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# Securing biodiversity, securing our future: A national mission on biodiversity and human well-being for India

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ABSTRACT

Highly populated tropical countries face tremendous pressures in reconciling the needs for improved economic security and the protection of declining biodiversity. India is no exception and its biodiversity is under severe pressure due to complex interactions among land use change, other human economic activities, and climate change. Preservation and restoration of biodiversity is perhaps the cheapest and least risky way to mitigate the impacts of threats such as climate change, diminishing food and nutritional security, declining economy, absence of affordable healthcare, rising zoonotic diseases and lack of capacity to address these issues. Here we describe a framework for biodiversity conservation – the National Mission on Biodiversity and Human Well-Being (NMBHWB) for India – which integrates biodiversity, ecosystem services, climate change, agriculture, health, bio-economy and capacity building in the realm of biodiversity science. We provide an overview of the seven Programs of the Mission which make it interdisciplinary, integrative, and comprehensive in its approach. The Mission explicitly links research with policy-making and implementation for effective management of biodiversity with sustainable development. With its emphasis on convergence and synergies among various goals, themes and project sites, the Mission will further develop new models for stakeholder consultations and co-production of knowledge. We posit that the NMBHWB will enable India to realize the United Nations Sustainable Development Goals and Targets while advancing India's commitments to the Paris Agreement on climate change and other international environmental conventions and treaties.

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## 1. Introduction

### 1.1. Background

The nations of the populous tropics, harbouring most of Earth's biodiversity, face tremendous pressures in reconciling the needs for improved economic security and the protection of declining biodiversity (Meng et al., 2019; Sandker et al., 2012). These pressures are likely to intensify in the post-COVID-19 world (McElwee et al., 2020). Yet biodiversity conservation has an important role to play in mitigating perennial problems such as infectious diseases, food insecurity, gaps in nutritional uptake, lack of rural livelihood opportunities, and the declining flow of ecosystem services such as fresh water. Many of these problems have been laid bare by the pandemic (Rondeau et al., 2020), and climate change is expected to exacerbate the decline in biodiversity (Segan et al., 2016). However, biodiversity-based natural solutions may have the potential to meaningfully address major environmental problems, and thereby foster human well-being.

The United Nations Sustainable Development Goals (SDGs) expressly link environmental protection with human welfare (UN Sustainable Development Group, 2018). For example, the Targets of SDG 15 (protection, restoration and conservation of terrestrial ecosystems and biodiversity) can be crucial for preventing future pandemics (SDG 3). Additionally, such efforts can combat climate change related disasters (SDG 13), impart clean energy solutions (SDG 7), contribute to ensuring food security (SDG 2), and provide alternative livelihoods to secure economic growth (SDG 8) and help alleviate poverty (SDG 1). Even before the pandemic, the UN Science Advisers had suggested redistributing these goals and targets across six entry points – (i) sustainable economies, (ii) access to food and nutrition, (iii) access to energy, (iv) decarbonization of energy, (v) urban development and (vi) global environmental concerns (biodiversity and climate change). Thus, frameworks integrating biodiversity, climate change, agriculture, health and bio-economy can lead to progress in achieving many targets with incremental investments.

Here we describe such a framework for biodiversity conservation, the National Mission on Biodiversity and Human Well-Being (NMBHWB) for India, the most populous tropical country in the world. The *raison d'etre* for this National Mission is to shift emphasis away from the mere protection of biodiversity and identification of drivers underlying biodiversity loss (Hughes, 2017; Barlow et al., 2016), and to integrate biodiversity conservation with people's social-economic well-being. In doing so, the Mission will help India realize the United Nations Sustainable Development Goals (UN SDGs) and Targets (UN Sustainable Development Group, 2018), while advancing India's commitments to the Paris Agreement on climate change and other international environmental conventions and treaties. Our approach supplement other approaches to conservation based on increasing protected areas and identifying drivers of change (Bawa et al., 2020).

With a deficit of $2.5 trillion in SDG financing, questions have risen about the likely progress toward the realization of different UN SDGs and associated targets (Naidoo and Fisher, 2020). The COVID-19 pandemic has jeopardized the attainment of these goals even further. Not only has it weakened the global economy but has also reduced cooperation between nations – which is deemed crucial for meeting these targets (Chapman and Tsuji, 2020). Thus there are calls for revisiting and revising the SDG Targets. One of the approaches suggested is to decouple the development goals (which address improvement of human well-being) from economic growth targets (Naidoo and Fisher, 2020). However, human well-being is not really independent of economic prosperity. Rather than lowering the metrics, perhaps what is required is a unified framework which can address as many targets as possible through the efficient use of resources at hand.

### 1.2. Why India needs a new national framework for biodiversity management

We believe that India requires a new approach to protecting and managing its biodiversity for at least three critical reasons.

First, India is one of the world's 17 'megadiverse' countries, accounting for 7–8% of global biodiversity on just 2.4% of the world's land area and with 18% of the world's human population (MoEFCC, 2018). This estimate is based on percentages of the world's species of birds (13.7%), mammals (8.6%), reptiles (7.9%), fishes (11.7%) and plants (~11.8%) found in India (FAO, 2013). Four of 36 global biodiversity hotspots are represented in India's landmass (MoEFCC, 2018).

Second, global studies documenting the human ecological footprint, declines in wildlife populations, and the conversion rates of natural ecosystems to other land uses place India among the regions experiencing the highest rates of biodiversity loss (Venter et al., 2015; Watson et al., 2016; Ceballos et al., 2017). Studies undertaken in various parts of India attest to negative impacts on biodiversity (Vyas, 2012; Baskaran et al., 2012; Pandit et al., 2007). According to the Forest Survey of India (FSI, 2015, 2017, 2019), dense forest continues to decline while open forest increases over the years, indicating progressive degradation of forest quality over time.

A World Bank report (Mani, 2015) estimates that the gradual diminishment of India's rich natural asset-base and the reduction in flow of ecosystem services may be resulting in annual losses of at least 5.7% of Gross Domestic Product (GDP). UNEP's Inclusive Wealth Report (UNEP, 2018) estimates that the value of India's natural capital stocks contracted from US$3605 billion in 1990 (at that time comprising 31% of total national capital) to $3242 billion in 2014 (then just 15% of total 2014 national capital). This change reflected a 0.44% average annual reduction in natural capital, combined with a large expansion of produced capital – indicating that over the period of a generation, India has drawn down its natural capital stocks while investing heavily in built infrastructure.

Yet, the ecosystem services emanating from India's forest biodiversity alone have been valued at 128 trillion rupees per year (Ghosh, 2015; Verma pers.com.). The value is far greater when services from non-forest ecosystems – grasslands, wetlands, freshwater, estuarine, coastal and marine ecosystems – are also taken into account. Beyond economic terms, biodiversity in India has been a perpetual source of cultural and spiritual enrichment, intimately linked to our physical and mental well-being (Torri and Herrmann, 2011; Anthwal et al., 2010). Our rich fabric of biodiversity has, over the centuries, sustained a uniquely vibrant and colourful tapestry of peoples, cultures and traditions that have shaped our identity (Upadhyay and Hasnain, 2017; Venkataraman, 2012). The erosion of this biological diversity, and loss of the ecosystem services that it underpins, can thus impose a huge cost on Indian society. Such negative accounts cast into doubt the benefits derived from the current development model, while undermining the future well-being of Indian citizens.

In contrast, restoration of biodiversity is perhaps the least costly and least risky way to mitigate the impacts of land degradation and climate-induced environmental disasters. A global review revealed that several climate change adaptation strategies were directly related to biodiversity conservation. These included increased expanse of Protected Areas, restoration of existing Protected Areas and other degraded sites, protection of movement corridors and monitoring and revival of ecosystem functions (Mawdsley et al., 2009). Effective conservation of biodiversity in and around farms can further increase agricultural productivity, nutritional security and livelihood security (IPBES, 2018; Scherr and McNeely, 2008). Biodiversity similarly offers relatively inexpensive and sustainable ways to foster human and veterinary health based on a rich heritage of Ayurveda traditions relying on the use of native plants and animals (Meena et al., 2009; Mahawar and Jaroli, 2006). The recent emergence of diseases of zoonotic origin (including COVID-19) is linked to intensified anthropogenic impacts on biodiversity (Everard et al.,

2020; Roe et al., 2020; Morand et al., 2014). Protection and restoration of biodiversity are thus also critical for building resilience against future emerging and re-emerging diseases of zoonotic origin (Everard et al., 2020; Roe et al., 2020).

