इसके लिए अंतर्राष्ट्रीय जलवायु वित्त संस्थाएँ, जैसे ग्रीन क्लाइमेट फंड कार्यरत हैं। जिससे विकासशील देशों को विकसित देशों से वित्तीय सहायता लेनी पड़ती है। जलवायु परिवर्तन से निपटने के लिए नवीकरणीय ऊर्जा स्रोतों में निवेश बढ़ाना आवश्यक है। निजी क्षेत्र को भी जलवायु परियोजनाओं में निवेश करने के लिए प्रोत्साहित किया जाना चाहिए, ताकि जलवायु समाधान के लिए आवश्यक पूंजी जुटाई जा सके। इससे जलवायु संकट के समाधान के लिए दीर्घकालिक आर्थिक लाभ हो सकते हैं।

**(v) वनस्पति संरक्षण और वृक्षारोपण**

वनों का संरक्षण और वृक्षारोपण जलवायु परिवर्तन को कम करने के लिए अहम उपाय हैं। पेड़-पौधे कार्बन डाइऑक्साइड को अवशोषित करते हैं और जलवायु परिवर्तन के प्रभाव को धीमा करने में मदद करते हैं। इसलिए वैश्विक स्तर पर वन क्षेत्र को संरक्षित करना और वृक्षारोपण को बढ़ावा देना आवश्यक है। बायोमास और बायोगैस के उपयोग को बढ़ाना भी जलवायु परिवर्तन के प्रभाव को कम करने में मदद कर सकता है।

**(vi) जलवायु अनुकूलन**

जलवायु परिवर्तन से बचाव के उपायों के साथ-साथ, हमें इसके प्रभावों से निपटने के लिए अनुकूलन उपायों की आवश्यकता है। जलवायु परिवर्तन के प्रभावों को कम करने के लिए बुनियादी ढांचे की मजबूती आवश्यक है, जैसे कि तटीय क्षेत्रों में तटीय सुरक्षा, बाढ़ नियंत्रण और जलवायु-लचीलापन वाले शहरों का निर्माण किया जा सकता है। जलवायु परिवर्तन के प्रभाव से कृषि और जल संसाधन प्रभावित हो सकते हैं, इसलिए इन क्षेत्रों में अनुकूलन उपायों को बढ़ावा देना जरूरी है, जैसे कि जलवायु-संवेदनशील कृषि तकनीकों का उपयोग और जल संरक्षण उपाय से कृषि और जल संसाधन प्रबंधन किया जा सकता है।

**(vii) वैश्विक जागरूकता और शिक्षा**

जलवायु परिवर्तन के समाधान के लिए वैश्विक जागरूकता और शिक्षा अत्यंत महत्वपूर्ण है बच्चों और युवाओं को जलवायु परिवर्तन के बारे में जागरूक करना और उन्हें समाधान में भागीदारी के लिए प्रेरित करने के लिए शिक्षा प्रणाली में जलवायु परिवर्तन का समावेश किया जाना चाहिए। दुनिया भर में जलवायु परिवर्तन के बारे में जन जागरूकता अभियान चलाने चाहिए ताकि लोग इसे अपनी जिम्मेदारी समझें और अपनी जीवनशैली में बदलाव लाएं।

जलवायु परिवर्तन एक गंभीर और चुनौतीपूर्ण समस्या है, जिसे केवल वैश्विक सहयोग के माध्यम से हल किया जा सकता है। पेरिस समझौता, नवीकरणीय ऊर्जा, कार्बन उत्सर्जन में कमी, वन संरक्षण और जलवायु अनुकूलन उपायों जैसी वैश्विक नीतियों को लागू करने से जलवायु परिवर्तन के प्रभावों को कम किया जा सकता है। हालांकि, इसके लिए सभी देशों और संगठनों को मिलकर काम करना होगा और हर नागरिक को भी जलवायु परिवर्तन के खिलाफ प्रयासों में भागीदारी करनी होगी।

