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TECHNICAL REPORT

A DPSIR (Drivers, Pressures, State, Impact, and Responses) Framework for Nature-Positive Atlas

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March 2026

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Acknowledgements

This work was conducted under the CGIAR Multifunctional Landscapes Program. We would like to thank all funders who supported this research through their contributions to the CGIAR Trust Fund (https://www.cgiar.org/funders/)

CGIAR Multifunctional Landscapes Program

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Citation

Yadav, Shweta, Tosin Somorin, and Alok Sikka. 2026. *A DPSIR (Drivers, Pressures, State, Impact, and Responses) Framework for Nature-Positive Atlas.* International Water Management Institute (IWMI).

Front cover photo: Tosin Somorin/IWMI
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Summary

Nature is fundamental to achieving all the Sustainable Development Goals (SDGs), impacting food, water, health, and economic prosperity, making its protection essential for people and the planet. Loss of nature undermines human wellbeing and weakens the economies that rely on natural capital assets for growth and development. Globally, more than half of the world's GDP is moderately or highly dependent on nature and its ecosystem services. Nature loss is a critical global crisis driven primarily by anthropogenic activities such as land and sea-use change, overexploitation, pollution, invasive species, and climate change, leading to 90% of nature loss over the last five decades. Since 1970, human actions have substantially altered the land surface and marine environments, while the wildlife populations have reduced significantly. According to the World Economic Forum report of 2020, more than half of the global GDP is moderately and highly dependent on nature. Under the business-as-usual scenario, the decline in nature and its services will cause an estimated economic loss of $430 billion annually worldwide to the key economic sectors, such as food production. Decline in nature also increases the risks of emerging infectious diseases and mental health issues. Measuring and mapping the change in nature is a key step to identifying the vulnerability hotspots. It is also a crucial step to halt and reverse the loss of nature and to meet the global targets for nature as mentioned in several global goals, such as in the Kunming Montreal Global Biodiversity Framework (KMGBF) under the UN Convention on Biological Diversity (CBD) and UN Decade of Restoration (2020-2030).

However, there is no universal method to measure the change in the state of nature (gain or loss). The lack of common methods and indicators limits progress in assessing nature loss. In this technical report, we proposed a **DPSIR** framework (Drivers, Pressures, State, Impact, and Responses) to provide a causal-chain analysis of the nature crisis. A DPSIR framework attempts to differentiate between the drivers and pressures of nature responsible for altering the current state of nature, thereby impacting the ecosystem and human wellbeing. This understanding helps in deciding the targeted interventions (Responses/actions) to address the drivers and pressures of nature. Under each component of the DPSIR framework, a non-exhaustive list of indicators is proposed to elucidate the cause-and-effect relationship for nature. Depending on the specific national context, scale, and data availability, the proposed number of indicators may vary. As the next step, a consensus will be sought to validate the proposed indicators of the DPSIR framework. The report advocates for a **State/Impact-Oriented Approach**, suggesting that monitoring the current state of nature is the essential first step to identify local pressures and prioritize conservation through mapping the vulnerability hotspots. Nature gain and loss will be measured by comparing the change in the state of nature (ecosystem extent, condition, and species) for a defined region in a defined temporal baseline.

The report also emphasized that integrating nature conservation with economic and climate goals is no longer optional. By using a structured DPSIR framework to map the state of nature, countries can transition from tracking nature loss and ecosystem degradation to achieving a nature-positive future. The framework also provides a roadmap to halt and reverse biodiversity loss by 2030 and 2050 and provide decision-makers with the systematic tools needed to transition from tracking environmental degradation to implementing targeted, effective interventions that secure a world living in harmony with nature.

1. Nature in Crises: The Urgency of Being Nature-Positive

Nature is declining at an alarming rate. Over the past five decades, nature and nature's contribution to people have declined across all systems, terrestrial, freshwater, and marine. Nature is increasingly being managed and harvested to keep pace with the rising global demand for food, water, fiber, energy, timber, and more. Nature was never an externality; rather, it is the basis for human life, and economic development is one part of human society (Locke et al. 2021). Since 1970, the global population doubled, with 45% increase in global consumption, and a fourfold increase in the global economy, lifting 1 billion people from extreme poverty (IPBES 2019). However, this remarkable growth comes at the cost of a decline in the natural ecosystem, which underpins both life on earth and economic growth. Evidently, over the past five decades, nature's capacity to support the quality of life has declined for 14 out of 18 indicators for nature's contribution to people, while the extraction of living material from nature has increased by over 200%(Diaz et al. 2019). Nature loss reduces the ecosystems' ability to function, threatening the existence and well-being of human and non-human life. Nature's capacity to support environmental processes and provide beneficial services such as provisioning (food, water, timber), regulating (air and water quality, carbon sequestration, pollinating crops, flood and drought protection), cultural (recreation, spiritual), and supporting services (nutrient cycle, healthy soil, energy) has declined globally with regional variations. Demand for provisioning and other services from nature beyond its capacity to replenish itself leads to the tipping point of nature's loss, which is irreversible. The hierarchical view of the nature-positive goal is given in Figure 1.

To address the nature crisis, we need to reduce the pressure on nature through nature-positive actions, such as ecosystem restoration, regenerative farming, species recovery through wildlife habitat protection, and transitioning to renewable energy. Nature is complex and is not uniform; the way nature reacts to our actions is not always what is expected. Therefore, monitoring and mapping the state of nature and the impact of our actions on it is the essential first step to tracking the nature crisis. Although nature loss is recognized as a global crisis, there is no universal method to measure the change in the state of nature (gain or loss). Moreover, the state of nature is often confused with pressures and impacts on nature. The lack of common methods and indicators limits progress in assessing nature loss.

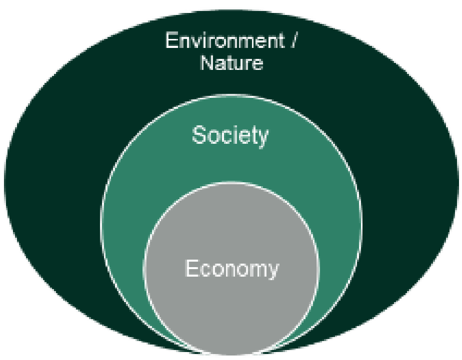

Figure 1. Nature as the context for all life and human activities, a hierarchical view of nature-positive goals (*Source*: Locke et al. 2021).

Aims and Objectives

In this report, we aim to propose a DPSIR framework to comprehend different drivers and pressures leading to nature loss, state, and impact of nature, and linking it further with responses/actions to address the root cause of the nature loss. This understanding helps in deciding the targeted interventions (Responses/actions) to address the drivers and pressures of nature loss. The report also aims to propose a non-exhaustive list of indicators representing drivers, pressures, state, impact, and response components of nature for a better understanding of the DPSIR framework, through a literature review.