Third, and on the positive side, UNEP estimates that human capital has maintained its relative share at 60% of India's total national capital (UNEP, 2018), meaning that it has strengthened considerably and kept pace over those years of rapid economic growth. Today, India has a secure base of scientific, technological and people-centric approaches to biodiversity conservation. Under the Biological Diversity Act 2002, the National Biodiversity Authority has been established, and so have State Biodiversity Boards and Biodiversity Management Committees for monitoring at local levels. The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, legitimizing the rights of forest-dwellers to land and other resources which had historically been denied to them, was instituted in 2006.

On the scientific front, conservation biology as a discipline has seen major advances in the country over the last few decades. Indian conservation biologists have developed conceptual tools to document biodiversity (e.g., *Avalanche Index*: Ganeshaiah et al., 1997), used digital tools for large-scale mapping and classification of vegetation (Roy et al., 2015; Krishnaswamy et al., 2009), conducted demographic and behavioural work on various animal species (Sukumar, 1989; Karanth, 1995), deployed molecular tools toward the conservation of threatened species (Mondol et al., 2009), documented indigenous knowledge and community-based management systems (Parrotta et al., 2009; Kothari et al., 2013), and examined social and economic factors critical for sustaining biodiversity (Gadgil, 1991; Lele et al., 2010). The Botanical Survey of India and Zoological Survey of India, established over 100 years ago, have described and documented several plant and animal species. Additionally, documentation of biodiversity occurs on online portals such as eBird, India and eFlora of India. Much of this information though remains in silo. India has strengths in both natural and social sciences, and has the capacity to integrate them to foster and promote sustainability. These are the necessary ingredients for success of a program to link conservation with societal benefits.

### 1.3. Mission program

The Mission will:

1. Transform biodiversity science in India by linking scientific research with mitigation of problems such as pandemics, climate change, economic insecurities, and realization of the UN SDGs and the UN *Strategy for Living in Harmony with Nature*,
2. Improve the prospects of meeting challenges in climate change, agriculture, and animal and public health using biodiversity and ecosystem services,
3. Strengthen public research institutions, academia and non-government organizations by adopting modern concepts and tools to explore, document, assess, monitor, and sustainably use India's vast but declining natural assets,
4. Create a cadre of hundreds of professionals trained in the new interdisciplinary science to protect, restore, sustainably use and secure India's biodiversity,
5. Place in public domain high quality and rigorously generated spatially explicit data and information on biodiversity and ecosystem services to enable management of environmental impact assessments and of development projects,
6. Initiate a mass movement to help every citizen feel pride in India's natural heritage, and to engage millions of people in appreciating, documenting, protecting and restoring life on earth.

In the following sections, we describe the various components of the Mission; linkages with other policies, national missions, international treaties and conventions; implementation; and key outcomes. We conclude with a discussion of the opportunities our framework offers for India and other countries.

## 2. Components of the mission

The Mission has two major components (Fig. 1)

### 2.1. First Major Component

**Program 1: NISARG Bharat (National Initiative for Sustained Assessment of Resource Governance)** for documenting, cataloguing, mapping, monitoring, and managing biodiversity for conservation and sustainable utilization of biological resources.

Program 1 is composed of 3 Sub-Programs:

**Sub-Program 1.1: Exploration, Discovery and Genetic Characterization of India's Biodiversity** will use field exploration, modern tools such as artificial intelligence and DNA sequences combined with approaches of computational biology to discover and further characterize India's biodiversity. The Sub-Program will additionally enhance the capacity and capability of the Botanical Survey of India (BSI) and the Zoological Survey of India (ZSI) to fully describe and sustainably use our biodiversity. **Sub-Program 1.1** will be closely linked with **Sub-Programs 1.2** and **1.3**. Along with other Programs described below, this Program will engage millions of citizens and students in the exploration and discovery of India's natural heritage. Students will be trained (see **Program 7** below) and encouraged to participate in field surveys for documenting occurrence and distribution of species and for collecting specimens. Citizen science engagement will also help document occurrence of different species across India. Citizens who wish to volunteer for field survey would be provided adequate training in this regard.

**Sub-Program 1.2: National Framework for Electronic People's Biodiversity Registers (e-PBRs)** calls for establishing a well-coordinated nation-wide framework of e-PBRs where processes, protocols, mechanisms, standards, and ethics of data collection, collation, and publishing are followed in letter and in spirit, appreciating the ecological and economic value of such information and respecting the national laws and policies of data exchange/sharing. This is our best opportunity to mainstream biodiversity and ecological sciences, drawing increased attention to the negative impacts of over-exploitation of biotic resources and carelessness toward the very habitats that support our life. If e-PBR is regarded as a process and an opportunity to help move the citizenry (irrespective of educational qualifications) from bio-illiteracy to bio-literacy, then devising a well thought-out and coordinated national framework for e-PBRs is crucial. Thus, it is the right time to transcend PBR processes into a digital and networked era.

**Sub-Program 1.3: Cataloguing and Mapping Life of India (CML)** will set up a portal to use digital tools and artificial intelligence to map India's biodiversity, people and cultures; identify areas of vulnerability and gaps in conservation; map restoration and afforestation projects to meet India's Intended Nationally Determined Contributions (INDCs); and support **Sub-Programs 1.1**, **1.2** and all other Programs. A generic participation module will facilitate citizen engagement in collection and use of spatially referenced data, and will build awareness of the rich biodiversity heritage of India and the need for conservation.

Implemented in collaboration with the BSI, ZSI, WII (Wildlife Institute of India) and other government agencies, and building on their past and current work, **Sub-Program 1.3** will also aggregate biodiversity data from various currently isolated databases (including online platforms such as e-Bird or eFlora of India) into a structured database complying with open and published biodiversity informatics standards, referencing all data along taxonomic, spatial and temporal axes. It will be the largest open-access resource for curated biodiversity information in India, and will conform to the National Data Sharing and Accessibility Policy (NDSAP) and other policies and laws of the Government of India. The mapping and cataloguing effort will be undertaken by an inclusive consortium of National, State, Local, Government and Non-Government organizations. All data and activities of this program will be served through an interactive web portal.

Furthermore, **Sub-Program 1.3** will collate information flowing

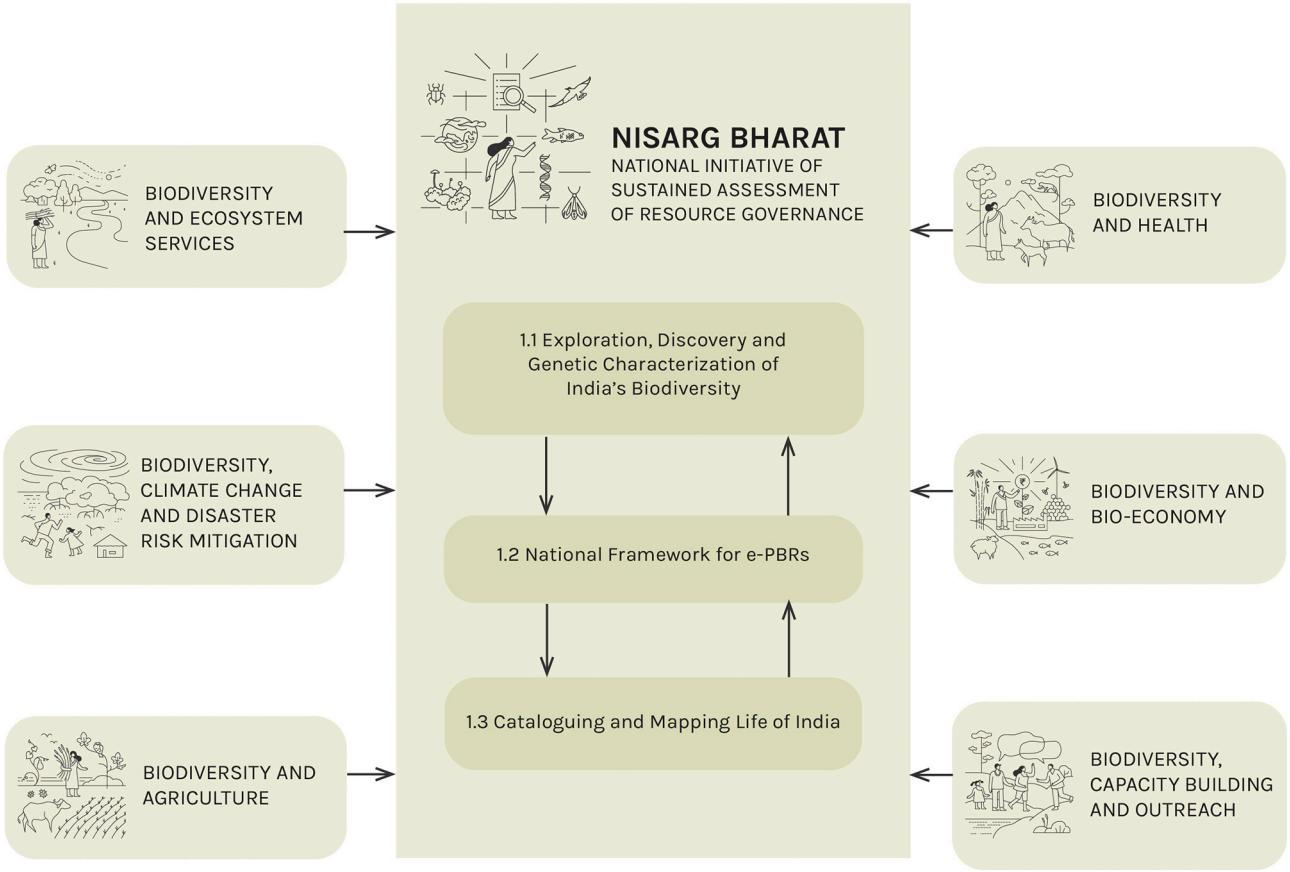


**Fig. 1.** The National Mission for biodiversity and human well-being. Program 1 NISARG Bharat represents the central component of the Mission.