**7. जलवायु परिवर्तन और आर्थिक विकास**

जलवायु परिवर्तन का केवल पर्यावरण पर ही नहीं, बल्कि अर्थव्यवस्था पर भी गहरा प्रभाव पड़ता है। जलवायु परिवर्तन के कारण होने वाली आपदाएँ, जैसे कि बाढ़, सूखा, और समुद्र स्तर में वृद्धि, सीधे-सीधे आर्थिक गतिविधियों को प्रभावित करती हैं। आर्थिक दृष्टिकोण से जलवायु परिवर्तन को समझना यह आवश्यक है कि यह कैसे विकास, उत्पादन, रोजगार और वित्तीय प्रणालियों को प्रभावित करता है और इसके समाधान के लिए क्या आर्थिक नीतियाँ अपनाई जा सकती हैं। जलवायु परिवर्तन विशेष रूप से विकासशील देशों में अधिक प्रभाव डालता है, जहाँ संसाधन सीमित होते हैं। जलवायु परिवर्तन के कारण कृषि, जल संसाधन, और बुनियादी ढांचे पर दबाव बढ़ने से इन देशों की आर्थिक विकास दर में कमी आ सकती है। जलवायु परिवर्तन का सबसे अधिक प्रभाव गरीब और असुरक्षित

समुदायों पर पड़ता है, जो पहले से ही गरीबी, भुखमरी और स्वास्थ्य समस्याओं से जूझ रहे होते हैं। इससे सामाजिक और आर्थिक असमानता बढ़ सकती है।

### 8. जलवायु परिवर्तन और भारत

जलवायु परिवर्तन के परिणाम स्वरूप भारत के हिमालय क्षेत्र में ग्लेशियर तेजी के साथ पिघल रहे हैं। जिससे नदियों का प्रवाह असंतुलित हो रहा है। गंगा-ब्रह्मपुत्र क्षेत्र में बाढ़ की तीव्रता में वृद्धि हुई है। दक्षिण भारत में समुद्र का जल स्तर बढ़ने से समुद्र तटीय क्षेत्रों में पानी भर रहा है। जिससे वहां के लोगों को समस्या उत्पन्न हो रही है। कृषि के क्षेत्र में जलवायु परिवर्तन के परिणाम स्वरूप मानसून अनिश्चित और अनियमित हो गया है। किसी वर्ष पर्याप्त वर्षा होती है, तो किसी वर्ष बहुत कम मात्रा में वर्षा होती है। जिससे किसानों की आत्महत्याएं बढ़ रही हैं। स्वास्थ्य के क्षेत्र में जलवायु परिवर्तन के परिणाम स्वरूप हीट स्ट्रोक का खतरा बढ़ रहा है तथा जल जनित रोगों में वृद्धि हुई है। यह निकट भविष्य में बहुत बड़े खतरे के रूप में मानव जीवन के सामने उपस्थित हो सकता है। जलवायु परिवर्तन को रोकने के लिए भारत सरकार के द्वारा अनेक योजनाओं का संचालन किया जा रहा है। जिसमें यातायात के क्षेत्र में इलेक्ट्रिक वाहनों को बढ़ावा दिया जा रहा है। ऊर्जा के क्षेत्र में सौर ऊर्जा को बढ़ावा दिया जा रहा है। घरेलू ईंधन के क्षेत्र में उज्ज्वला गैस योजना, जल जीवन मिशन योजना, स्वच्छ भारत योजना, अमृत भारत योजना, हिमालय पारिस्थितिकी संरक्षण योजना, गंगा संरक्षण योजना आदि के द्वारा जलवायु परिवर्तन के प्रभाव को काम करने का प्रयास किया जा रहा है। भारत सरकार ने राष्ट्रीय स्तर पर जलवायु परिवर्तन के संबंध में कार्य योजना लागू किया है। राज्य स्तर पर विभिन्न राज्यों के द्वारा राज्य कार्य योजना संचालित की जा रही है। जिससे जलवायु परिवर्तन के परिणाम स्वरूप पर्यावरण के हानिकारक प्रभाव से बचा जा सके।

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**भारतीय ज्ञान परंपरा में पर्यावरण संरक्षण और संवर्धन की संकल्पना**