The report will advocate for a State/Impact-Oriented Approach, suggesting that monitoring the current state of nature is the essential first step to identify local pressures and prioritize conservation through mapping the vulnerability hotspots. Measuring and mapping the change in nature is a crucial step to halt and reverse the loss of nature and to meet the global targets for nature. The report further illustrates the steps to measure and map the change in the current state of nature to identify the vulnerability hotspots for future actions and decision-making. Information about the depletion of natural ecosystems can help frame both country-level conservation goals and policy mechanisms for achieving the global goals for nature.

Limitations of this Study

In the absence of any universal and standard method to measure nature, this study proposed a DPSIR framework for nature and proposed indicators for a clear distinction between various drivers, pressures, state, impact, and response components of nature. Also emphasized monitoring and mapping the change in the state of nature as the first step to identify the vulnerability hotspots, followed by a reverse-method (state/impact-oriented approach) to trace back the specific pressure and drivers to address the nature loss.

However, the study also has certain limitations, such as:

- The application of the framework and its indicators is highly dependent on specific national contexts, ecosystem types, scale, and the availability of data, which can vary significantly.
- The proposed list of indicators is non-exhaustive and may need to be adjusted or changed depending on the scale and chosen natural ecosystem being studied.
- As a next step, the proposed indicators still need to be validated through stakeholder engagement, expert interviews, and on-ground piloting.

State of Nature Loss

Land and sea use changes, overexploitation of natural resources, climate change, pollution, and the spread of invasive alien species are recognized as the major human drivers (**Figure 2**) resulting in 90% of nature loss in the past five decades (IPBES 2022). Human actions have already altered 75% of the land surface; 66% of the ocean environment, and lost 85% of the wetland area since the 1700s. The free flow of over 63% of longer rivers (>1000 km) from the source to the sea has been disrupted globally (WEF 2020). Rich biodiversity is an indicator of both the health and wealth of nature. Biodiversity loss is identified as the top global risk within 10 years in terms of impact and likelihood by the World Economic Forum

Global Risk Report (WEF 2020). Around 25% of assessed animal and plant species are threatened by increased anthropogenic activities, and millions of species are facing extinction risk within this century, many within decades. Globally, between 1970 and 2020, the wildlife population showed a reduction of 73% with an average annual decline of 2.6%(WWF 2024). This decline varies across terrestrial (69% decline), freshwater (85% decline), and marine systems (56% decline) (IUCN 2023; WWF 2024). The global rate of species extinction has been estimated to be at least ten to a hundred times the background rate before human interventions. Nearly 32% of forest extent has been lost worldwide as compared to the pre-industrial extent. In some regions, the extent of forest increased, especially temperate and boreal forests, which comes along with increased fragmentation and functional changes (i.e., carbon sequestration). The conversion of peatlands, mangroves, and tropical forests for agricultural production and other uses reduces the Earth's capacity to sequester greenhouse gases (GHG) from the atmosphere, leading to 13% of total human CO_2 emissions exacerbating the effect of climate change. In the business-as-usual scenario, the increase in global temperature by 2 degrees Celsius will further increase the species extinction risk (1 in 20 species) and the loss of 99% of coral reefs, which support a quarter of all marine fish (WWF 2024). Therefore, addressing climate change and nature in isolation is no longer viable.

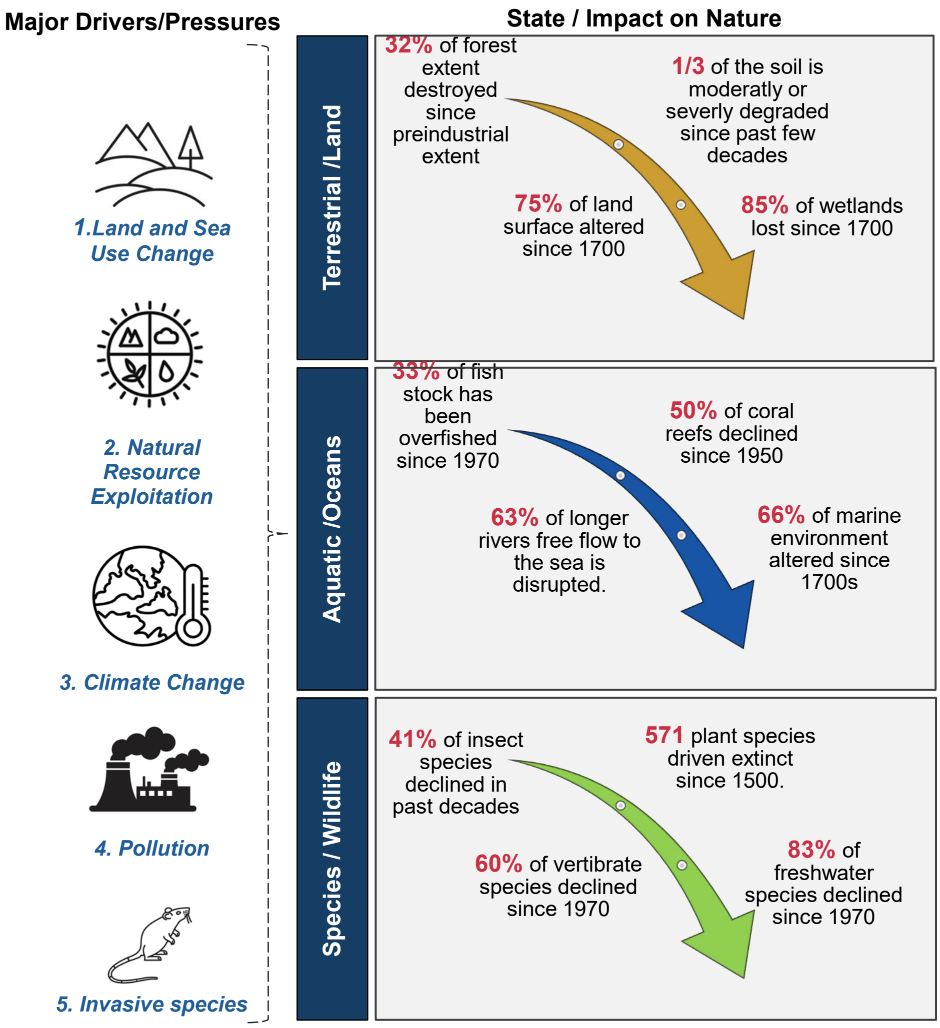

Figure 2. Major human drivers/pressures and their state/impact on Nature (Developed by authors (*data source*: IUCN 2023, WEF 2020; WWF 2024)).