from the other Programs, thereby contributing to several SDGs and corresponding Targets. Apart from the specific Targets that each of the other Programs will address (details in next section), all of them will concurrently work toward achieving SDG Targets 12.2 (sustainable natural resource management and its efficient use) and 15.9 (incorporation of ecosystem and biodiversity values within national and regional planning, development endeavours and poverty alleviation schemes).

### 2.2. Second major component

The second major component will consist of six Programs, each with field-based projects to realize the identified SDGs.

The six programs on Ecosystem Services, Climate Change and Disaster Risk, Agriculture, Health, Bioeconomy and Capacity Building and Outreach, described below, are linked with each other, with biodiversity as the common underlying theme—biodiversity providing solutions to our most pressing environmental challenges in enhancing the flow of ecosystem services, mitigation of climate change and disasters, resilient agroecosystems, public health, and green economy. These are some of the most critical planetary and human needs, and there is no better way to mainstream biodiversity in our daily lives than by engaging thousands of students, professionals and citizens in biodiversity informatics and by enhancing the capacity of our institutions in the practice of biodiversity science.

**Program 2: Biodiversity and Ecosystem Services:** Biodiversity and its associated benefits, including ecosystem services, are critical to human well-being. This is especially true in India, where hundreds of millions rely on biodiversity-associated services as a source of daily sustenance and well-being. Managing our precious living systems for a sustainable flow of societal benefits at the national scale requires extensive work across India's diverse biomes. Broadly, **Program 2** will a) identify, quantify and map key ecosystem services that sustain the well-being of millions of people across diverse biomes and assess trade-offs among services, b) examine the impacts of land use change and invasive species on ecosystem services, and c) develop plans for reducing degradation and enhancing restoration of ecosystem services (Fig. 2). Key outcomes include nature-based management of ecosystems and climate resilient action plans for economic development. The Program will help meet SDG Targets 15.1 (conservation, restoration and sustainable use of ecosystems and the services thereof), 15.4 (conservation of mountain ecosystems, including biodiversity), 15.5 (curbing habitat degradation and biodiversity loss, protecting threatened taxa), and 15.8 (control of invasive alien species).

Finally, **Program 2** will explore threats to biodiversity including endangered species (e.g., habitat connectivity and impacts of land-use change), and develop landscape- and habitat-specific conservation action plans that protect biodiversity while maximizing benefits to people.

**Program 3: Biodiversity, Climate Change and Disaster Risk Management:** Climate change and extreme weather events, in combination with non-climatic stressors, can disrupt degraded ecosystems. On the other hand, well-functioning ecosystems can help mitigate the impacts of such events and provide options for adaptation to climate change, while also reducing net emissions of greenhouse gases. Preparing for climate change impacts requires national-scale investments in protective natural systems – these can, and must form, the core of a rational program of disaster risk management and adaptation planning.

This Program will a) investigate, quantify and map vulnerability of managed, semi-natural and natural ecosystems and their ecosystem services to climate change and extreme events, b) determine the contributions of these diverse ecosystems (rivers, wetlands, estuaries, forests and grasslands) to mitigating the impacts of extreme weather events and climate change related disasters, and c) provide data for policies

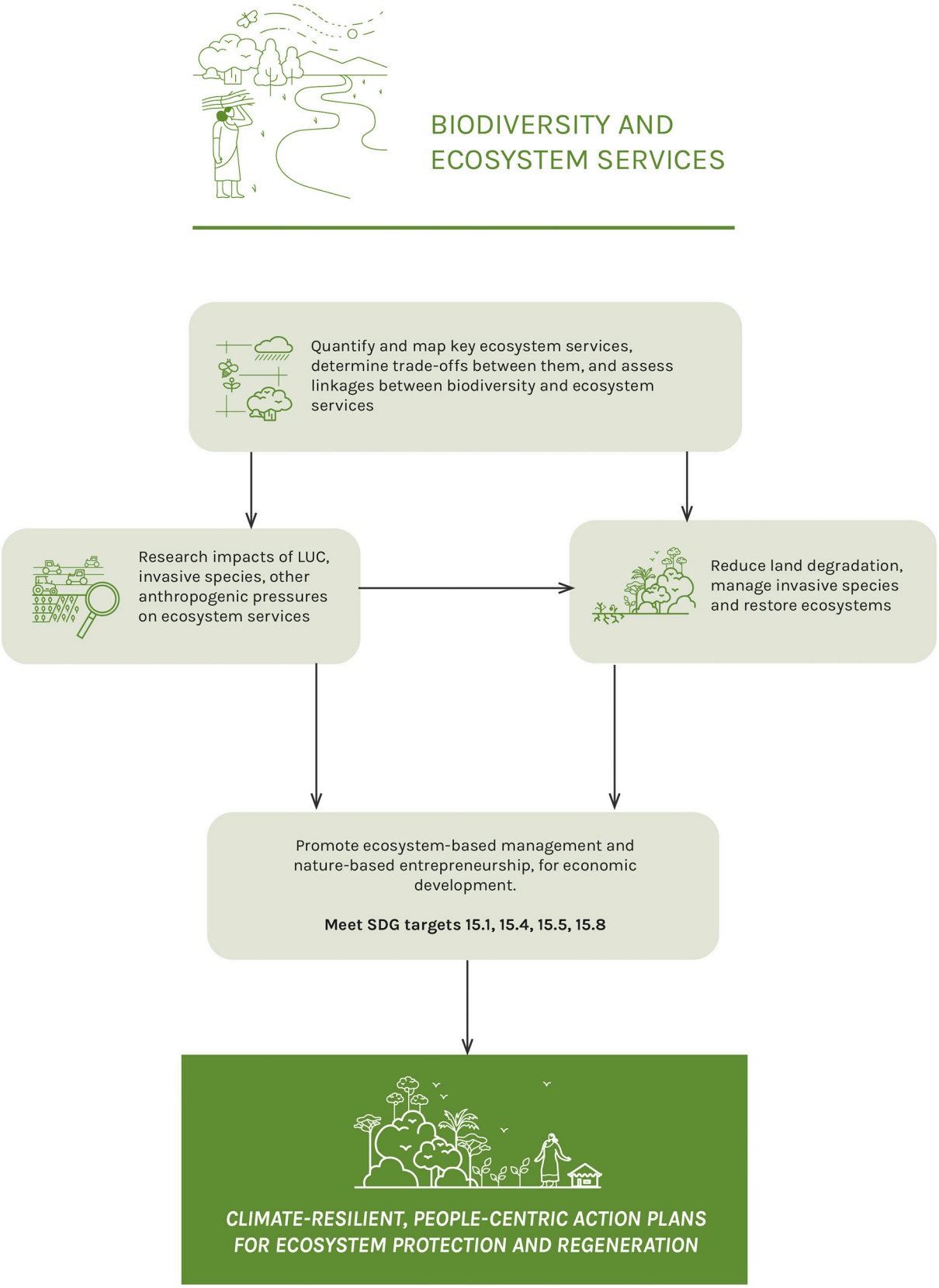


**Fig. 2.** Objectives and outcomes of Program 2: biodiversity and ecosystem services.

toward climate change mitigation and adaptation, and protection against natural disasters such as cyclones, heat waves, floods, landslides and droughts (Fig. 3). Key outcomes include evidence-based proposals for climate change mitigation and adaptation policies investing in natural infrastructure at local and landscape scales. The Program will aid in meeting SDG Targets 13.1 (enhancement of resilience and adaptive capacity to climatic hazards and natural disasters) and 13.2 (integration of climate change mitigation and adaptation measures into national policies, strategies and planning). Working synergistically with **Program 2**, this Program will also contribute to meeting SDG Targets 15.1, 15.4 and 15.8.