विनीत कुमार गुरु  
इतिहास

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**सारांश:**

भारतीय ज्ञान परंपरा में प्रकृति के प्रति आदर सहअस्तित्व और संरक्षण की अवधारणा प्राचीन ग्रंथों से लेकर आधुनिक सामाजिक आंदोलनों तक दिखाई देती है। समसामयिक पर्यावरणीय समस्याओं के समाधान में पारंपरिक ऐतिहासिक विश्लेषण और पर्यावरणीय आंदोलन दोनों की भूमिका महत्वपूर्ण है। इस शोध पत्र में पारंपरिक ग्रंथों के साथ-साथ समकालीन इतिहासकार और पर्यावरणवादियों के कार्यों को जोड़कर परंपरा की उपयोगिता और सीमाएं परखी गई हैं और यह जानने का प्रयास किया गया है कि वर्तमान पर्यावरण चेतना को परंपरा किस तरह दिशा दे सकती है।

**शोध पद्धति:**

प्रस्तुत शोध पत्र विषय संबंधित साहित्य विश्लेषण के आधार पर तैयार किया गया है।

**शोध का उद्देश्य:**

- (1) भारतीय ज्ञान परंपरा में पर्यावरण की अवधारणा को समझना।
- (2) वैदिक उपनिषद और पौराणिक साहित्य में पर्यावरणीय विचारों का विश्लेषण करना।
- (3) भारतीय जीवन शैली में पर्यावरण संरक्षण की व्यावहारिक रूपों की पहचान करना।
- (4) आधुनिक पर्यावरणीय नीतियों में पारंपरिक भारतीय दृष्टिकोण की प्रासंगिकता पर विचार करना।

**(1) भारतीय ज्ञान परंपरा में पर्यावरण की अवधारणा:**

भारतीय दर्शन में ब्राम्हंड की उत्पत्ति पंच महाभूतों-पृथ्वी, जल, अग्नि, वायु और आकाश से मानी गई है। इन तत्वों को देवता का स्वरूप दिया गया है। अथर्ववेद में कहा गया है-

“माता भूमिः पुत्रोऽहं पृथिव्याः”

अर्थात् पृथ्वी हमारी माता है और हम उसके पुत्र हैं। इस दृष्टिकोण ने मनुष्य और प्रकृति के बीच संतान और मातृत्व का संबंध स्थापित किया, जिससे शोषण की जगह संरक्षण की भावना उत्पन्न हुई।

**(2) वैदिक साहित्य में पर्यावरणीय चिंतन:**

ऋग्वेद में सूर्य, वायु, जल अग्नि आदि प्राकृतिक तत्वों की आराधना की गई है। यजुर्वेद में कहा गया है-

“धेनवः पृथ्वीः मे मातरः”

अर्थात् पृथ्वी हमारी माता के समान है, उसका दोहन नहीं पालन करना चाहिए। अथर्ववेद में पर्यावरण संतुलन हेतु वनस्पतियों के संरक्षण का उल्लेख मिलता है।

“वनस्पतिनां पतये नमः”

अर्थात् हम वृक्षों के स्वामी (प्रकृति) को प्रणाम करते हैं। इन वैदिक मंत्रों से स्पष्ट होता है कि प्राचीन भारत में पर्यावरण संरक्षण धार्मिक कर्तव्य के रूप में देखा जाता था।

**उपनिषदों में पर्यावरणीय दर्शन:**

उपनिषदों ने प्रकृति को ब्रह्म का रूप माना है। “ईशोपनिषद्” में कहा गया है संपूर्ण जगत में ईश्वर का वास है। इस दृष्टिकोण से प्रकृति का शोषण नहीं बल्कि सम्मान आवश्यक है। उपनिषद के ये विचार आधुनिक ईको-स्पिरिचुअलिटी की अवधारणा से मेल खाता है।

**पुराणों और लोक परंपराओं में पर्यावरणीय मूल्य:**

पुराणों में वृक्षों, नदियों, पर्वतों और पशु-पक्षियों को देवतुल्य माना गया है। वट, पीपल, नीम, तुलसी की पूजा आज भी पर्यावरणीय संतुलन की दिशा में योगदान करती है। नदी पर्व जैसे- “ गंगा दशहरा,

नर्मदा जयंती आदि नदियों के संरक्षण का लोक उत्सव है। वन महोत्सव, गौ सेवा, भूमि पूजन जैसे संस्कार भी प्रकृति संरक्षण के अंग हैं।