Economic Impact of Nature Loss

Nature's resources and ecosystem services underpin the global economy. Region-specific nature-dependency indicates that the global economy significantly depends on nature (**Figure 3**). For instance, countries like India and Indonesia are highly dependent on nature, >30% (Figure 3). Nature's wealth, such as clean air and water, healthy soil, and resilient ecosystem is the source of economic growth, productivity, and livelihoods. In contrast, loss of nature undermines human prosperity and weakens the economies that rely on natural capital assets for growth and development. Globally, more than half of the world's GDP ($44 trillion of economic value generation) is moderately or highly dependent on nature and its ecosystem services (WEF 2020). Businesses depend directly on nature for operations, supply value chain, physical security, business continuity, and more. When nature loss aggravates the disruption in the society in which businesses and economies operate, it leads to physical and market risks. The highly nature-dependent sectors are agriculture ($2.5 trillion), construction ($4.0 trillion), and food and beverages ($1.5 trillion), which generate close to $8 trillion in gross value added (GVA). The industries that are highly dependent on nature contribute 15% to the GDP, while those that are moderately dependent on nature contribute to 37% of the GDP (Damania et al. 2025; WEF 2020)

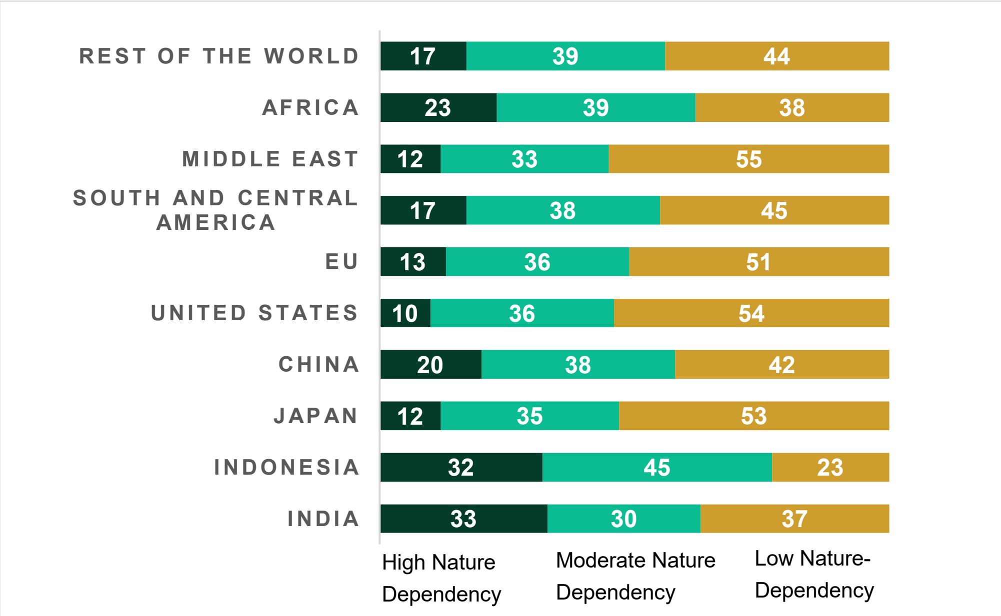

Figure 3. Distribution (%) of Nature-Dependency by regions; India and Indonesia with high nature-dependency (Developed by authors (*data source*: WEF 2020)).

The decline in ecosystem services by the five major drivers of nature loss is estimated to cost $430 billion/year globally to the eight key sectors (**Figure 4**), under the business-as-usual scenario (VanderWilde et al. 2025). These losses indicate the immediate costs due to physical risks associated with how the sector depends on nature, such as low revenue from supply chain disruption and operational costs from damage to assets. For instance, the estimated annual losses for the food production sector are $253 billion, along with the decline in ecosystem services such as pollination, biomass provisioning, and rainfall regulation. The value of pollination services alone is estimated as $25 billion/year, which is largely at risk due to land use change, pollution, and climate change. Loss of animal pollinators affects more than 75% of global food crop types, risking $235 billion to 577 billion of global crop output annually, which forces some countries to invest in alternative options of hired pollinating services and mechanical pollinations (Damania et al. 2025; VanderWilde et al. 2025).

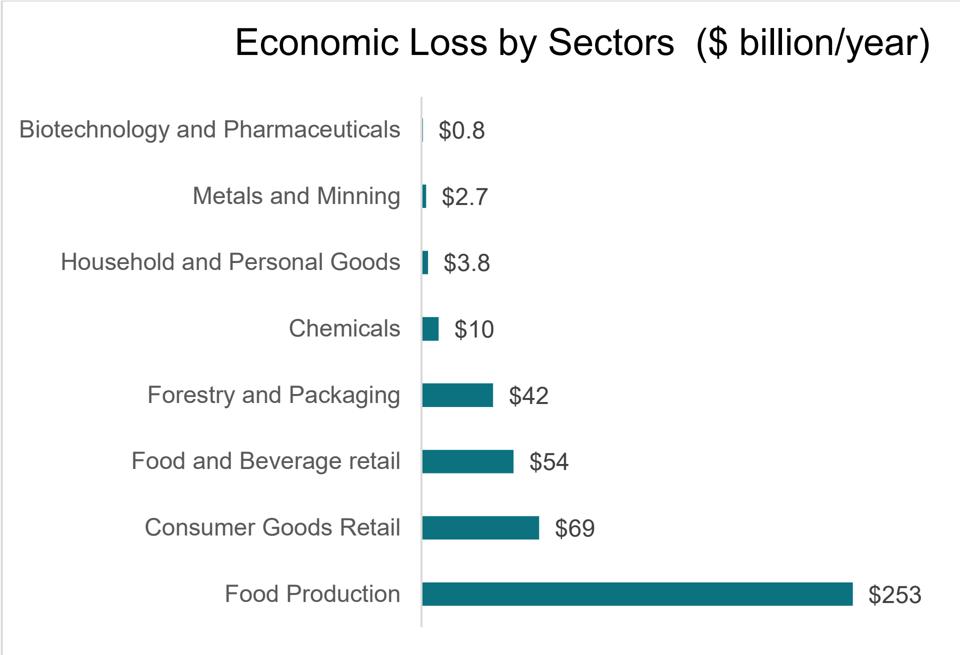

Figure 4. Estimated economic loss per year in eight key sectors globally (USD billion) due to decline in nature and its services, under the business-as-usual-scenario (Developed by authors (*data source*: VanderWilde et al. 2025)).

2. Global Goals for Nature

The overarching goal is to **halt and reverse biodiversity loss and environmental degradation** to achieve a measurable net gain in the health, extent, and resilience of ecosystems and species by a set date (e.g., 2030 or 2050). The global goals for biodiversity, sustainable development, and climate all recognize the role of nature, which underpins a stable climate and human well-being (**Table 1**). The **Kunming Montreal Global Biodiversity Framework** (KMGBF) under the UN Convention on Biological Diversity (CBD) in 2022 sets a long-term vision of **a world living in harmony with nature by 2050,** which includes halting and reversing the loss of nature by 2030 (UNEP 2022). The KMGBF includes the 2030 targets to conserve 30% of Earth's land, oceans, coastal areas, and inland waters, complete or begin the restoration of at least 30% of the degraded land and waters, and reduce pollution and invasive species by 50%, and to bring human-induced species extinction to zero by 2030 (UNEP 2022). Nature is fundamental to achieving all the Sustainable Development Goals (SDGs), impacting food, water, health, and economic prosperity, making its protection essential for people and the planet. The 5P (people, planet, prosperity, peace, partnership) principle of the SDG goals for 2030 emphasized that social and economic development depends on nature conservation and protection. Two of the SDGs, mainly SDG-14 (Life below Water) and SDG-15 (Life on Land), specifically focus on conserving, restoring, and sustainably managing the natural resources, the ecosystem, and biodiversity in the oceans and the lands. The status check for the Paris Climate Agreement – known as the global stocktake – explicitly recognized the KMGBF and emphasizes the importance of conserving, protecting, and restoring nature, including halting and reversing deforestation and managing ecosystems to absorb carbon from the atmosphere and to help people adapt to climate change. Despite these global goals, the national commitments are still struggling to avoid the dangerous tipping point of nature loss.