**Program 3** will further enable the government, in partnership with civil society, to build a comprehensive portfolio of proactive, efficient investments in nature-based solutions to climate risks, serving as a model for developing and developed countries across the world.

**Program 4: Biodiversity and Agriculture:** India harbours a large number of wild relatives and land races of agricultural and horticultural plants. This rich agrobiodiversity plays a critical role in meeting the food and nutritional security and livelihood requirements of the country's poor (Swaminathan, 2012; Swaminathan and Kesavan, 2018; Dev, 2018). An estimated 100 to 150 million people and scores of marginalized communities in the country depend directly on terrestrial and

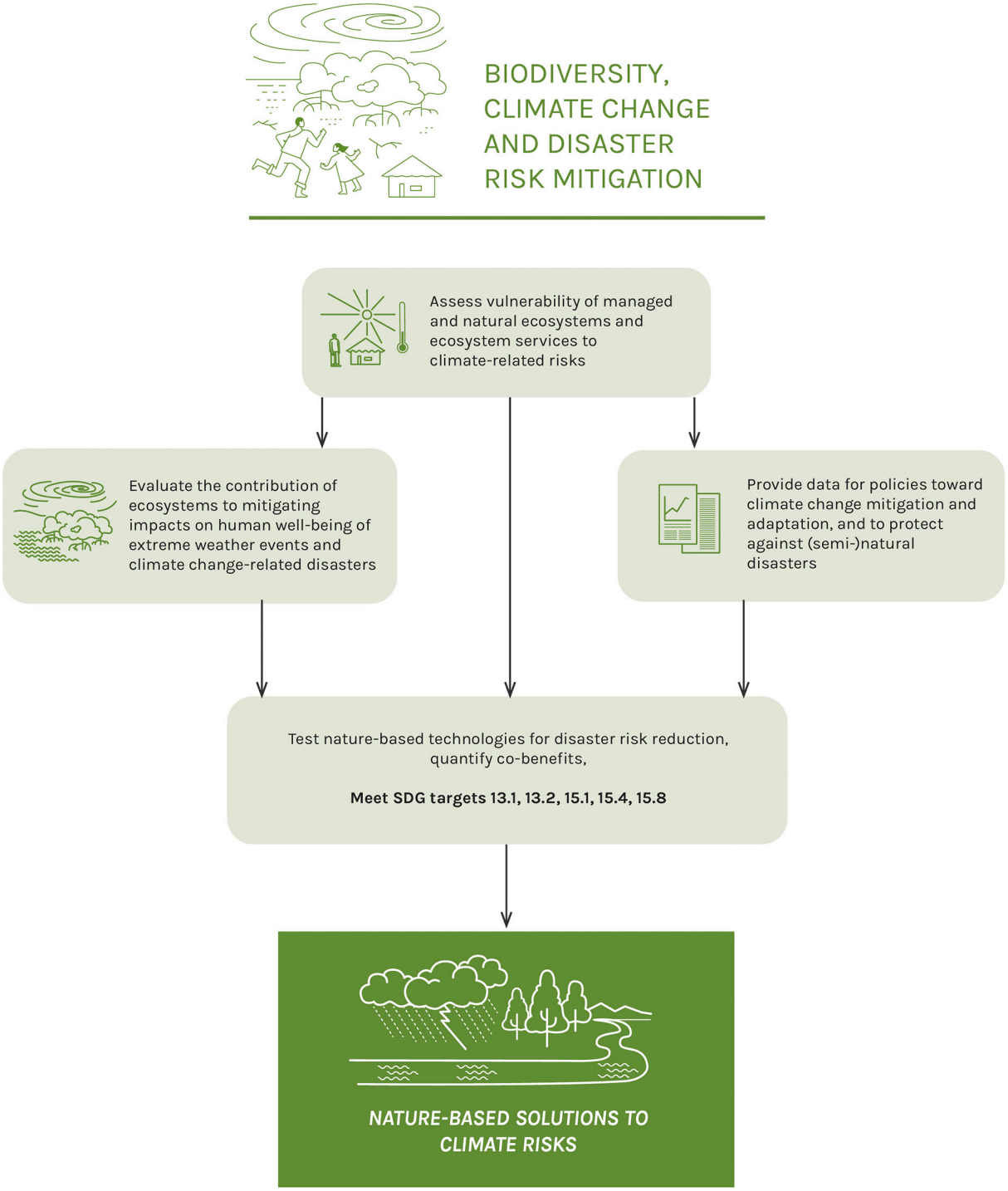


**Fig. 3.** Objectives and outcomes of Program 3: biodiversity, climate change and disaster risk mitigation.

aquatic biodiversity for their livelihoods. However, there has been little emphasis on exploring how this biodiversity can be augmented for climate resilient agriculture, enhancement of nutritional and food security, and promotion of new enterprises based on agrobiodiversity to stabilise rural incomes and livelihood opportunities.

The main goals of **Program 4** are: a) to assess on-farm biodiversity and its nutritional and economic potential across India, b) incorporate additional biodiversity in agricultural systems to enhance nutrition and food security and c) explore the potential of new agrobiodiversity-based enterprises to increase farmers' incomes (Fig. 4). Key outcomes include climate-resilient, agrobiodiversity-based rural livelihoods, institutions and policies for protecting and enhancing agrobiodiversity, and widespread improvements in nutritional security. Program 4 will contribute toward the realization of SDG Targets 2.3 (doubling agricultural productivity and incomes of farmers, indigenous peoples, pastoralists and fishermen), 2.4 (ensuring sustainable food production systems and implementation of resilient agricultural practices that enhance productivity, maintain ecosystems, and increase adaptive capacity against climatic disasters), and 10.1 (income growth for the lower 40% of the population, at a rate greater than the national average).