#### **बौद्ध और जैन दृष्टिकोण:**

बौद्ध धर्म में अहिंसा केवल मानव तक सीमित नहीं बल्कि सभी जीवों तक फैली हुई है। जैन धर्म का अहिंसा और जीव दया का सिद्धांत पर्यावरण संरक्षण में बहुत महत्व रखता है।

#### **(3) भारतीय जीवन शैली में पर्यावरणीय आचरण:**

भारतीय जीवन शैली में संतुलन और संयम का विशेष स्थान रहा है। जल, अन्न, तथा ऊर्जा का उचित उपयोग। ग्राम्य जीवन प्रणाली जो स्थानीय संसाधनों पर आधारित थी। वास्तु शास्त्र और आयुर्वेद जैसे विज्ञान भी पर्यावरण संतुलन पर आधारित हैं। इस प्रकार भारतीय परंपरा में पर्यावरण केवल ज्ञान का विषय नहीं, जीवन का व्यावहारिक तत्व रहा है।

#### **(4) ऐतिहासिक अध्ययन आधुनिक इतिहासकारों का योगदान:**

##### **रामशरण शर्मा:**

रामशरण शर्मा ने प्राचीन और मध्यकालीन भारतीय समाज, ग्राम्य व्यवस्था और कृषक जीवन अवस्था पर गहरा शोध किया। उनके ऐतिहासिक अध्ययन से पता चलता है कि किस प्रकार सामाजिक आर्थिक संरचनाओं और कृषि आधारित जीवन शैली ने स्थानीय पारिस्थितिक संतुलन को प्रभावित किया और किन स्थितियों में संसाधनों का अधिक दोहन हुआ। उनके समकालीन सामाजिक आर्थिक विश्लेषण से पारंपरिक व्यवस्थाओं की पर्यावरणीय व्याख्याओं में योगदान मिलता है।

##### **इरफान हबीब:**

इरफान हबीब ने भारत के पारिस्थितिक इतिहास पर कार्य किया है। उनके संपादित और लिखे हुए ग्रन्थों में मानव पर्यावरण, कृषि के विकास और जलवायु पर्यावरणीय परिवर्तनों का ऐतिहासिक विश्लेषण मिलता है। इरफान हबीब का दृष्टिकोण यह स्पष्ट करता है कि ऐतिहासिक प्रक्रियाएं और पर्यावरण एक दूसरे को प्रभावित करते हैं जो आधुनिक पर्यावरण नीति के लिए ऐतिहासिक सबक प्रदान करता है।

##### **रोमिला थापर:**

रोमिला थापर ने प्राचीन भारत के ऐतिहासिक परिदृश्य का विस्तृत अध्ययन किया है और उन्होंने पुरातात्विक तथा पर्यावरणीय कारकों जैसे नदियों के बहाव में परिवर्तन या कृषि पद्धतियों को सभ्यता के उत्थान पतन से जोड़कर देखा है। उनकी ऐतिहासिक व्याख्याएं इस बात पर प्रकाश डालती हैं कि पर्यावरणीय बदलाव किस तरह सामाजिक और आर्थिक संरचनाओं को प्रभावित कर सकते हैं।

ऊपर दिये गये इतिहासकारों के कार्य पारंपरिक ग्रन्थों के विश्लेषण को ऐतिहासिक और सामायिक संदर्भ देते हैं। जिससे यह समझने में सहायता मिलती है कि किस प्रकार परंपरागत जीवन पद्धतियां और प्रशासनिक नीतियां संसाधन प्रबंधन को प्रभावित करती थीं।

#### **आधुनिक पर्यावरण आंदोलन एवं कार्यकर्ता:**

##### **सुंदरलाल बहुगुणा:**

यह चिपको आंदोलन में प्रमुख नेताओं में से एक है जिन्होंने वृक्षों की रक्षा हिमालय की पारिस्थितिकी के संरक्षण के लिए व्यापक जन अभियान चलाया। चिपको आंदोलन ने स्थानीय परंपराओं और सहायक सामाजिक संरचनाओं को आधार बनाकर वृक्षों की रक्षा को जन आंदोलन में बदला।