Table 1. Global nature goals and targets with dates.

<table>
<tr><th>Global Goals</th><th>Targets</th><th>Date</th><th>References</th></tr>
<tr><td rowspan="3">Kunming Montreal Global Biodiversity Framework (KMGBF)</td><td>Living in harmony with nature</td><td>2050</td><td rowspan="3">(IPBES 2019; UNEP 2022)</td></tr>
<tr><td>The integrity, connectivity, and resilience of all ecosystems are maintained, enhanced, or restored, substantially increasing the area of natural ecosystems by 2050.</td><td>2030, 2050</td></tr>
<tr><td>Human-induced extinction of known threatened species is halted, and by 2050, the extinction rate and risk of all species are reduced tenfold, and the abundance of native wild species is increased to healthy and resilient levels.</td><td>2030, 2050</td></tr>
<tr><td>Sustainable Development Goals (SDG)</td><td>SDG-14 (Life below water): Conserve and sustainably use the oceans, seas, and marine resources for sustainable development.
SDG-15 (Life on Land): protecting, restoring, and sustainably using terrestrial ecosystems, combating desertification, halting land degradation, and preserving biodiversity.
SDG -13 (Climate Action): Take urgent action to combat climate change and its impacts, recognizing its link to ecosystem health.
SDG -6 (Clean Water and Sanitation): Ensure availability and sustainable management of water and sanitation for all, crucial for ecosystems and human health.
SDG -2 (Zero Hunger): Achieve food security, improve nutrition, and promote sustainable agriculture, which relies heavily on healthy land and biodiversity.</td><td>2030</td><td>(UN, 2015); (Locke et al. 2021)</td></tr>
<tr><td>UNFCC Paris Agreement</td><td>Limit global warming to well below 2°C (preferably 1.5°C) above pre-industrial levels by peaking greenhouse gas (GHG) emissions by 2025 and reducing them drastically (around 45% by 2030) to reach net-zero by mid-century</td><td>2050</td><td>(UNFCC, 2015),</td></tr>
<tr><td rowspan="2">UN Decade of Restoration (2020-2030)</td><td>Enhancing global, regional, national, and local commitments and actions to prevent, halt, and reverse the degradation of ecosystems</td><td>2030</td><td rowspan="2">(UNEP and FAO 2021; IUCN 2023)</td></tr>
<tr><td>Increasing our understanding of the multiple benefits of successful ecosystem restoration.</td><td>2030</td></tr>
</table>

	Applying this knowledge in our education systems and within all public and private sector decision-making	2030

3. DPSIR Framework for Nature

As the world faces unprecedented nature loss and environmental degradation, a DPSIR (Drivers, Pressures, State, Impact, and Responses) framework is proposed to comprehend the link between various drivers and pressures influencing the current state of nature with a range of impacts essential for effective decision making (**Figure 5**). There are several frameworks recognizing different aspects of nature, such as frameworks for river restoration, pollination, and specific biodiversity issues. However, a limited general DPSIR framework on nature inhibits the attainment of the nature-goal. Pressures on nature are often confused with drivers, and the state of nature is often mixed with impacts. The proposed framework links nature issues with socio-economic developments which are the driving forces (Drivers), exerting pressures on nature (Pressures), consequently altering the state of nature (State), impacting the ecosystem and human wellbeing (Impact), thereby enabling the targeted interventions (Responses/actions) to address the drivers and pressures (Maxime et al. 2009). This approach is widely applied as an environmental management tool, such as in the Millennium Ecosystem Assessment (MEA) framework linking ecosystem services and society, offering decision-makers a systematic approach to deal with sustainability goals (MEA, 2003).

Drivers (D) are the underlying demographic and socio-economic forces creating demand for nature (natural resources and ecosystem services) and generating pressure on nature, such as population growth and economic development. Pressures (P) are the direct stress on nature driven by underlying drivers resulting from both anthropogenic and natural activities, such as pollution and climate change. State (S) are the observable outcome of the pressures acting on nature, indicating the positive and negative changes in its current state (i.e., extent, condition, and species). The Nature Positive Initiative (NPI), following the KMBGF goals for nature, drafted a state of nature metric to be tested on the ground and recommends ecosystem extent, condition, and species as the universal indicators for qualitative and quantitative assessment of the state of nature (NPI 2025).