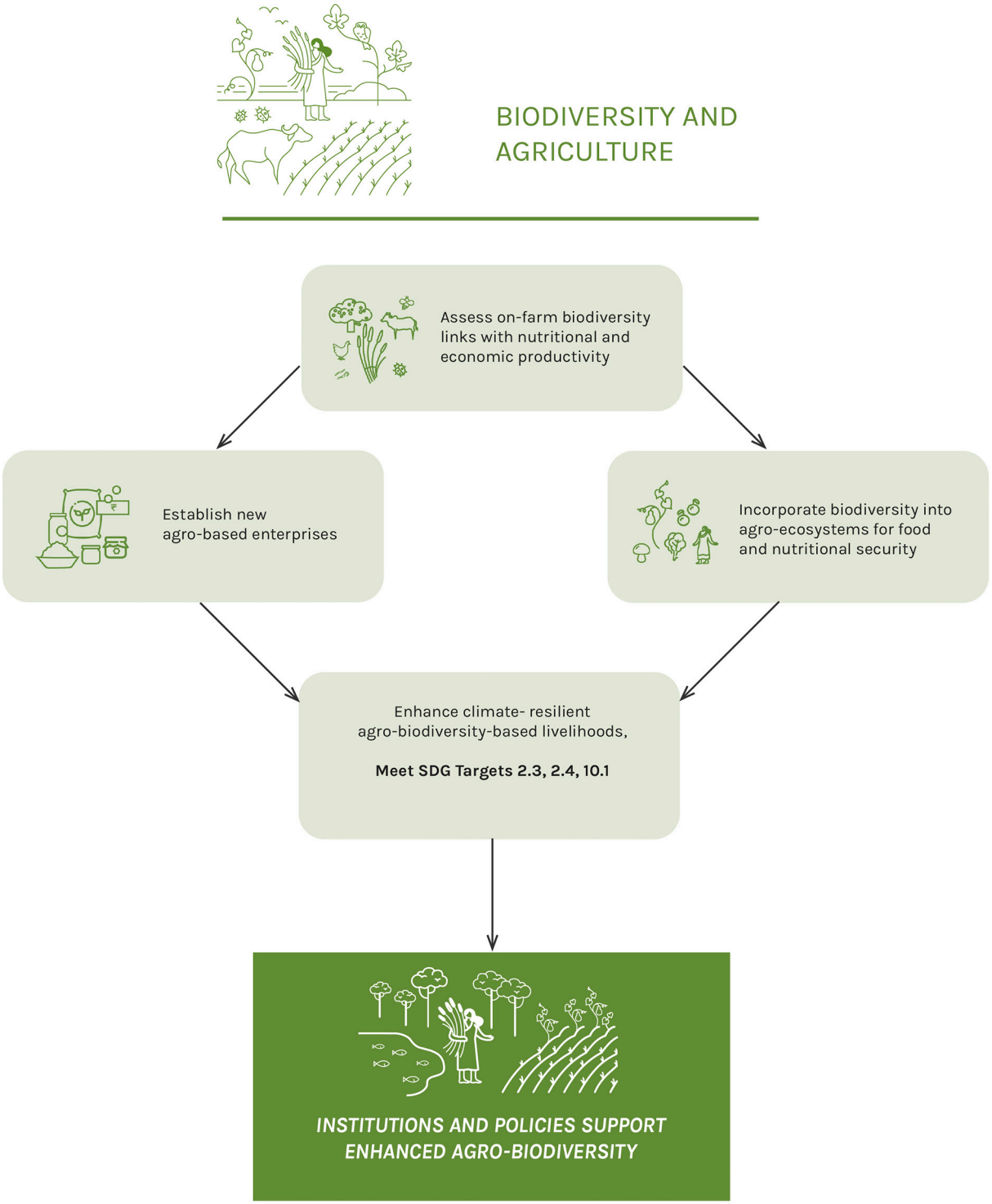


**Fig. 4.** Objectives and outcomes of Program 4: biodiversity and agriculture.

**Program 5: Biodiversity and Health:** Despite medical advances in many areas, the current scale and pace of economic and industrial development in India are negatively impacting the health of its citizens in many ways. There is an increasing potential for the emergence of new health risks and epidemics/pandemics due to climate and land-use change. Current and future health risks are anticipated to extract a dire toll on our nation. However, our rich biodiversity offers many cost-effective solutions. The OneHealth framework, which has become extremely relevant in the context of the COVID-19 pandemic, offers an overarching framework linking biodiversity, animal and human health. The Biodiversity and Health program has two sub-programs. These seek on the one hand to improve our ability to predict and interrupt the emergence of new and re-emerging infectious diseases, and on the other to provide scientific underpinnings to traditional treatments, based on medicinal plants, for known illnesses. In this way, better understanding and sustainable use of India's biodiversity will help us find economically viable solutions to current and future health challenges.

The first sub-program (**OneHealth and Zoonoses**) will a) examine

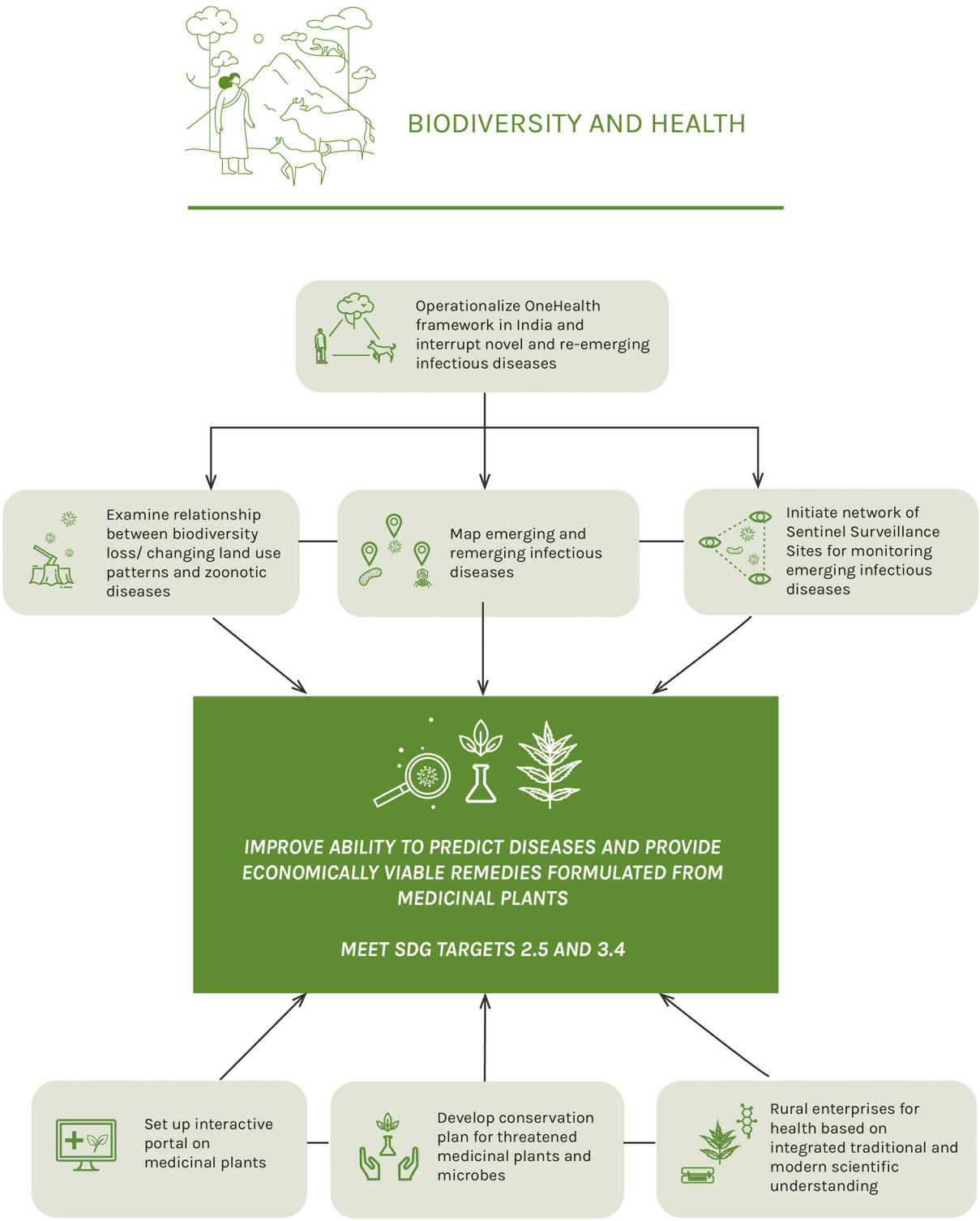


**Fig. 5.** Objectives and outcomes of Program 5: biodiversity and health.

relationships between biodiversity loss, changing land use patterns, and zoonotic diseases, thereby informing policy and practice toward controlling the spread of emerging and re-emerging infectious diseases, b) operationalize the OneHealth framework in India, and c) in partnership with a range of organizations, initiate a mapped network of Sentinel Surveillance Sites for emerging infectious diseases.

The second sub-program (**OneHealth and Medicinal Plants**) will a) set up an interactive portal on medicinal plants, b) develop conservation plans for threatened medicinal plants, and c) integrate traditional knowledge with modern scientific knowledge for a broader understanding of the pharmacology of medicinal plants. Each of these initiatives can immediately be applied to support and seed rural enterprises for health and livelihood security **(**Fig. 5**)**.

The key outcomes of this Program will be information portals and networks of institutions for operationalization of the OneHealth framework, monitoring and surveillance of infectious diseases, and full realization of the potential of India's vast medical heritage and associated richness of medicinal plants for public health. The Program will help achieve SDG target goals 2.5 (maintenance of genetic diversity of seeds, cultivated plants, domesticated animals and their related wild species) and 3.4 (reduction of premature mortality, promotion of mental health and well-being).

**Program 6: Biodiversity and Bio-economy:** The broad aim of this Program is to identify and promote sustainable development pathways that are based on bio-resources, and are both economically viable and ecologically sustainable. Attribution of 'value' to nature will be addressed in two ways. A formal approach includes development of a framework to incorporate ecosystem services into the National Income Accounting system used in India, following the Ecosystem Accounting protocols of UN System of Environmental-Economic Accounting (currently under revision, https://seea.un.org/ecosystem-accounting). A second approach envisages actions that are valuable to local communities – namely, livelihoods generation and the realization of biodiversity benefits in a sustained manner. It envisages livelihoods through market stimulation following replacement of abiotic inputs in industrial processes by biotic ones, as well as production of bio-resource based final goods and services. Realization of biodiversity benefits requires planning and monitoring, targeted investments in resource-generating activities such as ecosystem restoration, and appropriate institutional frameworks. Potentials and strengths of local bio-economies will be evaluated by this Program in 81 sample locations (9 biogeographical zones x 3 socio-economic characteristics x 3 ecosystems of varying richness) across the country.

In the process, the Program will estimate (a) 'market value' of sustainable flow of bio-resources and their value (over time) in biodiversity hotspots and other areas with significant biodiversity, (b) cost of stabilising, augmenting and sustaining bio-resource flows in ecosystems faced with a rapid but recent decline in biodiversity and ecosystem services and (c) cost of restoring, stabilising, augmenting and sustaining ecosystems with a rich biodiversity history and/or potential (Fig. 6).