##### **वंदना शिवा:**

यह जैव विविधता, बीज सर्व नियंत्रण पारंपरिक कृषि और किसान के अधिकारों पर सक्रिय रही हैं। इन्होंने औद्योगिक कृषि के विरुद्ध आवाज उठाई है और स्थानीय जैविक कृषि के पक्ष में कार्य किया है।

##### **अनिल अग्रवाल**

अनिल अग्रवाल ने पर्यावरण और विकास के बीच के संबंधों पर नीति आधारित शोध एवं जन जागरूकता का काम किया।

**सालिम अली:**

यह एक भारतीय पक्षीविद और प्राकृतिक इतिहास के अग्रगामी व्यक्ति थे। उनके कार्यों ने भारत में पक्षी सुरक्षा और अभयारण्य की संरक्षण को निर्णायक समर्थन दिया।

**परंपरा और आधुनिक नीति का संवाद:**

जहां पूर्वकालीन धार्मिक सांस्कृति मान्यताओं (वृक्ष पूजा, नदी पूजा तथा अहिंसा आदि) ने स्थानीय स्तर पर संरक्षण का एक सामाजिक आधार तैयार किया वहीं औद्योगीकरण, औपनिवेशिक नीतियों और आधुनिक आर्थिक दबावों ने इन पारंपरिक व्यवस्थाओं को चुनौती दी। इतिहासकारों के विश्लेषण से हमें यह समझने में सहायता मिलती है कि किस तरह सामाजिक और आर्थिक बदलावों ने पर्यावरण पर प्रभाव डाला। साथ ही चिपको आंदोलन, 'अम'पसमदज अंससमलए नर्मदा आंदोलन जैसे समकालीन पर्यावरण आंदोलन में परंपरागत और आधुनिक दोनों दृष्टिकोण को जोड़ते हुए नीतिगत परिणाम भी दिलाये— जैसे वन कटाई पर रोक, राष्ट्रीय उद्यानों का संरक्षण और पर्यावरणीय प्रभाव का सार्वजनिक विमर्श।

**निष्कर्ष:**

इस प्रकार कहा जा सकता है कि भारतीय ज्ञान परंपरा ने पर्यावरण को केवल संसाधन नहीं बल्कि चेतन तत्व माना। वैदिक ऋषियों से लेकर आधुनिक संतों तक सभी ने मानव और प्रकृति के सहअस्तित्व का संदेश दिया। आज आवश्यकता है कि हम इस पारंपरिक ज्ञान को आधुनिक शिक्षा नीति और जीवन शैली में समाहित करें ताकि पृथ्वी की रक्षा और मानव सभ्यता की स्थिरता सुनिश्चित हो सके। जहां इतिहासकारों के कार्य हमें ऐतिहासिक संदर्भ से सबक देते हैं वहीं पर्यावरणविदों के सार्वजनिक कार्य इन परंपराओं को यथार्थ में बदलते हैं।

**संदर्भ:-**

1. ऋग्वेद, यजुर्वेद, अथर्ववेद विभिन्न सूक्त।
2. ईशोपनिषद्, कठोपनिषद्।
3. महाभारत और भागवत पुराण।
4. पण्डित जवाहरलाल नेहरू— डिस्कवरी ऑफ इंडिया।
5. कपिल देव द्विवेदी— भारतीय पर्यावरणीय दर्शन।
6. पी.आर.शर्मा — इण्डियन ट्रेडीशन एंड इकोलॉजी।
7. रामशरण शर्मा— जीवनी और प्रमुख कार्य।
8. इरफान हबीब— मानव और पर्यावरण।
9. रोमिला थापर— की विभिन्न पुस्तकें।
10. सुंदर लाल बहुगुणा— चिपको आंदोलन पर लेख।
11. वंदना शिवा— जैव विविधता पर लेख।
12. सालिम अली— जीवनी और पक्षी संरक्षण में योगदान।



Publisher:

**Ramkripal Richhariya and Sons Publication**

Chhatarpur (M.P.)

Email : [richhariyapublicationchp@gmail.com](mailto:richhariyapublicationchp@gmail.com)

Cont.- 9131184032