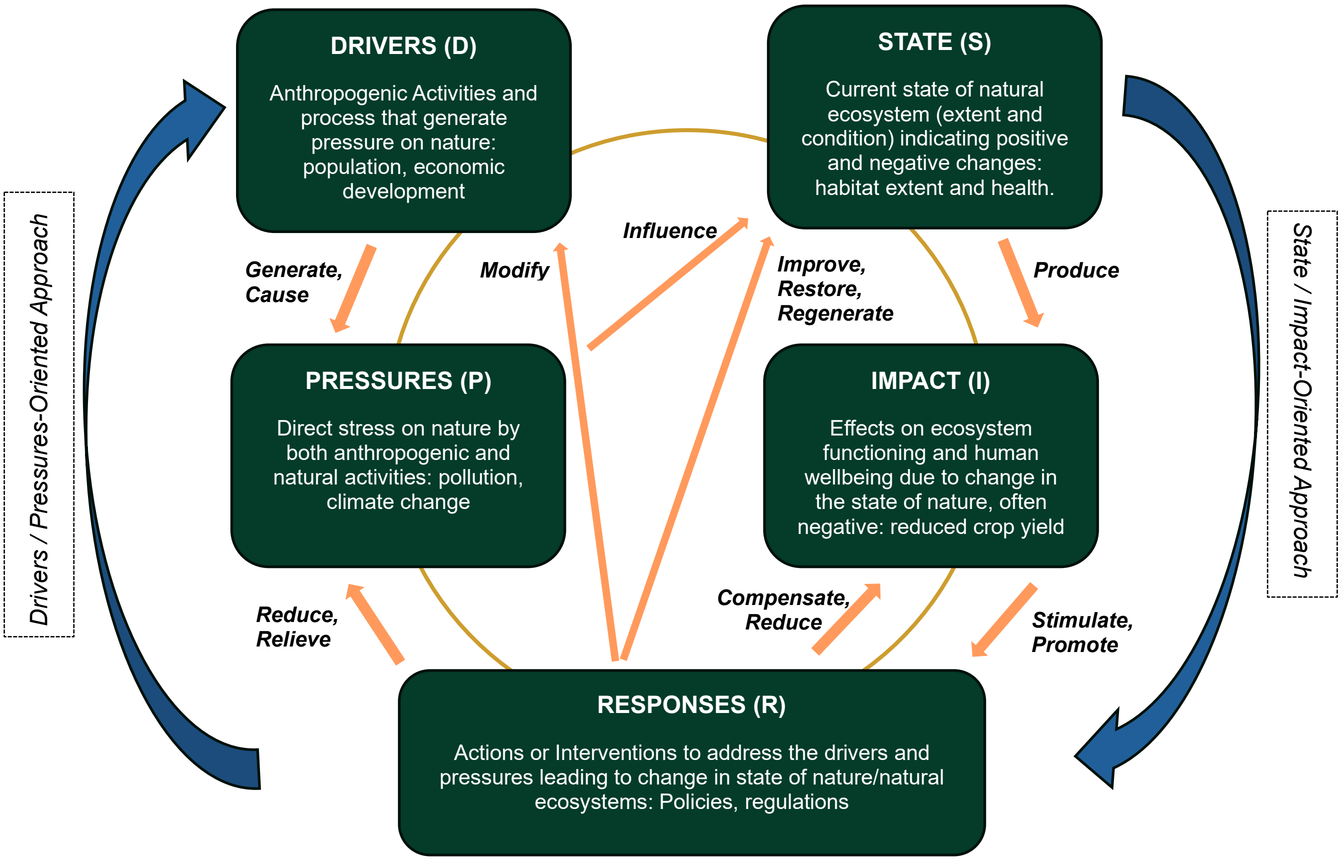

Figure 5. Proposed DPSIR Framework for Nature (*Source:* authors' creation).

Impact (I) measures the effects of the alterations in the state of nature on ecosystems' functioning and human-wellbeing (socio-economic aspect), such as crop yield change due to reduced soil health and economic losses due to declined biodiversity. Impact is often "negative" as they affect adversely the functioning of the ecosystem (terrestrial, aquatic, and atmosphere), in rare cases, it is positive. Responses (R) are the societal and policy actions or interventions to address the root causes of change in the state of nature/natural ecosystems (the drivers and pressures). This mainly emphasizes the efforts to restore and regenerate nature by society, government, and other stakeholders, such as increasing areas under active restoration, investment in nature-based solutions (NBS), and environmental regulations (Maxim et al. 2009).

To avoid confusion between drivers, pressures, state, and impact components of the DPSIR framework for nature, a comprehensive set of indicators for each component of nature was proposed (Table-2) through an extensive literature review. It provides a clear understanding of the drivers and pressures leading to the change in the state of nature and how it impacts the ecosystem and human well-being. The indicators are developed based on a diverse range of literature, including global and national reports (IPBES 2019; IUCN 2023; Justice et al. 2025; Locke et al. 2021; NPI 2025; Roe 2019; UNEP 2022; WWF 2024; Block et al. 2024; SBTN 2020; TNFD 2023). Depending on the specific national context, ecosystem type, scale, and data availability, the proposed number of indicators may vary for different studies. Therefore, the proposed framework provides a non-exhaustive list of indicators that can change, but the framework approach remains the same for a better understanding of the different drivers, pressures, and state/impact of nature. One can use the proposed list of indicators for assessment as per their specific context and nature of the issue.

As the next step, the proposed indicators will be validated through multiple rounds of stakeholders' engagement, expert interviews, and on-ground piloting of the framework. Therefore, a consensus will be sought as the next step to further validate the proposed indicators. The indicators can be categorized into the core-indicators (indicators essentially included in all nature-related work assessments) and supplementary indicators (additional indicators), with deeper insights depending on the country-specific context, chosen ecosystem, scale, and data availability.

Table 2. Proposed Indicators for the DPSIR framework for Nature (*Source*: IPBES 2019; IUCN 2023; Justice et al. 2025; Locke et al. 2021; NPI 2025; Roe 2019; UNEP 2022; WWF 2024; Block et al. 2024; SBTN 2020; TNFD 2023).

DPSIR	Indicators	Rationales	Measurement/Units
DRIVERS (D)			
Demographic:	Population growth rate	Population growth increases demand for natural resources, land, and ecosystem services	% Change annually or decades
	Population density	High population density often correlates with increased pressure on local ecosystems	Persons/km²
	Urbanization rate	Urbanization drives nature loss through habitat conversion, fragmentation, and altered ecosystem processes	Annual Change in urban area; % Urban Population;
Economics:	GDP per capita	Economic growth historically correlates with increased resource consumption and environmental pressures	Total GDP; GDP per capita
	Percent GDP by sectors	Different economic sectors have varying impacts on biodiversity and nature; extractive industries typically have higher impacts	% GDP by Sector: Employment by Sectors
	Income inequality	Inequality can affect resource use patterns and conservation priorities	Gini Coefficient
	Natural resource dependence	High resource dependence indicates direct pressures on ecosystems	% Nature dependency by sectors; % GDP from natural ecosystems
Technological:	Agriculture intensification index	Agricultural intensification can reduce land demand but increase pollution pressures	kg fertilizer /ha; % irrigated area; machinery per 1000 ha
	Energy consumption	Energy systems drive climate change and habitat conversion (e.g., hydropower, biofuels)	Total energy consumption (Mtoe); % consumption by source
	Digital technology adoption	Digital technology adoption affecting resource efficiency	% Adoption
Cultural and Institutional:	Consumption pattern (per capita)	Increase in consumption pattern increase pressure on nature and natural resources	Material footprint per capita
	Education Attainment	Education attainment increases the environmental literacy	% population attended primary, secondary and tertiary education
	Environmental policy for conservations	Policy frameworks shape incentives for conservation or exploitation of nature	number and coverage of environmental laws: policy indices
	Subsidy/ incentive policies in sectors	Perverse incentives and subsidies encourage nature and biodiversity loss	Number of subsidies/incentives implemented
PRESSURES (P)			
Habitat Loss and Degradation:	Deforestation rate	Deforestation is a primary driver of biodiversity loss globally	Annual forest loss; % change
	Land use change rate	Conversion of natural habitats to agriculture, urban areas, or other uses is	Area converted by land use type (ha/year)