Building and sustaining bio-economy will also require increasing capacity among teachers, researchers, practitioners and professionals. On the economics of biodiversity and ecosystem services in India, the Program will (a) develop materials for teaching and training at undergraduate and postgraduate levels, (b) undertake refresher courses for teachers/supervisors/researchers, (c) undertake training of practitioners designing, planning and implementing interventions, and (d) undertake training of professionals advising and managing institutions governing bio-resources. **Program 6** will help meet SDG Targets 7.2 (increase renewable energy in global energy mix), 8.4 (improve efficiency in consumption and production, decouple economic growth from environmental degradation), 9.4 (increase resource-use efficiency and adopt clean technologies in retrofit industries) and 11.6 (reduce adverse per capita environmental impact of cities). In collaboration with **Program 4**, it will also address SDG Target 10.1.

**Program 7: Biodiversity Capacity Building and Outreach.** Sustaining human and environmental ecosystems requires a universal recognition of biodiversity and its relevance to human well-being. At present, the level of public awareness and engagement with biodiversity in India is inadequate. This lack of public involvement threatens the long-term success of all measures undertaken so far to conserve and promote the sustainable use of India's ecosystems. At the same time, India still has few researchers trained in biodiversity studies. The result is an inadequacy of trained biodiversity personnel, a deficiency in citizen engagement, and a lack of widespread awareness of biodiversity and its importance for humanity. This Program aims to engage India's citizenry in various roles (Fig. 7). First, we will build more capacity in biodiversity science through a range of training programs targeting undergraduates, post-graduates and biodiversity professionals. This will catalyse a new generation of Indians who can synthesize interdisciplinary concepts and tackle real-world problems related to biodiversity.

But a task of this scale cannot be generated and utilized at a country-wide level by professionals alone. Citizen engagement is helping to fill this need through large-scale projects under the rubric of 'citizen science'. This Program will support such existing efforts and provide training and resources to initiate more innovative citizen engagement projects, while also increasing social inclusiveness and ensuring widespread geographical coverage. Finally, the Program will urgently mainstream biodiversity into India's consciousness and public discourse by strengthening communication in various media and other platforms, and provide policy-guiding outreach to targeted groups of professionals, including government officials and private entrepreneurs, who can incorporate biodiversity conservation and sustainable use into the national fabric of our socioeconomic advancement. To this end, in addition to direct efforts, it will be important to collaborate with and support other networks and initiatives across the country such as the EChO Network steered by the Principal Scientific Adviser (PSA) to the Government of India, the outreach and communication efforts of BSI and ZSI, the WII wildlife management and academic training, the Kerala Institute of Local Administration Panchayat training, and the United Nations Development Programme-National Biodiversity Authority (UNDP-NBA) training. The Program will address SDG Targets 4.7 (ensuring every learner acquires necessary knowledge and skills for promoting sustainable development) and 12.8 (making sure that people all over the world are provided with relevant information and awareness for sustainable development and living in harmony with nature).

In its entirety, activities under the Mission will involve a large number of scientists and practitioners, numerous institutions, and a significant number of citizens during the implementation phase. Two unique elements of implementation will be convergence and synergies among goals, themes and project sites. For example, sites for electronic People's Biodiversity Registers (e-PBRs) to be prepared by Biodiversity Management Committees (BMCs) may also be the sites for various themes of agriculture, ecosystem services, climate change mitigation, bio-economy, citizen science, school education and media outreach.

We are currently developing roadmaps for these programs, which include monitoring and evaluation components that are too detailed to be included here.

## 3. Aspirational districts

Although the groundwork of the Mission will be spread all over India, special attention will be paid to biodiversity hotspots, understudied landscapes and socio-ecological systems, and Aspirational Districts. The 'Transformation of Aspirational Districts' program was launched in 2018 in a bid to improve India's Human Development Index (NITI Aayog, 2018). In this program, the Government of India identified 117 of 739 districts which were lagging behind in one or more focal areas: health and nutrition, education, agriculture and water resources, financial inclusion and skill development, and basic infrastructure. The basic idea is to encourage these districts to improve in these aspects so as to promote equitable growth and development across the entire country.

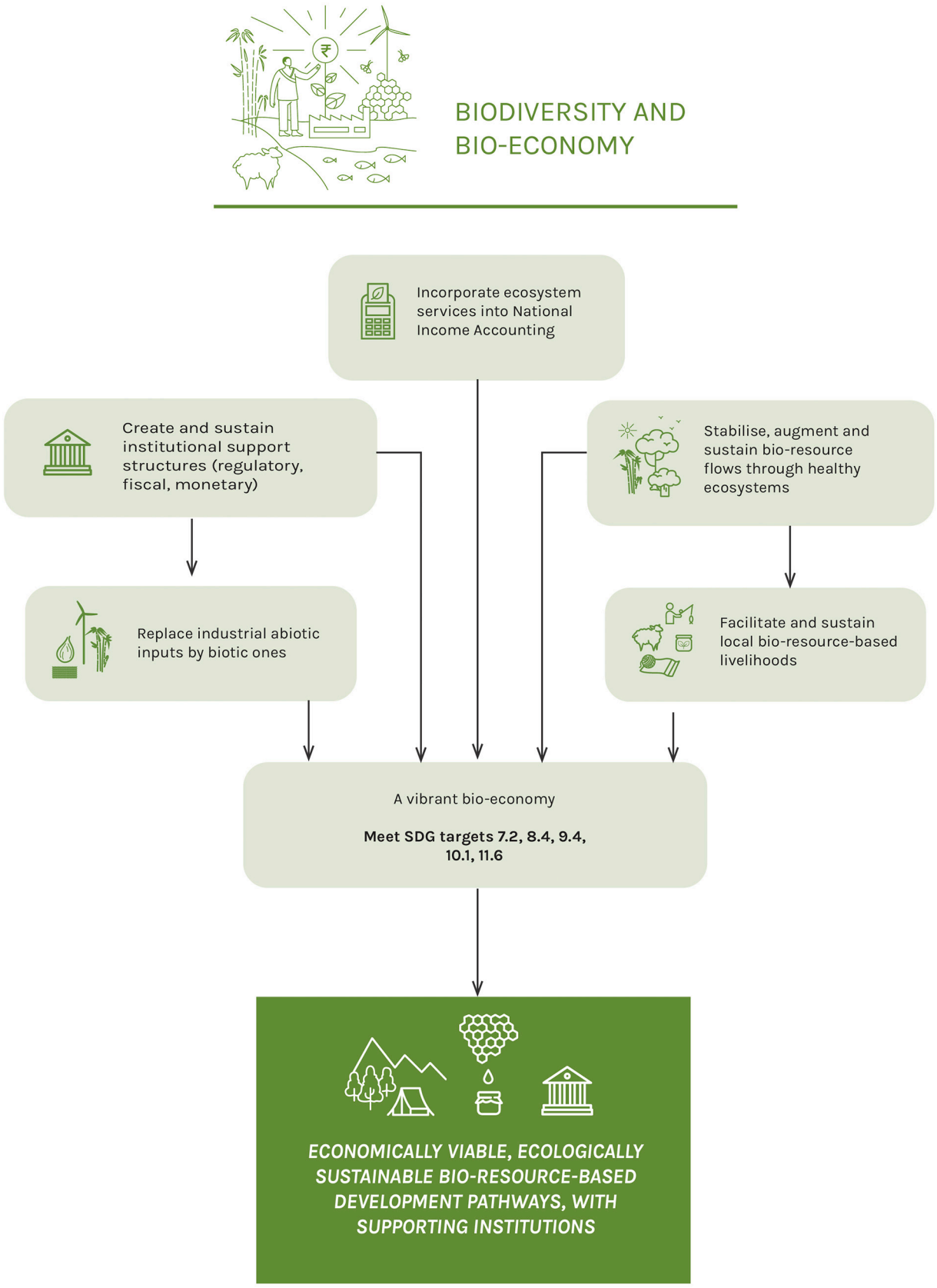


**Fig. 6.** Objectives and outcomes of Program 6: biodiversity and bio-economy.

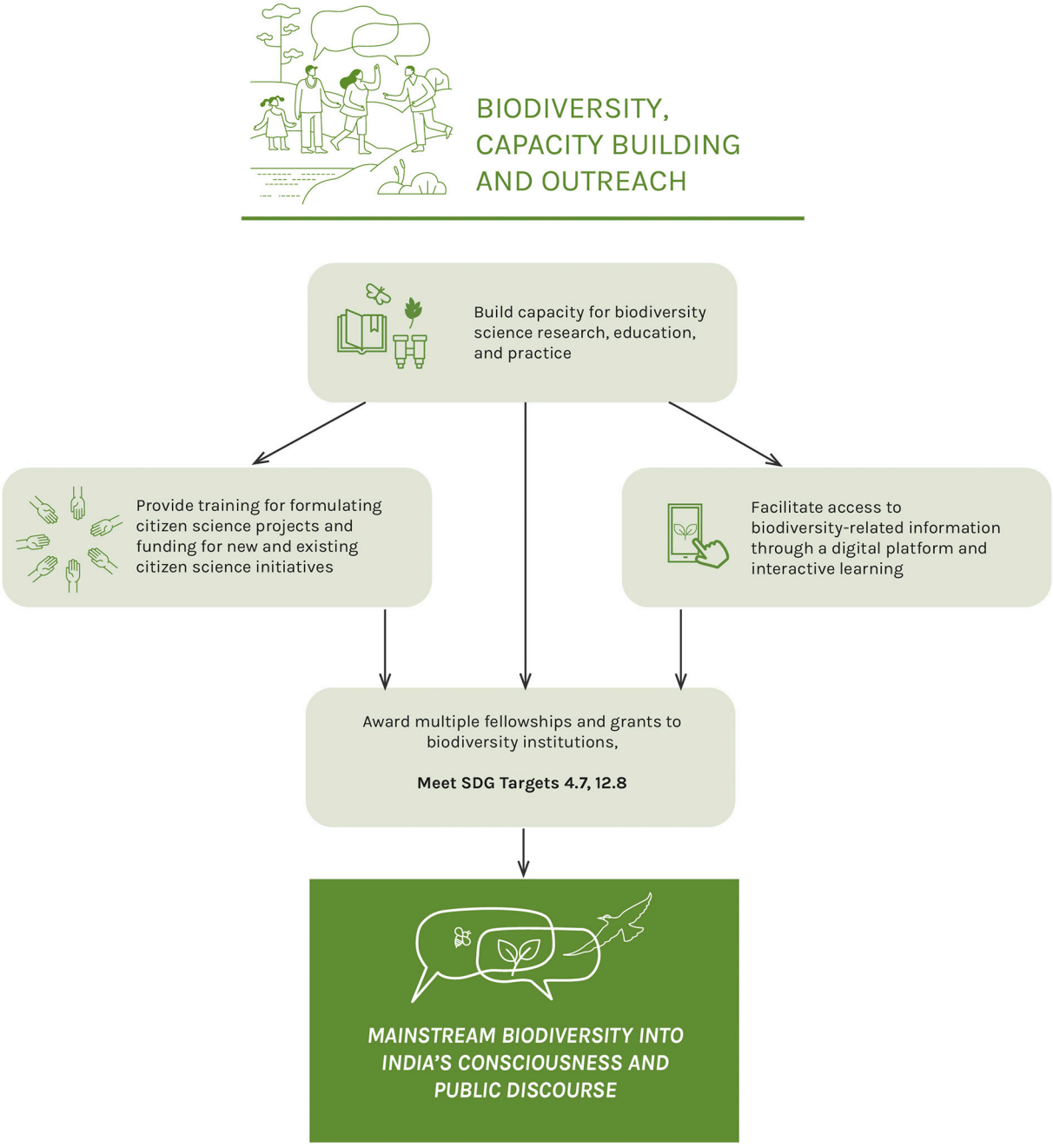


**Fig. 7.** Objectives and outcomes of Program 7: biodiversity, capacity building and outreach.

The goal of the NMBHWB is to embed biodiversity as a key consideration in all development programs, particularly in sectors such as agriculture, water resources, climate change mitigation, ecosystem services, public health and bio-economy. The Aspirational Districts offer an excellent opportunity to mainstream biodiversity into the development processes.

## 4. Linkage to national policies, institutions, and international treaties for biodiversity

India may be well-positioned to become a globally recognized leader in biodiversity conservation. This could seem a surprising assertion, since India – like almost all other countries – has made slow and uneven progress on international conventions and agreements such as the programs of the Convention on Biological Diversity (CBD; CBD Secretariat, 2000b). These include the Aichi Biodiversity Targets (CBD Secretariat, 2010), the Cartagena Protocol of Biosafety (CBD Secretariat, 2000a), and the Nagoya Protocol on Access and Benefit Sharing (CBD Secretariat, 2011). Progress on these targets is notoriously difficult to measure transparently (OECD, 2019), but one of the more verifiable targets is Aichi Target 1, which encourages countries to ensure that their populations are aware of biodiversity and appreciate its value (Target 1: "By 2020 people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably"). Among 16 countries recently surveyed by the Union for Ethical Biotrade (UEBT, 2018; UEBT, 2019), India scored lowest in public awareness of biodiversity (IPBES, 2018).

Crucially, however, young people the world over are more aware of biodiversity than their elders, and India's population is relatively young. As general educational standards continue to rise rapidly in India, biodiversity must become an integral part of curricula from grammar

school through post-secondary school. A National Biodiversity Mission can help push this important generational-change agenda forward.

India ratified the UNFCCC Paris Agreement in 2016, committing itself to an ambitious 2030 goal of reducing the greenhouse gas emissions intensity of its economy by 33–35% below 2005 levels. Key to this effort will be the sequestration of an additional 2.5–3 billion tonnes of $CO_2$, to be achieved by increasing forest cover, improving forest stock quality, and sourcing 40% of the country's power capacity from renewables (NRDC, 2020; Seidler and Bawa, 2016). Reforestation and ecosystem restoration – the re-establishment of critical green infrastructure – must therefore form a central pillar of India's short- and long-term climate mitigation and adaptation strategy. To realize these national goals, State Forest Departments will need to coordinate broadly with civil society and academia to substantially increase the scope and effectiveness of their efforts. A National Mission can help facilitate such coordination.

These and many other challenges demand strengthened 'inclusive' approaches to biodiversity management. These will be complementary to improvements in conventional 'top-down' conservation approaches based on Protected Areas and strengthened Environmental Impact Assessment processes to stem the loss of irreplaceable ecosystems and habitats to development projects. Other large-scale challenges include the restoration of degraded 'wastelands', ensuring ecological flow regimes in rivers, and assessment and monitoring of biodiversity in the face of environmental change and unsustainable over-exploitation of natural resources. A National Biodiversity Mission can help integrate these efforts, which are presently spearheaded by separate ministries and departments.

Importantly, it has been recognized that India's post-COVID economic recovery needs to entail an inclusive and green economy that concomitantly helps India move toward the SDG targets (Kedia et al., 2020). A blend of land-sharing and land-sparing conservation approaches, maximizing benefits and minimizing costs to local communities, will be an integral part of this Mission. Its implementation will therefore take the country several strides toward fulfilment of India's commitments to international agreements, while speeding up associated processes such as the effective execution of PBRs.

Scientific inputs from the Mission will assist in development of evidence-based strategies and policies for numerous other National Missions, programs and schemes, and will significantly upgrade India's deployment of emerging technologies related to geospatial informatics and environmental sensing. Analysis of ecosystem functioning and community assemblage rules, as well as documented local perceptions and indigenous knowledge of local ecosystem dynamics, will be valuable for (among others):

- National Mission for Green India,
- National Wildlife Action Plan,
- National Mission for Sustaining the Himalayan Ecosystem,
- National Mission on Sustainable Agriculture,
- National Biodiversity Strategy and Action Plan (NBSAP)
- National Water Policy

In addition, the Mission will aid in fulfilling India's commitment to international treaties and agreements including:

- Convention on Biological Diversity (CBD),
- UN Framework Convention on Climate Change (UNFCCC),
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES),
- Cartagena Protocol on Biosafety,
- Rotterdam Convention on Prior Informed Consent,
- Intergovernmental Panel on Climate Change (IPCC),
- Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

With reference to public health, the Mission offers the opportunity to advance the OneHealth framework for meeting the challenges of infectious diseases (see also **Program 5** above). In particular, there is an opportunity to create an Inter-Ministerial Task Force (IMTF) that could include representatives from (1) Ministry of Agriculture and Farmers Welfare, (2) Ministry of Environment, Forest and Climate Change (MoEFCC), (3) Ministry of Fisheries, Animal Husbandry and Dairying, (4) Ministry of Health and Family Welfare, (5) Department of Science and Technology (DST) and Department of Biotechnology (DBT), (6) Ministry of Tribal Affairs (MoTA), (7) Ministry of Women and Child Development, and members from civil society and private sector, with the task of formulating guidelines for the implementation of the One-Health framework. COVID-19 adds urgency to this need.

Effective implementation of policies depends on efficient governance, which in turn relies on smoothly functioning institutions. The relevant institutions advancing biodiversity science and sustainable use of bio-resources to benefit society and human well-being range from grass-roots organizations and instruments such as PBRs, BMCs and State Biodiversity Boards (SBBs) to public institutions such as State Forest Departments and research institutions, and national institutions including the BSI, ZSI, WII, public and private universities and a range of government and non-government organizations.