		the leading cause of nature loss and species extinction	
	Habitat fragmentation index	Degree of fragmentation of natural habitats (patch size, connectivity) reduces habitat quality and species viability	Mean patch size; connectivity indices
	Wetland loss rate	Wetlands are among the most biodiverse and threatened ecosystems	Annual wetland loss (ha/year); % total wetland area
	Coastal habitat loss	Loss of mangroves, seagrass beds, coral reefs, and coastal wetlands	% Area loss
Overexploitation of Natural Resources:	Overfishing	Percentage of fish stocks harvested beyond maximum sustainable yield disrupts ecosystem function	% fish stock overfished; fish mortality rate
	Timber harvest rate than the sustainable yield	Volume of timber harvested relative to forest growth rate degrades forest ecosystems	Ratio to sustainable yield; harvest volume (m3/year)
	Non-timber forest product extraction rate	Collection rates of medicinal plants, fuelwood, and other products	Collection volume (m3/year)
	Groundwater extraction rate	Groundwater withdrawal relative to recharge rates	Withdrawal rate (m3/year), %of total annual recharge
	Sand and gravel mining		
Pollution:	Nitrogen and Phosphorus loadings	Nutrient pollution causes eutrophication and biodiversity loss	N and P for land (Kg/ha); N and P for waterbodies (mg/L)
	Pesticide Use intensity	Volume and toxicity of pesticides applied per unit area, directly harm non-target species and disrupt ecosystems	Pesticide applied (kg/ha); toxicity weighted indices
	Plastic pollution	Plastic pollution affects wildlife through ingestion and entanglement	Weight of plastic waste generated (Tones); % plastic waste entering in environment
	Heavy Metal Contamination	Soil and water contamination by heavy metals	Concentration in soil (ppm), in water (mg/liter)
	Air Pollution level	Air pollution affects ecosystem health and species distributions	Concentrations of particulate matter (PM2.5, PM10) and other air pollutants
	Wastewater generated	Liquid waste disturbs the aquatic ecosystem and biodiversity	Wastewater generated per capita annually, total generation (ton), % treated and %reused
	Solid waste generation and disposal	Waste generation affects the soil, water, and air, through pollution, habitat destruction and biodiversity loss	Waste generated per capita annually, total generation (ton), % treated and %reused
Invasive Species:	Invasive species establishment rate	Invasive species are a major driver of biodiversity loss	Number of new invasions per year
	Area affected by invasive species	Invasive species alter ecosystem structure and function	Hectares affected by major invasive species.
	Pathways of introduction	Pathways of invasive species introduction in the environment help prevent in their distribution	Ornamental plants import
Climate Change:	Greenhouse Gas Emissions (GHG)	Climate change is an increasingly dominant pressure on biodiversity (mainly CO_2, CH_4, N_2O)	Total emission ($MtCO_2e$); per capita per year
	Land use change emissions	GHG emission from deforestation and land conversion is both a pressure on biodiversity and a climate forcing;	$MtCO_2e$ per year from land use change
	Observed climate change	Changing precipitation, temperature and extreme weather events disrupt the natural ecosystem	Average Temperature increase (Degree) per year; Precipitation change pattern; Frequency of extreme natural events in a year.

	Sea level rise	Rate of Sea level Rise affecting coastal ecosystem- mainly for coastal countries	Rate (mm/year)
STATE (S)			
Ecosystem Extent:	Forest cover and tree cover	Forests harbor most of the terrestrial biodiversity	Total forest area, tree cover (ha), % change as per historic extent ; % of land area; area under types of forest
	Wetland extent	Wetlands are critical for biodiversity and ecosystem services	Total wetland area (ha), % change as per historic extent
	Grassland and Savanna extent	Grasslands are among the most threatened and least protected ecosystems	Total grassland area (ha), as per historic extent
	Marine and coastal ecosystem	Coastal ecosystems are highly productive and biodiverse (coral reefs, seagrass beds, mangroves)	Total area by ecosystem type (ha);% change as per historic extent
	Peatland extent	Peatlands provide unique habitat for range of species and provide ecosystem services	Total area peatland (ha);% change as per historic extent
	Freshwater ecosystem extent	Freshwater ecosystem (lakes, ponds, rivers) holds immense biodiversity and provides ecosystem service	Total area (ha) by freshwater ecosystem type (lakes, ponds) and total length (Km) for rivers.% change
	Protect area coverage	Percentage of land (National parks, wildlife sanctuaries) and sea (marine protected area) under formal protection, these are cornerstones for biodiversity and ecosystem conservation.	Total Protected area (ha), % of terrestrial and marine area protected; area by IUCN category, % change
	Indigenous and community conserved area	Area and effectiveness of community-managed conservation areas support biodiversity	% area protected
	Areas under Area-based conservation measures	These are geographic areas delivering long-term biodiversity conservation beyond formal Protected Areas complementing protected areas (watershed protection zone, sacred sites, sustainable fisheries closures)	% area under area-based conservation measures
Ecosystem Condition and Health:	Ecosystem integrity index	Composite measure of ecosystem structure, composition, and function relative to reference conditions	Index value (0-1); trends over time
	Forest fragmentation and canopy cover	Forest fragmentation reveals health of forest and ecological shifts from larger, continuous forests to fragmented landscapes.	Patch density (PD); landscape shape index (LSI); Canopy density by NDVI
	Freshwater ecosystem health	Freshwater ecosystem (surface-rivers, lakes; groundwater)	Water quality of rivers, lakes and groundwater (water quality indices); Environmental flow (Rivers) and connectivity (river network fragmentation indices)
	Soil health	Supports biodiversity and ecosystem services (filtration)	Soil organic carbon (annual carbon sequestration rate), soil NPK, bulk density, aggregate stability.
	Species richness; abundance	Species richness is a fundamental measure of biodiversity; Abundance; extinction risk; average change in population	Species density per area; number of species per taxonomic group; population trend for indicator species; Red list index; living planet index
	Endemic species status	Endemic species are irreplaceable components of national biodiversity	Number of endemic species: % threatened
	Pollinator diversity and abundance	Pollinators maintain ecosystem health and biodiversity	Population of key pollinators (Bee, butterflies)

Ecosystem Services:	Forest carbon sequestration	Carbon storage is a critical regulating service linking biodiversity and climate	Total Carbon stock (MTC); Annual sequestration rate (MtC/year)
	Water provision by surface and groundwater	Freshwater availability regulates water supply for human use (ecosystem services)	Water yield (m3/year)
	Flood regulation	Capacity of ecosystem (forest and wetlands) to mitigate flooding	Retention capacity
	Soil erosion control	Soil retention by vegetation cover	Retention capacity
	Coastal protection	Storm surge attenuation by mangroves and coral reefs	Wave height reduction (m); water flow velocity reduction (m/s)
	Fisheries productivity	Sustainable catch potential	Catch per unit effort/number of days
	Other key ecosystem services as per region		
IMPACT (I)			
Impact on Human Wellbeing:	Food security Impacts	Biodiversity loss affects agricultural productivity and food diversity	Crop yield change, dietary diversity indices, and prevalence of food insecurity
	Water security impacts	Ecosystem degradation compromises water security (quantity and quality)	Population experience water stress: % Water stress/water scarce area; %Population receiving unsafe drinking water
	Health impacts	Biodiversity loss and ecosystem degradation increase health risks (air/water pollution, zoonotic diseases, heat stress)	Incidences /Number of Environmental-related diseases; disability-adjusted life years (DALYs)
	Climate vulnerability	Population exposure to climate impacts exacerbated by economic loss	Population exposure
	Cultural and mental wellbeing	Loss of traditional practices tied to nature; Loss of quality of life.	Region-specific
Impact on Economy and Livelihood:	Loss of ecosystem services values	Economic value of ecosystem service losses due to degradation	% of GDP loss due to services loss; Annual loss (USD/year)
	Livelihood loss in resource-dependent communities/region	Biodiversity loss disproportionately affects vulnerable populations dependent on natural resources	Income changes (Income loss/year); employment losses in sectors highly dependent on nature(Job loss/year); poverty incidence
	Agricultural productivity losses	Crop yield declines due to pollinator loss, soil degradation, and other factors	Yield gaps; economic losses (USD/year)
	Fisheries loss	Economic and social consequences of overfishing and marine ecosystem degradation	Catch declines; income losses; employment impacts
	Tourism revenue losses	Decline in nature-based tourism revenue due to ecosystem degradation	Tourism revenue changes (USD/year); visitor numbers
	Economic loss in the industry	Economic loss to major industries/sectors highly, moderately, and scarcely dependent on nature	Economic loss (USD/year)
	Infrastructure damage	Costs of infrastructure damage from floods, landslides, and other events linked to ecosystem loss	Economic loss (USD/year)
	Insurance cost	Increased insurance premiums due to natural disaster risks linked to nature loss (natural ecosystems like forests, mangroves)	Economic loss (USD/year)
Equity and Justice Impacts:	Distributional impacts across income groups	Differential impacts of biodiversity loss on different socioeconomic groups	
	Impacts on indigenous peoples	Indigenous peoples are stewards of much of the world's biodiversity	

	and local communities		
	Gender-differentiated impacts	Different impacts on women and men due to gender roles in resource use	
	Environmental justice concerns	Disproportionate exposure of marginalized communities to environmental hazards	
RESPONSES (R)			
Restoration and Management responses:	Ecosystem restoration area	Restoration is essential for meeting nature-positive targets- Area under active restoration (forests, wetlands, lakes, rivers, ponds, grasslands, coastal and marine, etc.)	Total area under restoration (ha); annual restoration rate (ha/year)
	Restoration effectiveness	Success of restoration efforts in recovering biodiversity and ecosystem functions	% of restoration projects meeting targets; biodiversity recovery rates per year
	Sustainable agriculture adoption	Area under organic, agroecological, or other biodiversity-friendly practices	Area (ha)
	Invasive species management	Area under invasive species control and number of species eradicated	Area managed (ha/year); number of successful eradications
	Sustainable fisheries management	Percentage of fisheries under science-based management plans	% stocks under management plans; percentage certified sustainable
	Wildlife management	Anti-poaching efforts, human-wildlife conflict mitigation, species recovery programs	
Policy and Legal Responses:	Environmental legislation	Number and strength of laws protecting nature (biodiversity and ecosystems)	Number of biodiversity-related laws, coverage, and stringency indices
	National nature and biodiversity action plans	Number and Implementation of action plans crucial for nature gain	Adoption and implementation progress
	Protected area designation rate	Expansion of protected areas is a primary conservation response	Annual increase in protected area (ha/year; %)
	Environmental impact assessment requirements	Coverage and effectiveness of EIA processes	Coverage area under EIA (ha)
	Green procurement policies	Government and corporate policies favoring biodiversity-friendly products	Number of policies
Finance Response:	Conservation finance	Total funding allocated to biodiversity conservation from public and private sources	Total conservation expenditure (USD/year); per capita; % of GDP
	Green finance and biodiversity Investment, climate finance	Private sector investment in nature-positive activities (biodiversity-positive)	Investment volume (USD/year)
	Payment for ecosystem services and Biodiversity offset schemes	Area and funding under PES schemes	Area under PES (ha); total payments (USD/year); number of beneficiaries
	Nature-based solution (NBS) investment	Private sector investment in NBS for climate and biodiversity	Investment (USD/Year)
	Corporate biodiversity commitments	Number and scope of companies with biodiversity targets and disclosure	Number of companies with targets
Knowledge and Awareness Responses:	Environmental education programs	Coverage and reach of biodiversity education initiatives	Number of students reached, curriculum integration, and public awareness levels

Citizen science participation	Number of citizen scientists contributing to nature (biodiversity and ecosystem) data	Number of citizen scientists
Traditional resource management practices	Continuation or revival of sustainable traditional practices	Area coverage(ha)

Notes: *The unit of measurement can be different in different regions. It is a non-exhaustive list of indicators.*

3. Mapping the State of Nature: State/Impact-Oriented Approach

To better understand what responses are needed on the ground to halt and conserve nature, we propose monitoring and mapping of the current state of nature as the initial step, and subsequently addressing the pressures and drivers leading to the change in the state of nature. Monitoring the current state of nature is also essential to comprehend whether our efforts and responses are contributing to the overall decline or the nature recovery. Flipping the focus to a state/impact-oriented approach in the DPSIR framework (Figure 5) is highly effective for nature-positive planning. Furthermore, prioritizing an area for effective conservation and restoration also changes with the state of nature. Positive change in nature represents a gain in the state of nature due to effective response actions in a defined region and a defined period. A negative change in nature represents nature loss due to pressures exerted by socio-economic drivers in a defined region and period. Both positive and negative changes in nature will be calculated by comparing the initial state of nature and the current state of nature as given in equation1 and 2.

$$\textbf{Positive Change in Nature}_{(extent,\ condition,\ species)} = \textbf{New State of Nature}_{(Current)} - \textbf{Initial State of Nature}_{(as\ per\ baseline)} \quad \text{Eq.1}$$

$$\textbf{Negative Change in Nature}_{(extent,\ condition,\ species)} = \textbf{Intitial State of Nature}_{(as\ per\ baseline)} - \textbf{New State of Nature}_{(current)} \quad \text{Eq.2}$$

The unit of change will be decided based on the chosen ecosystem, indicators, and region. If the actual state of nature is greater than the set nature target, it indicates that positive progress has been made to achieve the nature goal. Once the state and impact are clearly mapped, we can follow the reverse method to identify the pressures and drivers without being distracted by broad economic trends, which might not be the actual cause of the local decline in nature. The fundamental steps to measure the state of nature (**Figure 6**).

Figure 6. Steps for mapping the State of Nature (*Source:* authors' creation).

i. The first step is to set the target for nature or for a specific natural ecosystem based on the national priorities and or global nature goals to achieve within a specific duration. The standardized system of ecosystem classification (IUCN Global Ecosystem Typology; Keith et al. 2020) is used to categorize the ecosystem areas.

ii. Define the temporal baseline in years; it could be any historical baseline (pre-industrial era, or 2000, or 2020) to measure the change in the state of nature and to compare the subsequent measurements using the same baseline. In some studies 2020 is taken as the baseline year for nature restoration, such as in the UN Decade of Restoration.

iii. Define the precise scale of monitoring and mapping the state of nature, such as national, regional, and local or grid-based. At the national level it will measure the overall national progress towards the set target, whereas at the local level, it will measure the site-specific conservation planning and local targets.

iv. Collect the baseline data and data for subsequent years of the target to compare the change in the state of nature. Fill the data gaps through targeted surveys. Select the priority indicators based on the data availability and targets set as per national priorities. The selected indicator can be further refined based on the lessons learned during the initial years of monitoring. Data could also be collected from the existing data sources at the global, national, and the local levels, and through remote sensing, and modeling studies. The baseline selection, frequency of monitoring, and measurement depend upon the national/regional and global targets and or the urgency of the nature crisis in the region or a country.

v. The final steps include the mapping of the current state of nature to assess the progress made towards the set target and set baseline year to identify the priority area and to further identify the underlying pressures leading to the change in the state of nature for remedial actions.