This ambitious Mission will work with all such institutions, building their capacity, enhancing their interactions with multiple stakeholders, and engaging them in targeted policy and practical outputs/outcomes.

## 5. Implementation

The idea of the Mission was developed by a group of scientists, members of the Biodiversity Collaborative, who attended a meeting convened by Author 1 on 9th July 2018, in Bengaluru. A concept note developed by the authors of this manuscript was presented at the inaugural Prime Minister's Science, Technology and Innovation Advisory Council (PM-STIAC) meeting on 9th October 2018. Subsequently, a precursor grant by the Office of the PSA to the Biodiversity Collaborative enabled many consultations with scientists, managers and conservationists from a range of national institutions with expertise in biodiversity science.

The Mission is national in scope. The PSA worked with the MoEFCC to designate the NBA as the nodal agency for the implementation of this Mission. As a statutory body established for the implementation of the Biological Diversity Act of 2002, and with a footprint all over India through SBBs and local BMCs, the NBA has the potential network and reach to facilitate the implementation of NMBHWB across India. Thus far, more than 280 participants from more than 110 institutions including State Forest Departments and SBBs have participated in consultations facilitated by the National Biodiversity Authority (NBA). A core of the country's leading biodiversity science and conservation organizations, from public, academic and civil society sectors will lead the implementation of all the Programs of the National Mission. In addition, extensive grants and fellowship programs under each theme will ensure the involvement of scores of other organizations and engage hundreds of professionals in basic and applied research, education and outreach. The implementation of the NMBHWB is designed as two functions, i.e., governance and management, corresponding broadly to the functions of provisioning and production, respectively (Ostrom, 1990). The design of institutions using this typology is shown to be effective when the goal is to manage public goods or common property resources. In the case of the NMBHWB, the goal is *to build capacity across all sections of Indian society, and a credible and comprehensive biodiversity information base for embedding biodiversity as a key consideration in all development programs, particularly in such sectors as agriculture, mitigation of climate change, ecosystem services, health and bio-economy – with the primary objective of restoring and enhancing biodiversity and its sustainable use in India.*

Each Mission Program will have a budget, and, apart from core activities, will also have a grants program under the direction/supervision of the NMBHWB Grants Committee to further strengthen research,

education, training, and outreach in biodiversity science as well as implementation of sustainable use, restoration and conservation projects.

A Mission Management Unit will be established within the NBA and this will primarily coordinate the provisioning functions while a Mission Secretariat will be established in Bengaluru and this will be responsible for the production function.

## 6. Concluding remarks: opportunities for India and beyond

The National Mission for Biodiversity and Human Well-Being is a unique initiative in that it places biological diversity (the *diversity of life itself*) as the guiding principal at the heart of a network of interlinked action-research programs. In this sense the NMBHWB has a broader set of goals than do the other India National Missions. In pursuit of these goals, we will be actively coordinating with other Missions, including the Green India Mission, the Sustainable Himalayan Ecosystems Mission, and the Sustainable Agriculture Mission. To sum up, we here highlight several distinguishing aspects of our vision for the National Biodiversity Mission.

### 6.1. Integrative action

The Mission is interdisciplinary, integrative, and comprehensive in its approach, pulling together ecological and social-economic dimensions of India's biodiversity and its links with human well-being. The Mission explicitly links knowledge generation (research) with policy-making and implementation for effective management of biodiversity with sustainable development. With its emphasis on convergence and synergies among various goals, themes and project sites, the Mission will develop new models for stakeholder consultations, co-production of knowledge, and integrated action on interconnected issues of agriculture and nutrition, health, ecosystem services, climate change mitigation, and bio-economy.

### 6.2. Local participation and governance

COVID-19 has generated considerable discussion about humanity's relationship with nature and our own ability to cooperate toward common goals (Iwuoha and Jude-Iwuoha, 2020; Rutz et al., 2020). The pandemic has underlined the importance of local governance and resilience as well as self-reliance (Janssen and van der Voort, 2020). Among all tropical countries where much of biodiversity lies, India's democratic institutions offer the highest potential to strengthen decentralized governance of local ecosystems, which, when linked with public health and a reimagined agriculture with emphasis on nutrition, food security and climate change mitigation, can redefine society's interaction with its natural heritage. As an example, Gadgil (2000) was a pioneer in advocating initiatives such as People's Biodiversity Registers, an important component of the Mission, for documentation and sustainable use of biodiversity by *Gram Sabhas* at the grass roots level. By exploring the potential of green jobs in a reimagined agricultural sector, in ecological restoration, and in the bio-economy, the Mission can accelerate recovery from the pandemic and make us less vulnerable to climate change.

### 6.3. Biodiversity protection

The Mission will significantly increase India's ability to curtail ongoing habitat loss and species extinctions, both of which are critical issues in conservation. The Mission has several Programs that will contribute to effective action based on evidence and information. Documentation and visualization of biodiversity trends will be important themes of all 3 sub-programs under **NISARG Bharat**, especially **Sub-Program 1.1 (Exploration and Discovery)** and **1.3 (Cataloguing and Mapping)**. These will provide critical information to underpin policy and management interventions. The Grants Program will target specific threatened species and habitats, and develop policy/management interventions. Databases in **Sub-Program 1.3** will provide baseline data to monitor and mitigate changes. The Mission will be able to work directly with MoEFCC and the various state Forest Departments as needed, to build capacity and professionalism and to help upgrade the management of Protected Areas. Indeed, the Mission is again unique in taking a more comprehensive approach to perennial problems in biodiversity science.

### 6.4. A unique model

The Mission offers the potential for India to develop new models for the practice of biodiversity science that explicitly takes sustainable development into account. Various countries have excellent programs on individual themes of the Mission. Examples include: National Biodiversity Network (NBN), a collaborative endeavour for collecting and mapping biodiversity information across the United Kingdom, and the Joint Nature Conservation Committee (JNCC) that keeps an updated list of biodiversity indicators for on-going and future biodiversity assessments in the country (JNCC, 2019); the Atlas of Living Australia (ALA) project that documents and showcases Australian biodiversity; the South African National Biodiversity Institute (SANBI), which publishes yearly biodiversity assessment reports; the National Commission for the Knowledge and Use of Biodiversity, Mexico, which has initiatives such as Atlas of Nature and Society and BIOS: Nature and Society for supporting research, academic exchange and dissemination of information about the biodiversity of Mexico (Biodiversidad Mexicana); the Brazilian Biodiversity Information System that has an open access source for biodiversity-related data (Sistema de Informação sobre a Biodiversidade Brasileira); and China that focuses on ecosystem assessments rather than species (Xu et al., 2017).

We in India can learn a great deal from such examples. However, the NMBHWB not only seeks to integrate data across genes, species, ecosystems and biomes, as do some of the initiatives in other countries, but also explores linkages of biodiversity with health, agriculture and rural livelihoods, climate change and green growth. Understanding these connections will materially advance new research frontiers in biodiversity science and human well-being. The implementation of the Mission, along with the recently-launched Long Term Ecological Observatories Program on Biodiversity and Climate Change (MoEFCC), and citizen engagement will support the emergence of India as a global leader in biodiversity management, and as a model to other countries for comprehensive biodiversity documentation.

### 6.5. Finding opportunity in crisis

Finally, among the nations of the world, India faces some of the greatest environmental risks and the greatest environmental opportunities. This Mission is designed specifically to transform the former into the latter wherever possible. In the introduction to this paper, we emphasized the bio-cultural and bio-physical diversity of India's regions. We may then be asked, "Does India need yet another centralized programme running things? Shouldn't we rather focus on devolving environmental decision-making to the local level, and supporting knowledgeable local stakeholders in devising the most appropriate responses for their diverse constituencies?" We believe the answer lies in the scale and urgency of current crises. The world's ongoing experiences with COVID-19 have shown that rapid, unified and coherent responses to large-scale crises tend to secure the best outcomes. Furthermore, challenges such as land degradation, climate change and biodiversity loss cannot be addressed piecemeal, chiefly because our knowledge and capacities remain inadequate and uneven. Nevertheless, the knowledge of local stakeholders must be relied on in planning and implementation. One of the central tasks of this Mission is to help strengthen capacity, and thus to make the devolution of implementation strategies workable.

## CRediT authorship contribution statement

The manuscript was conceived by KB. All the authors contributed to writing the manuscript. Additionally, AS and RS worked on the graphics included in this manuscript.

## Declaration of competing interest

The authors declare no conflicts of interest.

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