Box 1. State of Wetlands: Mangroves Change in India from 2020 Baseline

Mangroves are a unique ecosystem that thrives between the land and sea interface (Figure 7). As per the current assessment, the total mangrove cover of the country is around 5000 km^2, accounting for 0.15% of the total geographical area of India (Figure 8). India has the world's highest recorded mangrove forest biodiversity with 23% flora and 77% of fauna species. However, rapid coastal development and climate change have substantially contributed to mangrove degradation, putting the mangrove biodiversity and ecosystem services at risk. (FSI, 2023).

Figure 7. Mangroves in Goa, India
(Source: Goa Forest Department, India)

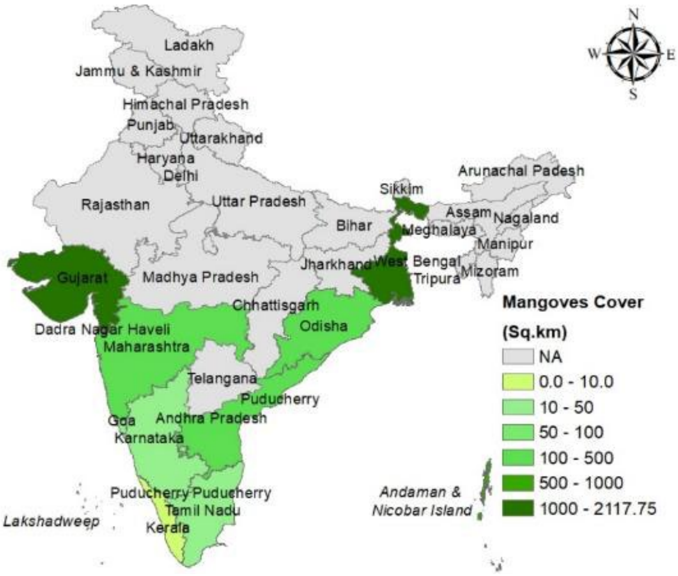

Figure 8. Mangrove cover of India in 2020-2021
(Data source: FSI, 2023)

Change in the extent of mangroves in India was calculated from the baseline year of 2020, following UN Decade of Restoration (2020-2030). Based on the available data for 2023, the change in the current state of mangrove was estimated from baseline and mapped as a percent change in Figure 11.

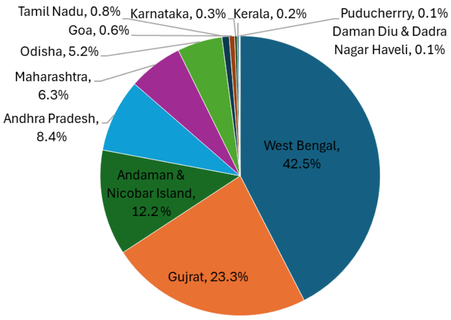

Figure 9. Percent distribution of mangrove cover by state in India *(Data Source*: FSI,2023*)*.

In comparison to the baseline of 2020, the country has lost 7.43 km^2 of the mangrove coverage (Figure10). The maximum loss in extent was in Gujarat (36%) and the Andaman & Nicobar Islands (4.6%), as shown in Figure 11. The result suggests that national restoration efforts should target the area with maximum loss as a priority area for interventions through schemes such as Mangrove Initiatives of Shoreline habitat and tangible income (**MISHTI**) launched in 2023-2024 by the government of India.

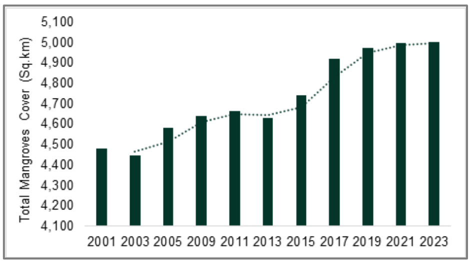

Figure 10. Trends in Mangrove coverage extent in India (2020-2023)

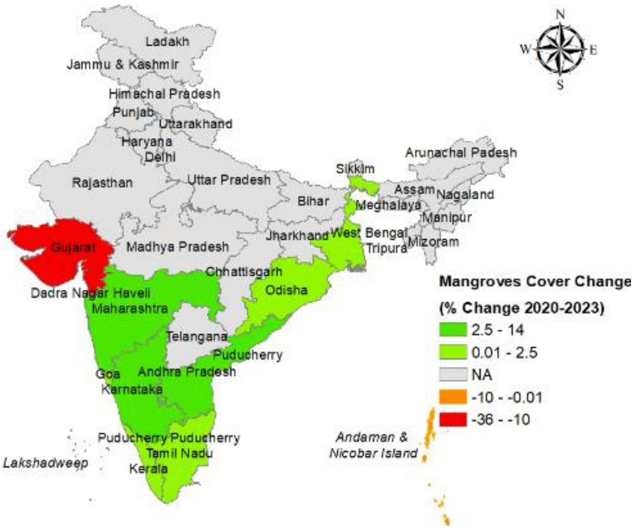

Figure 11. Percent change in extent of mangrove cover in India (2020-2023).

4. Conclusions

The report emphasizes that achieving a nature-positive world is an urgent necessity for both environmental stability and global economic resilience. A nature-positive world by 2050 is an ecological and economic imperative that requires a fundamental shift in how we measure and manage the current state of nature. The report underscores that nature is not an externality but the foundation of human wellbeing and economic stability. A primary technical barrier identified is the lack of a universal method or globally accepted standard for measuring the change in the state of nature, and a technical ambiguity in the understanding of various drivers, pressures of nature, and their state and impact.

- This report proposes the **DPSIR framework** (Drivers, Pressures, State, Impact, and Responses) for nature as a systematic tool to differentiate between the indirect drivers and direct pressures that alter the state of nature, impacting ecosystem and human well-being. It provides a non-exhaustive list of indicators for each DPSIR component to clarify cause-and-effect relationships, though these require further validation through expert and stakeholder consensus as the next step. The framework acknowledges that the number and type of indicators will vary based on national context, type of ecosystem, scale, and specific data availability.
- Prioritizing the State of Nature-the report recommends monitoring and mapping of the **current state of nature** (ecosystem extent, condition, and species) as the first step before addressing pressures and drivers following a State/Impact-oriented approach of the DPSIR framework. It is designed to identify vulnerability hotspots, allowing decision-makers to prioritize conservation areas and determine whether current responses are successfully halting decline or promoting recovery. By understanding the current state of nature and its impact on human wellbeing, concerned stakeholders can work backward to identify specific local pressures and their underlying drivers.
- The major limitation of this report is that the framework and its indicators are highly data-dependent and can vary significantly with specific national contexts, ecosystem types, scale, and the availability of data. And the proposed indicators still need to be validated through stakeholder engagement, expert interviews, and on-ground piloting.
- The framework provides a technical roadmap to support international targets, such as the Kunming-Montreal Global Biodiversity Framework (KMGBF) and the UN Decade of Restoration (2020-2030), aiming to halt and reverse biodiversity loss by 2030.

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